The effect of *Camelina sativa* cake on fatty acid composition and sensory quality of eggs and broiler meat

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Summary

Camelina sativa is an oilseed crop of the *Brassica* family. Camelina oil, high in omega-3 fatty acids (ω-3 FA), is successfully used as an ingredient in food production. Due to its high oil content and favourable fatty acid composition, *Camelina sativa* cake (CSC), a by-product of oil pressing process, has attained interest as a potential feed ingredient. In July 2008, EU Comission gave a directive, which enables the feed use of *Camelina sativa* and its derivatives.

The effects of CSC on poultry performance and FA composition and sensory quality of poultry products have been studied in several experiments. Increasing the CSC content in broiler diet impaired feed intake, weight gain and feed conversion but mortality was decreased. Broiler breast meat ω-3 FA content increased with increasing dietary CSC and the ω-6/ω-3-ratio decreased. Dietary CSC had no adverse effect on the sensory quality of broiler meat.

Laying rate and FCR of hens was unaffected by dietary CSC. Increased dietary CSC decreased feed intake and egg weight. Mortality was unaffected, but weight gain decreased with increasing dietary CSC. Yolk ω-3 FA content increased and ω-6/ω-3-ratio decreased with increasing CSC in diet. No systematic effect on sensory quality of eggs was observed.

At the moment CSC and camelina oil are used as feed ingredients in commercial layer diets.

Keywords: camelina, omega-3 fatty acids, eggs, broiler meat

Introduction

Increasing interest has been shown for the possibilities to affect the nutritional value of animal products by feeding. Special attention has been paid on the fatty acid composition of eggs and meat.

In human nutrition, serum fatty acid composition is a good biomarker of the fatty acid composition of the diet (Karvonen et al., 2002). Alpha-linolenic acid can affect several cardiovascular risk factors, including serum lipids, blood pressure, and hemostatic factors, and thus reduce the risk for coronary heart disease (Karvonen et al., 2002).

According to Karvonen et al. (2002), there is also epidemiologic evidence of the cardioprotective effects of α-linolenic acid. In the European Community Multicenter Study on Antioxidants, Myocardial Infarction, and Breast Cancer (EURAMIC) study, the relative risk for myocardial infarction was highest in subjects with the lowest α-linolenic acid concentration in adipose tissue (Guallar et al. 1999, ref. Karvonen et al. 2002).

Camelina sativa L. crantz (false flax), an ancient agricultural crop, is rich in essential omega-3 fatty acids (ω-3 FA). Camelina oil can be used in both edible and industrial products. Reported seed oil content ranges from 29 to 39 percent (Budin et al., 1995). The α-linolenic acid content, which is one of the essential ω-3 FAs, is high and varies between 30 and 40% of the oil (Karasti, 2008).

Camelina plant

Camelina plant belongs to the Brassicaceae family. Based on data obtained from Finnish official variety trials, the average growing time varies between 104 and 108 days and the crop between 1562 and 1920 kg/ha, plant length between 93 and 95 cm, 1000 seed weight between 1.3 and 1.5 g, protein content of the seeds between 27.7 and 28.6% and the oil content between 39.0 and 39.7% (Kangas et al. 2008).

Camelina oil contains higher amount of tocopherol and tocotrienol than e.g. canola, flax or soyabean oil (Budin et al. 1995). The erucic acid content of many camelina oil samples is higher than the maximum allowed in canola oil (2 percent), but camelina breeding lines that have no erucic acid have been identified, and lower erucic acid lines are being developed (Ehrensing & Guy, 2008).

Camelina oil in human nutrition

As a model to human nutrition, the effects of camelina oil has been studied with pigs. Eidhin et al. (2003) concluded, that the camelina oil diet increased ω-3 long-chain fatty acids, in particular eicosapentaenoic acid (EPA) and improved the ratio of ω-6 to ω-3 fatty acids in plasma.

Karvonen et al. (2002) studied the effects of camelina oil on serum lipids and on the fatty acid composition of total lipids in comparison to rapeseed and olive oils. In their experiment, sixty-eight hypercholesterolemic subjects aged 28 to 65 years were randomly assigned after a 2-week pretrial period to 1 of 3 oil groups: camelina oil, olive oil and rapeseed oil. For 6 weeks, subjects consumed 30 g of test oils daily. At the end of the study, the proportion of α-linolenic acid in fatty acids of serum lipids in the camelina group, was significantly higher compared to the 2 other oil groups. Respectively the proportions of 2 metabolites of α-linolenic acid (eicosapentaenoic and docosapentaenoic acids) increased and differed significantly in the camelina group from those in other groups. During the intervention, the serum low-density lipoprotein (LDL) cholesterol concentration decreased significantly by 12.2% in the camelina oil group, 5.4% in the rapeseed oil group, and 7.7% in the olive oil group.

Based on these observations, the usage of camelina oil in margarine and other food products is nutritionally justified and beneficial. Raisio Nurition Ltd. has supplemented the food products with camelina oil starting in year 2003 with margarine products.

Regulatory framework of Camelina feed use

Before July 2008, the Camelina cake was not an approved feedstuff in the EU. Based on the opinion given by EFSA (2007), EU Comission gave a directive (EU, 2008), which enables the feed use of *Camelina sativa* and its derivatives. The permission provides that the amount of total glucosinolates in the diet does not endanger animal and public health. The toxicity of the glucosinolates is generally attributed to the (iso)thiocyanates, and thus the protection of animal and public health against the toxic effects of glucosinolates is ensured by the provision for volatile mustard oil in complete feed, for which the maximum level is expressed as allyl isothiocyanates (EU, 2008).

In September 2008, the U.S. Food and Drug Administration's (FDA) Division of Animal Feeds provided clarification to states regarding the limited use of Camelina sativa oilseed meal as a commercial feed ingredient. Although FDA prefers a written request for distribution of camelina meal, states may approve the limited use of camelina meal for in-state commerce. For example, the Montana Department of Agriculture has limited the use of Camelina sativa oilseed meal as a feed ingredient to feedlot beef cattle and growing swine at no more than 2 percent of the final ration. However, it can be used in diets of broiler chicken diets at an inclusion rate of no more than 10 % of the diet.

Camelina products as feed ingredients

Laying hens

Due to its high oil content and favourable fatty acid composition, *Camelina sativa* cake (CSC), a by-product of oil pressing process, has attained interest as a potential feed ingredient.

The fatty acid composition of hen egg can be modified by feeding (Juneja, 1997; Sim & Nakai, 1994). However, modification of the fatty acid content of hen eggs may cause sensory problems. A diet containing flax seed had a negative effect on sensory quality of eggs (Jiang et al., 1992). However, Kiiskinen et al. (1996) did not find any adversary effects when adding flax oil in the diet.

In one of the first experiments with laying hens, Rokka et al. (2002) studied the effect of Camelina sativa enriched diet on the composition and sensory quality of hen eggs. In their experiment white Leghorn hens at the age of one year (n=18 per treatment) were fed a standard laying diet or standard laying diet supplemented with 5 % Camelina oil (CO) for a period of three weeks. The content of ω-3 FAs in egg yolk, especially the content of α-linolenic acid, increased as a result of feeding CO (Table 1).

Table 1. Fatty acid composition of the egg yolk lipids (Rokka et al., 2002).

	Control	Camelina oil -diet
C16:0 (palmitic)	25.50	23.82
C18:0 (stearic)	8.83	9.32
C18:1 (oleic)	43.33	39.57
C18:2 ω-6 (linolic)	12.00	13.38
C20:4 ω-6 (arachidonic)	1.95	1.23
C18:3 ω-3 (alfa linolenic)	0.60	5.02
C20:5 ω-3 (EPA)	-	-
C22:6 ω-3 (DHA)	1.25	1.81
ω-3 total	1.85	6.83
ω-6 total	13.95	14.61
ω-6/ω-3	7.54	2.14

Modifying the diet with CO did not affect the foaming, emulsifying and gelling properties of the eggs. Therefore, the authors concluded that bakeries and the egg processing industry could use CO eggs as a source of ω-3 FAs in their products.

In multi-comparison tests ten trained panellists were asked to evaluate the odour, taste and general acceptance of the yolks compared to the control sample. The results of these tests showed better scores for the CO group than for the other test group fed with flax seed oil diet. The results are consistent with the results obtained earlier by Zubr (1997).

In another experiment 54 LSL hens were divided to three different groups (Valkonen et al., 2006). The control group received normal diet consisting of grains, soybean meal, vegetable oil, minerals and vitamins. The two experimental groups were fed diets in which part of the soybean meal was replaced with either 50 or 150 g CSC/kg feed. The feeding had no effect on the egg production. However, a slight reduction of feed intake was found with dietary CSC inclusion. The proportion of ω-3 FAs in egg yolk was higher in CSC groups than in the control group. CSC feeding had a favourable effect on ω-6: ω-3 FAs in egg yolk. The sensory tests revealed no significant effect of CSC inclusion in the diet.

In a third Finnish 52-week experiment conducted by Valkonen et al. (2007) the effects of CSC on performance of laying hens and nutritional and sensory quality of eggs was studied. In layer diets 0, 25, 50, 75 or 100 % of soybean meal was replaced with CSC. Laying rate and feed conversion rate of hens was unaffected by dietary CSC. However, increased dietary CSC decreased feed consumption and egg weight. Mortality was unaffected by CSC, but weight gain decreased with increasing dietary CSC.

Yolk ω-3 FA content increased and ω-6/ω-3 -ratio decreased with increasing CSC in the diet (Table 2). Dietary CSC had no systematic effect on sensory quality of eggs.

Table 2. Proportion of selected fatty acids in egg yolk (g per 100g fatty acids) at 69 weeks of age (Valkonen et al., 2007).

CSC %	N	16:0	18:0	18:1	18:2	18:3	20:4	20:5	22:6	total ω-3	total ω-6	ω-6: ω-3
0	4	23.6	9.15	45.3	12.8	0.72	2.04	0.00	1.41	2.42	15.2	6.30
7	4	23.6	8.77	45.0	13.2	1.26	1.59	0.00	1.64	3.22	15.2	4.73
13	4	23.1	9.21	43.7	13.6	2.13	1.36	0.06	1.89	4.47	15.4	3.45
20	4	22.1	9.64	43.0	13.8	2.90	1.19	0.08	2.05	5.43	15.6	2.88
26	4	21.9	9.26	41.5	14.6	3.74	1.10	0.08	2.21	6.46	16.4	2.53
SEM		0.120	0.142	0.234	0.186	0.075	0.027	0.002	0.052	0.097	0.189	0.064
	C1	***	ns	***	***	***	***	***	***	***	ns	***
	C2	***	*	***	***	***	***	***	***	***	***	***
	C3	ns	ns	*	ns	ns	***	***	ns	ns	*	***
	C4	***	**	ns	ns	ns	ns	***	ns	ns	ns	ns

C1=control vs. other groups, C2= linear effect of CSC, C3=quadratic effect of CSC, C4=cubic effect of CSC.

However, the authors reported a linear increase in the relative thyroid weight with increasing CSC inclusion. This may reflect presence of goitrogenic substances in CSC (Tripathi & Mishra, 2007).

Valkonen et al. (2007) concluded, that CSC can be used in layer diets as a source of protein and omega fatty acids without significant detrimental effects on hens' health or performance. In addition, the high ω-3 FA content of CSC ameliorates the fatty acid profile of egg yolk, especially the ω-6:ω-3-ratio, without significant effects on the sensory quality of eggs.

Sands et al. reported (ref. Lundeen, 2007) that palatability of camelina seeds was good when fed as whole seeds. However, the observed levels of omega-3 in the eggs were significantly less than expected. Instead, feeding camelina meal produced eggs with 10 times the amount of ω-3 FA levels compared to feeding whole seeds.

Broilers

In the first Finnish experiment with broilers, Ryhänen et al. (2007) observed linearly reduced growth of the birds, when 5 or 10 % of CSC was fed. CSC also depressed the feed intake and feed conversion ratio during the starter phase (1-14 days). However, CSC did not cause any significant enlargement of the thyroid gland, nor were any liver lesions observed. Feeding of CSC significantly increased the ω-3 FA level in broiler meat. This was mainly due to an increase in α-linolenic acid. Feeding did not seem to have any adverse effect on the sensory quality of broiler meat.

In the second experiment the effects of CSC on performance and FA composition and sensory quality of meat were studied in a 38-day broiler experiment (Valkonen et al., 2007). Broiler diets contained 0, 5, 10, 15, 20 or 25 % CSC.

Also in this experiment, increasing the CSC content in broiler diet impaired feed intake, weight gain and feed conversion but mortality was decreased. Broiler breast meat ω-3 FA content increased with increasing dietary CSC and the ω-6/ω-3-ratio decreased (Table 3.).

Table 3. Proportion of selected fatty acids in male broiler breast meat (g per 100g fatty acids) (Valkonen et al., 2007).

CSC %	N	16:0	18:0	18:1	18:2	18:3	20:4	20:5	22:6	total ω-3	total ω-6	ω-6: ω-3
0	4	22.4	8.10	33.9	16.0	1.75	2.81	0.43	0.57	4.67	20.3	4.45
5	4	21.9	8.39	30.7	17.0	3.47	2.87	0.75	1.11	8.03	21.6	2.71
10	4	20.4	8.62	29.9	17.0	5.38	2.59	0.95	0.93	10.0	21.3	2.22
15	4	20.2	8.86	28.3	17.5	5.31	2.95	0.97	1.33	10.7	22.6	2.12
20	4	19.9	9.04	27.7	16.0	6.47	3.02	1.44	1.43	13.0	21.0	1.62
25	4	20.2	9.54	23.7	18.0	6.82	3.37	1.51	2.35	15.1	23.7	1.57
SEM		0.485	0.523	1.201	0.498	0.345	0.344	0.002	0.167	0.703	0.752	0.174
	C1	**	ns	***	o	***	ns	***	***	***	*	***
	C2	**	*	***	o	***	ns	***	***	***	*	***
	C3	o	ns	ns	ns	ns	ns	ns	o	ns	ns	***
	C4	ns	ns	ns	*	ns	ns	ns	*	ns	ns	*
	C5	ns	ns	ns	ns		ns	ns	ns	ns	ns	o

C1=control vs. other groups, C2=linear effect of CSC, C3=quadratic effect of CSC, C4=cubic effect of CSC, C5=quartic effect of CSC.

The average proportion of thyroid glands increased linearly with increasing dietary CSC content. The amount of abdominal fat in proportion to bodyweight decreased linearly with increasing dietary CSC content. However, dietary CSC had no effect on the sensory quality of broiler meat.

Acamovic et al. (1999) observed low digestibility coefficients of camelina meal for nitrogen and dry matter, which suggested that non-starch polysaccharides and other compounds such as the glucosinolates may interfere with the utilisation of camelina meal in poultry diets.

Conclusions

EU directive (EU, 2008), which enables the feed use of *Camelina sativa* and their derivatives, is a prerequisite for practical feed use. Based on several experiments with laying hens and broilers, it can be concluded that 5-10% CSC in broiler diets and 28% CSC in layer diets has no remarkable effects on poultry performance or on product sensory quality, but will enhance the fatty acid composition of egg yolk and broiler meat.

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