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COMPARISON OF RATIONS FOR DAIRY COWS WITH SOYBEAN MEAL OR WITH RAPESEED MEAL IN WHICH THE MAIN SOURCE OF PROTEIN IS SUNFLOWER MEAL

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Abstract

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The aim of experiment is to check whether the inclusion of soybean meal in the diet will improve performance of dairy cows fed ration with sunflower meal as main protein source. This problem is important for East Europe and other regions where sunflower is the principal and cheapest protein source for ruminants. The trial is conducted with twenty four Holstein cows at 39 ± 10 days in milk in the beginning of the experiment, using the switch-back scheme. The cows were divided into two groups equalized by number of lactation, days in milk, milk yield in previous lactation, and last week before the experiment. They were fed rations with or without soybean meal for 4 weeks, and then rations were exchanged each for the other during another 4-week period. The first two weeks of each period of the trial were left for accommodation to the new ration and second two weeks - for collection of data for milk yield and composition. The cows in both groups were fed *ad libitum* with totally mixed rations. The two experimental rations contained approximately 2.5 kg alfalfa hay, 23 kg maize silage (32.35% dry matter and 19% grain in dry matter), 0.6 kg molasses and 11.5 kg concentrate mixture. The difference between the two experimental rations was in concentrate mixture composition. For the first ration concentrate mixture contained 12.7% soybean meal (SBM ration). In the concentrate for second ration, soybean meal and 5.9% of grain were replaced by 19% rape seed meal, canola type (RSM ration). The two concentrate mixtures contained 26% sunflower meal (SFM) (supplying 30% of crude protein /CP/ of the ration), and 8% dry distillers grain with soluble (DDGS) from maize (supplying 7.2% of total CP of ration). The two experimental rations were equal in feed units for milk (FUM = 6 MJ net energy for milk) and crude protein content. During each experimental period, as well as average for the two periods of trial, there were no significant differences ($P > 0.05$) in dry matter intake, milk yield, milk composition, as well as in dry matter and net energy (Feed units for milk) utilization for milk production, between rations. There was a tendency for higher live weight losses, and for bigger decrease in body condition score in cows receiving RSM ration. In conclusion under the conditions of the experiment, it is possible to replace, the expensive soybean meal with rapeseed meal, canola type in ration with sunflower meal as a main protein source.

Key words: Dry distillers grain with solubles (DDGS), rapeseed meal, sunflower meal, soybean meal, milk yield, milk composition

Abbreviations: DDGS – dry distillers grain with soluble; CM – concentrate mixture; CP – crude protein; FUM – feed units for milk, RSM – rapeseed meal; SBM – soybean meal; SFM – sunflower meal

Introduction

In our previous experiment milk production was significantly lower when sunflower meal (SFM) was the only supplemental protein, compared to diets with SBM or RSM in cows with above 30 kg daily milk yield (Yildiz et al., 2015). In other experiments SFM was also worse protein source, compared to SBM or RSM (Agapov, 2010; Magometovich, 2011).

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However, blend of SFM and SBM supports better production of dairy cows than either of protein sources alone (Nishino et al., 1980; Drackley and Schingoethe, 1986). It is expected that the combination of SFM and RSM will also be better than using them separately, because of presumably better amino acid balance (Yildiz et al., 2015) and better conditions for microbial protein synthesis into the rumen of cows.

The experiments for inclusion of SFM in different combinations with other available and cheaper protein sources in the rations, especially for high yielding cows are scarce. On the other hand it is important issue for Bulgaria and other countries where sunflower is the main oil bearing crop in order to evaluate the possibility to decrease the expensive imported SBM or to exclude it from ration of high producing dairy cows by a proper combination of locally available SFM, RSM and DDGS.

The aim of the present experiment was to determine whether it is possible to replace soybean meal with rapeseed meal, canola type, in a typical for Bulgaria and for the region diet based on maize silage and small quantity of lucerne hay and SFM with some DDGS, as main protein sources.

Materials and Methods

Twenty four multiparous Holstein cows (39 ± 10 days in milk) were used in a switch-back scheme to test two rations. The cows were divided into two groups equalized by number of lactations, days in milk, milk yield in previous lactation, and last week before experiment. They were fed rations with or without soybean meal for 4 weeks, and then rations were exchanged each for the other during another 4 weeks period. The first two weeks of each period of trial the animals were adapted to the new rations and the other two weeks were used for collection of data for milk yield and composition. The cows in both groups were fed *ad libitum* with totally mixed rations. The two experimental rations contained approximately 2.5 kg alfalfa hay, 23 kg maize silage (32.35% dry matter and 19% grain in dry matter) and 0.6 kg molasses. The aim of inclusion of 0.6 kg molasses in rations was to ensure minimum sugar content and encourage rumen fermentation. Additionally both groups received 11.5 kg concentrate mixture per cow.

The two experimental rations differed in concentrate mixture (CM) composition. Ingredient compositions of two concentrate mixtures are presented in Table 1. For the first ration CM contained 12.7% soybean meal (SBM ration). In the second ration CM soybean meal and 5.9% of grain (barley wheat and maize) was replaced with 19% rape seed meal canola type (RSM ration). The two CM contained 26% sunflower meal (SFM) (supplying 30% of CP of the ration), and 8% dry distillers grain with solubles (DDGS) from maize (supplying 7.2% of total CP of ration). The two experimental rations were equal in feed units for milk (FUM = 6 MJ net energy for milk) and CP content. The amino acid lysine was 5.54 – 5.55% of protein digestible in intestine in RSM ration, vs. 5.60% for SBM rations (Table 3).

Table 1
Ingredients composition of concentrate mixtures (CM)

Ingredients	CM with SBM, %	CM with RSM, %
Maize, ground	17	20
Barley, ground	16.1	10
Wheat, ground	15.8	13
DDGS of maize	8	8
Sunflower meal	26	26
Soybean meal	12.7	0
Rape seed meal	0	19
Limestone	1.4	1
Sodium bicarbonate	1.8	1.8
Sodium chlorate	0.7	0.7
Premix*	0.5	0.5

* Premix supplied in 1 kg concentrate mixture: 15 000 IU vitamin A, 2500 vitamin D_3, 120 mg vitamin E, 8 mg vitamin K_3, 2.55 mg vitamin B_1, 2.55 mg vitamin B_2, 0.64 mg vitamin B_6, 12 μg vitamin B_{12}, 320 mg vitamin PP, 5.1 mg dicalcium pantotenate, 300 mg choline chloride, 320 μg biotin, 100 mg manganese, 35 mg cupper, 250 mg zinc, 4 mg iodine, 0.45 mg selenium, 3 mg cobalt, 300 mg magnesium and $10x10^9$ CFU of *Saccharomyces cerevisiae* CNCM I – 1077.

Cows were kept tied in a barn and individually fed *ad libitum* a total mixed ration (TMR) two times daily (07:00 and 19:00 h). Feed intakes were recorded daily. Refusals were kept between 2 and 5% of offered TMR, by slightly adjusting the quantity of TMR. After drying up of refusal, remaining DM was subtracted from offered DM to calculate the real intake of different feeds and DM.

The cows were milked three times a day in herringbone milking parlour with individual measurement of milk in each milking. Samples of milk for analyses were taken once per week during the last two weeks of the trial. Samples were mixed by gentle inversion and composite by weight corresponding to the respective milking of each cow on sampling day. These samples were sent to laboratory for analysis where fat, protein, and lactose were determined using infrared spectroscopy (Milkoscan FT-120, Foss, Denmark).

Samples of forages were collected for 3 consecutive days at the end of each period. Samples were composited by period

and dried at 55°C for 48 h. Composites were ground through a 1-mm screen. Samples were corrected to 100% DM by drying an aliquot of the composite at 105°C for 24 h.

Samples of lucerne hay, maize silage, molasses and concentrate mixture were analysed for CP, ether extract (with petroleum ether), crude fiber, and ash (according AOAC in-

Table 2
Nutrient content and nutritive value of feeds

Items	Maize silage	Luzerne hay	Molasses	CM* with SBM	CM* with RSM
Chemical components, g.kg^{-1}					
Dry matter	323.5	867	754	857	861
Crude protein	28	135	77	218	217.6
Ether extracts	11.3	21.8	23	23.9	26
Crude fiber	73	279	0	78.7	91.8
NFE*	192.1	360.4	566.4	496.3	467.6
Minerals	19.1	70.8	87.6	40.1	58
In 1 kg feed					
FUM*♦	0.37	0.57	0.94	1.1	1.09
PDI*♦, g	27	69	71	120.3	114
BPR*♦, g	-12	21	-27	46.7	55.6
Calcium, g	1.14	11.1	2.28	6.93	6.18
Phosphorus, g	0.92	2.09	0.23	6.2	6.84

* CM – Concentrate mixture, NFE - Nitrogen free extracts, FUM - Feed units for milk, PDI - Protein digestible in intestine, BPR - Balance of protein in the rumen

♦ Data were taken from Todorov et al. (2007)

Table 3
Average daily intake of feedstuffs and nutrients of one experimental cow receiving diet with soybean meal (SBM) or diet with rapeseed meal (RSM)

Item	First period		Second period		Average for the 2 periods	
	SBM	RSM	SBM	RSM	SBM	RSM
Feedstuffs intake per day:						
Lucerne hay, kg	2.45	2.43	2.41	2.44	2.43	2.44
Maize silage (31% DM), kg	22.54	22.31	21.2	22.42	22.37	22.36
Concentrate mixture, kg	11.27	11.16	11.1	11.21	11.19	11.18
Molasses, kg	0.59	0.58	0.58	0.59	0.59	0.59
Nutrients intake per day:						
Dry matter, kg	19.52	19.36	19.22	19.46	19.37	19.41
Feed units for milk*	22.69	22.35	21.97	22.45	22.33	22.4
Crude protein, g	3464	3426	3384	3441	3424	3434
Protein digestible in intestine (PDI)*, g	2175	2084	2115	2094	2145	2089
Lysine in % of PDI*	6.6	6.54	6.6	6.55	6.6	6.55
Methionine in % of PDI*	2.18	2.26	2.18	2.26	2.18	2.26
Balance of protein in rumen*, g	303	399	298	401	301	400
Crude fiber, g	3145	3258	3096	3275	3121	3267
Ether extracts, g	561	579	553	582	557	581
Calcium, g	131	122	129	122	130	122
Phosphorus, g	95	101	93	102	94	102

* Data were calculated according to Todorov (2007)

ternational 2007). Composition of the TMR was calculated based on results of analyses and quantity of different feeds (lucerne hay, maize silage, molasses and concentrate mixture) in the diets.

Body condition scores on a scale of 1 to 5 (Todorov, 1999) and body weight were recorded approximately 3 h after feeding for 2 consecutive days at the start of the experiment and at the end of each period.

Means of dry matter intake, milk yield, and milk composition were used in statistical analysis. Analysis of variance was conducted using the mixed procedure of SAS (2003). Significance was declared at $P < 0.05$.

Results and Discussion

Average intake

Average intake of different feedstuffs, net energy (FUM) and nutrients of the two groups of cows during the two periods and the average for both periods of the trial were very similar, and did not differ significantly ($P < 0.05$) (Table 3).

Milk production

Milk production, milk composition and yield of milk protein, milk fat and lactose did not differ significantly ($P > 0.05$) during the two periods of the experiment and depending on dietary protein sources (Table 4). There was a tendency for lower daily yield of milk protein when SBM in the ration of cows was replaced with RSM, but the difference was very small (about 2%). Equal milk yield with SBM or RSM as a source of supplemental protein in the ration of dairy cows was reported by other authors too (Ipharraguerre and Clark, 2005; Brito and Broderick, 2007; Martineau et al., 2013)

Christen et al. (2010) reported a certain decrease of percentage of milk fat when SBM was replaced with RSM, but in our experiments there was no such difference in fat percentage.

Decreases in body weight during the trial tended to be higher when cows received ration with RSM, than during the period when cows were fed with ration with SBM. The difference was bigger during the first experimental period because of slightly lower feed intake and slightly higher milk yield of cows receiving RSM, compared to those fed ration with SBM. The average difference in changes of live weight of cows during the entire trial was not significant ($P > 0.05$).

Feed conversion ratio

Feed conversion ratio and efficiency of protein utilization for milk production was approximately similar for rations with SBM and RSM during the two periods of trial and on the average for the two periods (Table 5). There was a tendency for better utilization of crude protein in the ration with SBM, but not as the utilization of protein digestible in small intestine was concerned. However, both tendencies were relatively weak (about 2% or smaller differences). The similar efficiency of dry mater, feed units for milk (FUM) and protein in two rations was not considerably affected by changes

Table 4
Milk yield and composition, body weight and condition score of experimental cows, fed ration with soybean meal (SBM) and ration with rapeseed meal (RSM)*

Items	First period		Second period		Av. for 2 periods	
	SBM	RSM	SBM	RSM	SBM	RSM
Milk yield, kg/day	32.3	32.4	31.4	31	31.85	31.7
Fat, %	3.84	3.81	3.78	3.8	3.81	3.81
Fat, g/day	1240	1234	1187	1178	1214	1206
Protein, %	3.22	3.19	3.24	3.2	3.23	3.2
Protein, g/day	1040	1034	1017	992	1029	1014
Lactose, %	4.12	4.13	4.13	4.14	4.13	4.14
Lactose, g/day	1331	1338	1297	1283	1314	1311
Body weight (BW) at beginning, kg	591	595	576	574	584	585
Body weight at end of period, kg	576	574	564	563	570	569
BW, g of change/ day	-536	-750	-429	-393	-483	-572
Body condition score at beginning	3.1	3.2	2.8	2.7	2.95	2.95
Body condition score (BCS) at end of period	2.8	2.7	2.6	2.6	2.7	2.65
BCS, change during experimental period	-0.3	-0.5	-0.2	-0.1	-0.25	-0.3

* Differences between groups were not significant ($P>0.05$)

in body weight or body condition changes during the experimental period (Table 4).

There were several other experiments reviewed by Yildiz and Todorov (2014) which found equal or even better milk yield of cows receiving RSM than SBM. What is specific in this trial is that main sources of protein in rations were sunflower meal together with small amount of DDGS. Therefore, it was possible to organize feeding of relatively high producing dairy cows only with relatively cheap protein sources (SFM, RSM and DDGS) produced locally in the Balkan region.

There were significant differences in the cost of feeds per cow (Table 6). The lucerne hay and maize silage were produced in the experimental farm, and their costs were used in the calculations. All other components were purchased and their actual prices were taken. Daily rations costs were by 7 – 9% cheaper when SBM was replaced with RSM. Approximately the same differences were observed for feed cost per 1 kg milk.

Conclusions

Under experimental conditions, when the ration of dairy cows with about 32 kg daily milk yield, consisted of approximately 2.5 kg lucerne hay, 23 kg maize silage, 0.6 kg molasses and 11.5 kg concentrate mixture, with sunflower as the

Table 5
Dry matter, net energy and protein efficiency in cows receiving ration with soybean meal (SBM) and ration with rapeseed meal (RSM)♦

Items	First period		Second period		Av. for 2 periods	
	SBM	**RSM**	**SBM**	**RSM**	**SBM**	**RSM**
Energy corrected milk (ECM)*, kg/day	34.08	34.00	32.94	32.51	33.52	33.26
ECM/ Intake of dry matter	1.75	1.76	1.71	1.67	1.73	1.71
Feed units for milk/ ECM	0.66	0.65	0.67	0.68	0.664	0.661
Protein in milk/Intake of crude protein	0.303	0.304	0.301	0.291	0.302	0.298
Protein in milk/Protein digestible in intestine	0.484	0.508	0.481	0.480	0.482	0.492

* Energy corrected milk = 0.327 × milk (kg) + 12.95 × fat (kg) + 7.20 × protein (kg).
♦ Average values for two rations are not different (P>0.05)

Table 6
Cost of feeds in ration with soybean meal (SBM) and ration with rapeseed meal (RSM) per cow per day and per 1 kg milk, in Euro

Items	Cost	First period		Second period		Average for the 2 periods	
	€/kg	SBM	RSM	SBM	RSM	SBM	RSM
Component of ration							
Lucerne hay	0.09	0.221	0.219	0.217	0.22	0.219	0.22
Maize silage	0.035	0.789	0.781	0.742	0.784	0.783	0.783
Molasses	0.22	0.13	0.128	0.128	0.13	0.13	0.13
Concentrate mixture with SBM	0.342	3.843		3.785		3.816	
Concentrate mixture with RSM	0.305		3.404		3.419		3.41
Total cost of ration per cow/day		4.983	4.532	4.872	4.553	4.948	4.543
Milk production per cow per day							
Milk yield per cow per day, kg		32.3	32.4	31.4	31	31.85	31.7
Energy corrected milk, kg/day		34.08	34.00	32.94	32.51	33.52	33.26
Cost of feeds per 1 kg milk							
Milk as it was milked		0.154	0.14	0.155	0.147	0.155	0.143
Energy corrected milk (ECM)		0.146	0.133	0.148	0.140	0.148	0.137
ECM when SBM ration =100%		100	91%	100	94%	100	93%

main protein source, it was possible to replace soybean meal by rapeseed meal. This change did not affect feed intake, milk yield, milk composition, body weight changes and feed efficiency. Daily cost of feed per cow or per 1 kg milk was by 6 to 9% lower, under Bulgarian conditions, when soybean meal was replaced by rapeseed meal.

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