EFFECT OF DIETARY SUPPLEMENTATION WITH RAPESEED AND FISH OIL MIXTURE AND ANTIOXIDANT ON RABBIT MEAT QUALITY

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ABSTRACT

The aim of the study was to determine the effect of a rapeseed oil (2%) and fish oil (1%) mixture and antioxidant on rabbit meat quality. The natural antioxidant vitamin E was added to the diet to protect fat from oxidation.
Thirty New Zealand White female rabbits were investigated. Animals were assigned to three feeding groups: group I – fed a pelleted basal diet with standard components; group II – fed a pelleted diet with 2% rapeseed oil and 1% fish oil; group III – fed a pelleted diet with 2% rapeseed oil, 1% fish oil, and 100% greater vitamin E content (increased from 50 to 100 mg/kg). Adding a mixture of rapeseed oil (2%) and fish oil (1%) to rabbit feed had a favourable effect on the composition of the lipid fraction of meat. There was a decrease in total saturated fatty acids and a significant increase in n-3 polyunsaturated fatty acids (especially EPA and DHA). The use of the natural antioxidant vitamin E in the diet of group III caused a significant increase in EPA and total n-3 PUFA as well as having a favorable effect on reducing the susceptibility of muscle lipids to oxidation during the frozen storage of meat. The addition of a rapeseed and fish oil mixture to rabbit diets had no effect on the sensory evaluation of the analyzed meat.

Key words: Rabbits, Rapeseed oil, Fish oil, Fatty acids, Meat.

INTRODUCTION

Functional food, which in addition to traditional nutritional value has health-promoting effects on the human body, has attracted the attention of researchers for many years. The main fatty acids found in meat and fat products of animal origin (except fish) are saturated and polyunsaturated fatty acids of the n-6 series. Polyunsaturated fatty acids (PUFA) such as C20:5 n-3 (EPA), C22:5n-3 (DPA) and C22:6n-3 (DHA), and conjugated linolenic acid (CLA) have health-promoting effects on humans. Among the many isomers of linolenic acid, two CLA isomers (cis-9, trans-11; trans-10, cis-12) have special biological activity (Carta *et al*., 2002*)*. They are known to inhibit the growth of cancerous cells, delay the development of atherosclerosis, reduce adipose tissue without effects on muscle weight, delay the development of type II diabetes, and show bacteriostatic activity.

The fatty acid profile of rabbit tissues depends on many factors such as breed, type of tissue, age and slaughter weight. Enriching complete diets with components high in n-3 PUFA makes it possible to programme the fatty acid profile of meat as a result of transferring certain components from the feed.

The aim of the present study was to determine the effect of a rapeseed oil (2%) and fish oil (1%) mixture and antioxidant on rabbit meat quality. Long-chain fatty acids from fish oil enrich tissue with n-3 PUFA in a physiologically most effective way, whereas rapeseed oil contains considerable amounts of α-linolenic acid, which is the precursor of long-chain n-3 PUFA and can be partly transformed to EPA, DPA and DHA in the body. The natural antioxidant vitamin E was added to the diet to protect fat from oxidation.

MATERIALS AND METHODS

Thirty New Zealand White female rabbits were investigated. Animals were assigned to three feeding groups: group I – fed a pelleted basal diet with standard components, group II – fed a pelleted diet with 2% rapeseed oil and 1% fish oil, group III – fed a pelleted diet with 2% rapeseed oil, 1% fish oil, and 100% greater vitamin E content (increased from 50 to 100 mg/kg). The fish oil used was a byproduct of fish (herring, sprat and mackerel) processing and contained 8.4% EPA and 13.6% DHA. Rapeseed oil was made from rapeseed variety Spencer and contained 27.6% linoleic acid and 10.2% linolenic acid.

The complete standard diet given to rabbits contained dried meadow grass, soybean meal, wheat bran, ground maize, milk replacer, NaCl, and a mineral and vitamin supplement The feeds were analysed for dry matter, crude ash, crude protein, crude fat, crude fibre and N-free extractives. The feed mixtures of all the groups were analyzed for the profile of higher fatty acids using gas chromatography. Females of the foundation stock were subjected to rationed feeding and received daily rations ranging from 150 g feed during the non-coupling period to 300 g during gestation and rearing of the young to 21 days. After this period, the rations were increased to meet the nutrient requirements of growing rabbits. After weaning, animals were moved to tiered cages, 4 animals per cage, and fed *ad libitum*. Females of the foundation stock were kept in cages on deep litter (straw), thanks to which the animals were able to make up for possible dietary fibre deficiency.

The experiment was terminated by the slaughter of animals at 3 months of age (6 animals per group). Carcasses were dissected and the samples of hind leg muscles were analysed for the profile of fatty acids using gas chromatography, total cholesterol by the colourimetric method with 10% $FeCl_3$ solution diluted 100-fold with sulphuric acid, vitamin E by the HPLC method using materials with solid consistency and malondialdehyde (TBARS) after 14 and 90 days of storage using the reaction of secondary oxidation products with thiobarbituric acid. The *musculus longissimus dorsi* was matured at 4°C for 3 days. The samples were heated to mild boiling in water (0.6% NaCl solution) at one part muscle to two parts water until the internal sample temperature reached 85°C. Heat-treated meat was cooled under cover to room temperature, sliced and evaluated. Sensory analysis included the evaluation of aroma intensity, aroma quality, tenderness, juiciness, taste intensity and taste quality on a scale of 1 to 5 points (10 evaluators). Overall sensory quality was also calculated.

The results were analysed statistically by analysis of variance and Duncan's test, using Statgraphics Plus 4.0 software.

RESULTS AND DISCUSSION

Table 1 presents the results of basic analysis for complete pelleted diets. The addition of a rapeseed oil and fish oil mixture increased the proportion of crude fat from 2.42% to 5.05%. In the methodology a 3% increase in the level of dietary crude fat was assumed. In practice, the increase was approximately 2.5%, which was probably due to the production process.

Table 1: Nutrient content of the feeds (%)

Group	Dry matter	Crude ash	Crude protein	Crude fat	Crude fibre	N-free extractives
I	89.4	5.83	16.7	2.42	12.2	58.1
II	87.8	5.47	16.3	5.05	12.0	54.5
III	88.7	5.30	16.3	5.04	11.9	55.4

Table 2 presents the results of concentration of fatty acids in feed mixtures. There were highly significant differences in the final body weight of the rabbits (90 days of age) between the control group and the experimental groups (group I – 2610 g, group II – 2790 g, group III – 2820 g). No significant effect of added fat to the diet on carcass fatness was found. Fat deposition in the body is affected by the degree of saturation of dietary fatty acids. Low-saturated fats can result in lower fatness (Crespo and Esteve-Garcia, 2002). The dietary factor used in the experiment had a significant effect (P≤0.05) on the muscularity of animals from the experimental groups.

Table 2: The concentration of fatty AIDS (% of Total AIDS) In feed mixtures

Item	Group - I	Group - II	Group – III
C8:0	0.00	0.00	0.00
C10:0	0.00	0.00	0.00
C12:0	0.00	0.00	0.00
C14:0	0.17	0.53	0.76
C16:0	16.27	11.55	12.19
C16:1	0.22	0.76	0.98
C18:0	2.13	2.01	1.92
C18:1	20.27	30.51	33.79
C18:2n-6	52.83	36.51	37.23
C18:3n-3	6.74	15.14	14.94
C20:0	0.57	0.44	0.58
CLAc9t11	0.06	0.07	0.12
CLAt10c12	0.05	0.08	0.09
CLAc9c11	0.00	0.00	0.00
CLAt9t11	0.09	0.02	0.04
C20:4n-6	0.00	0.00	0.00
C22:1	0.10	0.32	0.39
C20:5n-3(EPA)	0.00	0.67	0.91
C22:6n-3(DHA)	0.00	1.06	1.51
SFA	19.63	14.84	15.89
PUFA	59.77	53.57	54.60
PUFAn-6	52.83	36.52	37.24
PUFAn-3	6.74	16.87	17.36
PUFA/SFA	3.04	3.61	3.44
PUFAn-6/n-3	7.83	2.16	2.15

The addition of oil to the diet had no effect on carcass fatness. The analysis of the fatty acid composition of hind leg muscle lipids showed that the addition of rapeseed oil and fish oil to the pelleted diet had a favourable effect on the dietetic value of rabbit meat (Table 3).

The total level of saturated fatty acids was found to decrease. In the experimental groups, there were highly significant increases in the level of n-3 PUFA, especially EPA and DHA, according to the considerable proportion of these acids in fish oil. Koreleski *et al.* (1998) reported that the addition of rapeseed oil to the feed is paralleled by an increase in n-3 PUFA due to the synthesis of n-3 LC PUFA from the LNA precursor under the influence of the enzymatic action of desaturases and elongases. In the meat of the experimental groups, there was a highly significant increase in the isomer of linolenic acid CLAt10c12, which is known to inhibit the development of cancerous cells. The n-6 to n-3 PUFA ratio was favourable. The use of the natural antioxidant vitamin E in the feed of group III significantly increased EPA and total n-3 PUFA.

The cholesterol content of the body is determined by genetic and environmental factors, with nutrition playing an important role among the latter. Cholesterol quantity is affected not so much by the presence of saturated fatty acids in the diet as the relationships between these acids. The n-6 to n-3 PUFA ratio in the feed has an effect on the fatty acid composition of cell membrane phospholipids, which determines the permeability of these membranes. Studies have shown a positive correlation between cholesterol content and the degree of carcass fatness (Jelińska, 2005). In group III, there was a highly significant (P≤0.05) reduction in the amount of cholesterol in the analysed meat.

Considerable vitamin E deposition in the meat was observed after it was added to the diet. This is of great importance to the consumers because to ensure appropriate absorption of PUFA, they should be ingested together with vitamin E as a natural antioxidant; the recommended amount is 0.4 mg of α-tocopherol per g of acids (Gibney *et al.*, 2002).

Table 3: Level of fatty acids (% total acids), total cholesterol (mg/100 g) and TBA (mg/kg) in the muscle tissue of hind leg

Item	Group - I	Group - II	Group – III	se
C8:0	0.03	0.01	0.02	0.02
C10:0	0.53A	0.10B	0.14B	0.18
C12:0	0.34	0.10	0.14	0.10
C14:0	2.41a	2.51a	3.28b	0.16
C16:0	21.8a	17.6ab	19.9b	1.17
C16:1	3.25	3.27	4.22	0.45
C18:0	5.45	4.44	4.48	0.19
C18:1	21.8A	17.1B	17.9B	0.61
C18:2n-6	38.5	38.7	35.1	1.41
C18:3n-3	2.12A	5.47B	3.95B	0.93
C20:0	0.09A	0.06B	0.05B	0.01
CLAc9t11	0.05	0.06	0.06	0.01
CLAt10c12	0.01A	0.09B	0.08B	0.01
CLAc9c11	0.01	0.01	0.01	0.01
CLAt9t11	0.51A	1.29B	1.32B	0.12
C20:4n-6	1.77A	0.95B	0.88B	0.12
C22:1	0.03	0.02	0.06	0.04
C20:5n-3(EPA)	0.13A	1.52B	1.70B	0.01
C22:6n-3(DHA)	0.93A	6.32B	6,38B	0.17
SFA	30.7a	24.9b	28.0b	1.48
PUFA	44.2A	54.6B	49.7B	1.90
PUFAn-6	40.4	39.8	36,1	1.38
PUFAn-3	3.20A	13.3B	12.0B	0.91
PUFA/SFA	1.44A	2.20B	1.78A	0.18
PUFAn-6/n-3	13.4A	3.01B	3.05B	1.12
Cholesterol	66.3a	60.5	57.5b	3.61
Vitamin E	1.81A	2.19A	3,56B	0.47
TBA-RS14	0.34A	0.33A	0.17B	0.25
TBA-RS90	0.51A	0.52A	0.20B	0.14

a,b: means with different letters differ significantly at $P \leq 0.05$, A,B: at $P \leq 0.01$

The addition of vitamin E to the diet at a rate of 100 mg/kg had a beneficial effect on reducing the susceptibility of muscle lipids to oxidation processes during the frozen storage of meat. Similar findings were reported by Connor (2000) and Ramirez *et al*. (2005), who showed a positive effect of adding fat to rabbit diets on the level of desirable fatty acids and on reducing cholesterol in rabbit meat.

Cooking was applied as the meat preparation method for sensory analysis of the *musculus longissimus dorsi* (Table 4). This resulted from the fact that the analysis should give special attention to the aroma of the samples. This heat treatment method is the most effective in eliciting the intensity and typical aroma of rabbit meat, and is not objected to by panelists on the grounds of the samples being undercooked. No statistical differences were found between the groups in the overall sensory quality, which shows that the addition of rapeseed and fish oils had no negative effect on the sensory traits of meat.

Table 4: Sensory traits of meat (mean scores)

Trait	Group I	Group II	Group III	se
Aroma intensity	4.8	4.8	4.8	0.01
Aroma quality	4.2	4.0	4.0	0.05
Tenderness	4.4	4.8	4.8	0.22
Juiciness	4.4	4.6	4.6	0.07
Taste intensity	4.0	4.0	4.0	0.01
Taste quality	4.6	4.6	4.6	0.01
Overall sensory quality	4.40	4.45	4.46	0.06

CONCLUSIONS

In summary, the addition of rapeseed oil (2%) and fish oil (1%) to rabbit diets had a favourable effect on the composition of the meat lipid fraction. There was a decrease in the total level of saturated fatty acids and a highly significant increase in the level of n-3 PUFA (especially EPA and DHA) and linolenic acid isomers. The use of the natural antioxidant vitamin E in the diet of group III caused a significant increase in EPA and total n-3 PUFA, as well as having a beneficial effect on reducing the susceptibility of muscle lipids to oxidation during the frozen storage of meat. The addition of a rapeseed and fish oil mixture to rabbit diets had no effect on the sensory traits of the analysed meat.

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