Effects of replacing sunflower meal with camelina meal on dairy cows performances

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SUMMARY

The objective of this study was to evaluate the effect of different levels of dietary camelina meal (source of fats rich in polyunsaturated fatty acids, PUFA) on milk production and quality in multiparous cows. The monofactorial experiment used 24 cows, for two weeks, assigned randomly to three groups: control (C), which received a compound feed consisting of corn, wheat bran and sunflower meal (31% in the CF) in addition to the basal diet; experimental 1 (E1) which received the same basal diet and compound feed, in which 50% of the sunflower meal was replaced by camelina meal (15.5% in the CF); experimental 2 (E2) which received the same basal diet and compound feed, in which the sunflower meal was replaced completely by camelina meal (31% in the CF). The routine compositional raw milk analysis (fat, protein and lactose) were determined by infrared spectroscopy, techniques comply with AOAC Official Method 972.16:2006 and International IDF Standard 141C:2000. Gas chromatography was used to determine the fatty acids from the milk and compound feed. The experimental results have shown that the partial or total replacement of the sunflower meal with camelina meal didn't affect significantly ($P>0.05$) milk production and milk composition. On the other hand, milk quality, as reflected by the fatty acids (FA) composition was improved significantly by the dietary camelina meal. Thus, the concentration of PUFA, n-6 PUFA and CLA was significantly ($P<0.0001$) influenced by the treatment. As the concentration of PUFA and MUFA increased, the concentration of saturated fatty acids (SFA) decreased highly significantly ($P= 0.001$). In conclusion, the vegetal ingredients rich in PUFA have beneficial effects on milk quality, which in turn, improves the health state of the consumers.

Keywords: camelina, milk, fatty acids, breed

INTRODUCTION

Milk consumption is expected to increase over the next 20 years with the increase of the world population (World Health Organisation, 2003). The higher milk production must be accompanied by a better quality of the milk, which to meet consumer requirements in terms of health state. Milk quality doesn't refer just to the content of lipids, but also to their composition (class of lipids-cholesterol, mainly, and the composition in saturated/unsaturated fatty acids), which can change the technological, organoleptic and dietary traits of the milk (Chilliard, 1993).

Milk is a source of essential nutrients and an important source of energy, fat and high quality protein, whose proportion is influenced by several factors. Generally, milk fat amounts to 3-4%, protein to about 3.5% and lactose 5% (www.fao.org, Fox & McSweeney, 1998). Cow milk accounts for over 80% of the total milk production (Tamine, 2009). Cow breeds have been selected for the desired production (milk, meat, dual purpose), and also according to the environmental conditions (climate, feeds, etc.). This resulted in variable milk composition and/or milk production. However, the rigorous selection during the recent decades decreased this variability (Tamine, 2009). While the vegetal ingredients are rich in lipids with high concentrations of (mono and poly) unsaturated fatty acids that have a beneficial effect on human health, animal products have a higher concentration of saturated fatty acids, with detrimental effects to human health. Givens and Gibbs (2006) considered that the level of fatty acids beneficial to human health can be manipulated through feeding, but the addition of lipids to the diet interferes with rumen fermentation (Palmquist, 1994, Hăbeanu et al., 2014). Because the dietary saturated fatty acids, found mainly in animal foods, are detrimental to human health, their level in the foods has to be decreased, while maintaining a proper balance with the unsaturated fatty acids. It has been shown that vegetal oils or fats influence differently the quality of foods and the health state, the interest in specific FA becoming a priority (Dubois et al. 2007). There are recommendations for the daily intake of each type of FA, for instance, SFA, monounsaturated (MUFA) and, mainly, polyunsaturated (PUFA) and their long-chain derivatives. The fat from ruminants is a major source of CLA in human diets (Chin et al., 1992), so that its concentration in the human adipose tissue is also influenced by the consumption of milk fat (Jiang et al., 1999). N-3 fatty acids are important due to their impact on human/animal health (Bauchart et al., 2010, Mahecha et al., 2009, Riediger et al., 2009).

The quality surveys of animal foods generally approach technological, organoleptic, feeding economic and hygienic issues. Currently, the consumer became an important component of these studies, both regarding the perception as "image" and the influence on human health. On the other hand, the production of edible soya, sunflower and rapeseeds oil, the most significant crops in the temperate climate regions, has it major limitations, the most important one being the competition with human consumers (Hymowitz 1990; Downey 1990), and the predominant composition of n-6 and/or monounsaturated fatty acids, to the detriment of saturated fatty acids.

The purpose of our study was to evaluate the effects of the dietary camelina meal obtained by cold pressing as vegetal source supplying polyunsaturated fatty acids (n-3 mostly) compared to other sources (such as sunflower meal), on milk production and quality, as well as the correlation between different analysed parameters.

MATERIAL AND METHODS

Animals and feeds

The animals were supplied by INCDBNA Balotesti, Romania. The experimental conditions were in agreement with Council Directive 2010/63/EU legislation for the protection of animals used for scientific purposes.

The two-week monofactorial design experiment used 24 multiparous dairy cows with an initial average 103 ± 12.10 days in milk, and 19.70 ± 0.44 l/day, average milk yield. The animals were assigned randomly to 3 groups: control (C), which received a compound feed consisting of corn, wheat bran and sunflower meal (31% in the CF) in addition to the basal diet; experimental 1 (E1) which received the same basal diet and compound feed, in which 50% of the sunflower meal was replaced by camelina meal (15.5% in the CF); experimental 2 (E2) which received the same basal diet and compound feed, in which the sunflower meal was replaced completely by camelina meal (31% in the CF). The diets were isoenergy and isoprotein (Table 1).

Chemical analyses

Milk chemical composition

The routine compositional raw milk analysis (fat, protein and lactose) were determined by infrared spectroscopy, techniques comply with AOAC Official Method 972.16:2006 and International IDF Standard 141C:2000. A high capacity, fully automated MilkoScan 605 spectrophotometer (Foss, Denmark) was used.

The milk samples were collected during the last two days of the experimental period, both at the morning and evening milking, and the average value was used.

Fatty acids

The fatty acids were determined by gas chromatography (SR CEN ISO/TS 17764-2:2008). The method involves the transformation of the fatty acids from the sample of fat into methyl esters, followed by the separation of the components in a capillary chromatograph column and their identification by comparison with standards chromatograms. We used a Perkin Elmer-Clarus 500 chromatograph with capillary column and high polarity stationary phase (BPX70, 60m X 0.25mm inner diameter, 0.25 µm film), or high polarity cyanopril phases, which give similar resolution for different geometric isomers (THERMO TR-Frame 120m x 0.25mm ID x 0.25 µm film).

Table 1. Diets and compound feeds formulation and supply of nutrients

Item	Control	E1 (camelina 50)	E2 (camelina 100)
Diet formulation (kg DM/cow)			
Alfalfa hay	2.55	2.55	2.55
Brewers grains	0.82	0.82	0.82
Fresh Sudan grass	9.76	9.76	9.76
CF	5.85	5.87	5.89
Compound feed formulation (%)			
Corn	51.8	51.8	51.8
Wheat bran	12.9	12.9	12.9
Sunflower meal	31.0	15.5	0
Camelina meal	0	15.5	31.0
Calcium carbonate	2.3	2.3	2.3
Salt	1.0	1.0	1.0
Vitamin-mineral premix	1.0	1.0	1.0
Nutrient supply			
DM (kg/cow/day)	18.99	19.00	19.02
FU_{milk} (cow/day)	15.06	15.42	15.78
IDPN (g/ cow/day)	1772.32	1788.29	1804.25
IDPE (g/ cow/day)	1689.74	1689.29	1688.84
Ca (g/ cow/day)	136.17	141.25	146.34
P (g/ cow/day)	90.1	91.82	93.54

Statistical analysis

The monofactorial design experiment used multiparous cows. The experimental data were submitted to variance analysis using the software package SPSS- general linear model (SPSS Statistics version 20.0). The results were expressed as means and standard error of the mean. The fatty acids were expressed as percentage of the total fatty acids as methyl ester. The means were considered significantly different for $P<0.05$ and highly significantly different for P<00001. For P between 0.051 and 0.10 we considered that the factor of influence tended to influence the results. When significant differences were determined, the Tukey test was used to determine the particular groups. Pearson's correlation (SPSS logiciel software – correlation) was used to determine the interrelation between particular parameters.

RESULTS AND DISCUSSION

Camelina sativa, or the *wild flax*, is an oleaginous plant rich in essential n-3 fatty acids. Little is known about the effects of these plants on animal performance. Rather recent studies on ruminants (Wood and Fearon, 2009, Filleau et al., 2011, Hurtaud & Peyraud. 2007), poultry (Aziza et al. 2010) and piga (Hăbeanu et al., 2011), revealed the positive effects of the dietary camelina and/or camelina by-products on animal performance.

Effects on milk yield and milk composition

Table 2 shows the influence of two different levels of camelina meal (15.5 and 31%) on milk yield and milk average composition. As it can be seen from Table 2, the dietary camelina meal (which replaced partially or completely the sunflower meal), didn't affect significantly milk production (P = 0.55) and/or its composition (% fat, P= 0.58, % protein, P= 0.82, or % lactose, P = 0.99). The partial replacement of the sunflower meal caused a 5% reduction of the milk yield, while the total replacement of the sunflower meal determined a 1.8% increase of the milk yield, but the results were not affected significantly (P= 0.55). Milk fat decreased consequently to the use of camelina meal in the diet, irrespective of the level of inclusion (about ≈7% lower in the two experimental groups), which is in agreement with previous studies conducted by Hurtaud & Peyraud. (2007). On the other hand, both protein and lactose had rather similar values in all three groups, with nonsignificant differences (P> 0.05).

Table 2. Effect of the dietary camelina meal level on milk yield and milk composition

Item	Control	E1 (Camelina 50)	E2 (Camelina 100)	SEM	P
Milk yield, l/day	19.27	18.35	19.63	0.48	0.55
% fat	3.398	3.165	3.163	0.09	0.58
% protein	2.852	2.913	2.953	0.06	0.82
% lactose	4.451	4.446	4.448	0.04	0.99

P <0.05 (significant different); P <0.01; P <0.001 (distinctly different and highly significant different)

Pearson's correlation (r) from SPSS software was used to determine the interrelations between the data sets (Table 3). A positive correlation (r = 0.54), distinctly significant (P = 0.008) was noticed for the % of protein and lactose.

As expected, the increase of the milk yield decreased the proportion of solid fractions, the correlation between them and milk yield being negative, irrespective of milk composition. However, this is not a close correlation, the values not being close to the unit.

Table 3. Correlation between milk yield and milk solid fractions

Item		% fat	% protein	% lactose	Milk yield
% fat	Pearson's correlation	1	0.14	0.41	-0.28
	Value of P	-	0.51	0.052	0.19
% protein	Pearson's correlation	0.14	1	0.54**	-0.33
	Value of P	0.51	-	0.008	0.12
% lactose	Pearson's correlation	0.41	0.54**	1	-0.11
	Value of P	0.052	0.008	-	0.61
Milk yield (l/cow)	Pearson's correlation	-0.28	-0.33	-0.11	1
	Value of P	0.19	0.12	0.61	-

Centesimal fatty acids composition of the milk

Lipid structure can be influenced through feeding to obtain products with quality traits that support good health state. The key-elements in the milk quality studies were the fatty acids and their profile, because particular fatty acids have positive or negative influences on human/animal health (Chilliard et al. 2002, Jensen, 2002). Fatty acids composition can be manipulated in animal products by feeding the animals vegetal resources whose feeding characteristics are adequate for the beneficial change of the fatty acids profile (Bauchart et al., 2005, Hăbeanu et al., 2014, Scollan, 2000, Chilliard et al, 2002).

In our study, we aimed to improve the fatty acids profile of the milk by feeding camelina meal to the multiparous dairy cows. Camelina meal was obtained after the cold pressing oil extraction from camelina seeds; it has a proper content of PUFA, n-3 particularly.

Table 4 shows the centesimal fatty acids composition of the milk after the inclusion of two different levels of camelina meal, 15.5% and 31%.

The dietary camelina meal changed for the better the fatty acids composition of the milk. Wood et al. (2009), reported that the changed in animal feeds can easily change the FA profile and thus increased PUFA concentration in animal products.

Table 4. Centesimal fatty acids composition of the milk as effect of the dietary camelina meal

Fatty acids (% of total FA esters)	Control	E1 (Camelina 50)	E2 (Camelina 100)	SEM	Diet effect Value of P
C4:0 (butyric)	0.11	0.08	0.06	0.007	0.02
C12:0 (lauric)	3.46	3.46	3.46	0.07	0.49
C14:0 (myristic)	12.66	12.67	12.44	0.15	0.45
C16:0 (palmitic)	31.01	20.03	28.20	0.34	0.002
C16:1 (palmitoleic)	1.50	1.39	1.38	0.24	0.83
C18:0 (stearic)	9.16	9.17	8.85	0.24	0.83
C18:1 total trans	0.18	0.15	0.84	0.21	0.33
C18:1cis-9 (oleic)	23.05	25.13	25.34	0.40	0.04
C18:2n-6 (linoleic)	2.35	2.54	2.53	0.09	0.69
C18:3n-3 (α-linolenic)	0.47	0.45	0.45	0.01	0.75
C18:2 CLA	0.78	0.87	1.22	0.04	<0.0001
C20:2n-6 (eicosadienoic)	0.23	0.33	0.38	0.015	<0.0001
C20:3n-6 (dihomo-gamma linolenic acid)	0.14	0.24	0.30	0.01	<0.0001
C20:3n-3 (eicosatrienoic)	0.12	0.15	0.21	0.01	0.004
C20:4n-6 (arahidonic)	0.06	0.04	0.04	0.008	0.73
C22:1n-9 (erucic)	0.03	0.03	0.03	0.006	0.66
Total SFA	64.98	61.87	60.34	0.54	0.001
Total MUFA	27.67	29.58	30.48	0.39	0.01
Total PUFA	5.52	6.43	6.31	0.19	<0.0001
Total n-6 PUFA	4.92	5.81	6.64	0.18	<0.0001
Total n-3 PUFA	0.62	0.61	0.67	0.01	0.22
n-6/n-3 ratio	9.45	9.60	10.25	0.32	0.04

P <0.05 (significantly different); P <0.01; P <0.001 (distinctly different and highly significantly different), T = trend that the factor of influence (diet or breed) has affect (P between 0.51 ---0.10); Total SFA = C4:0+ C6:0 + C8:0 + C10:0 + C11:0 + C12:0 + C13:0 + C14:0 + C15:0 + C16:0 + C17:0 + C18:0 + C20:0; Total MUFA = C14:1 + C15:1+ C16:1 + C17:1 + C18:1cis-9 + C18:1 trans total; C22:1n-9; Total PUFA = C18:2n-6 +C18:3n-3 +C18:3n-6 + CLA + C20:2n-6 + C20:3n-6 + C20:3n-3 + C20:4n-6+C20:2 trans

We noticed in our experiment a very significant (P<0.0001) increase of the PUFA concentration in the milk obtained from the animals treated with camelina meal, particularly when the sunflower meal was completely replaced. Thus, PUFA concentration increased 1.17 times in E1 group and 1.14 times in

E2 group, compared to the control group. The same trend of very significant ($P<0.0001$) increase has also been noticed for n-6 PUFA, i.e. 1.3t times for E2 and 1.18 times for E1. Among the PUFA, the linoleic fatty acid (from n-6 family) had the most important proportion, followed by CLA which, although in small amount, has an intense biological activity (Bhatacharya et al. 2006). The dietary treatment had a very significant ($P<0.0001$) effect in the case of CLA too. CLA precursors are dietary PUFA, mainly linoleic and linolenic FA (Chilliard et al. 2002). The biohydrogenation of the linoleic and α-linolenic fatty acids in the rumen reaches 90-80% (Chilliard et al. 2002), so that the proportion of these fatty acids is rather low (≈2.48% linoleic, and 0.46% AG α-linolenic FA). Against our expectations, the values for the α-linolenic FA were similar among the three groups, the possible explanation being the biohydrogenation in the rumen and/or the duration of the experiment, which was rather short. As expected, the oleic acid (≈23-25%) had the highest proportion among the monounsaturated fatty acids (MUFA), displaying a trend that the treatment has effect ($P = 0.04$). as the proportion of PUFA and MUFA increases, the proportion of SFA decreases (by 4.7% in E1 and by 7% in E2). The palmitic fatty acid was predominant among the SFA (20-31%), followed by the myristic (≈12%) and stearic (8-9%) fatty acids.

CONCLUSIONS

The replacement of the sunflower meal by camelina meal didn't have a significant effect on milk yield and on milk components (proteins, fat and lactose). A diet enriched in polyunsaturated fatty acids influences very significantly their concentration in the milk, which means a higher feeding quality, with potential beneficial effects on consumer health.

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