USE OF LINSEED OIL AND ANTIOXIDANT (VITAMIN E) IN RABBIT DIETS TO IMPROVE DIETETIC TRAITS OF RABBIT MEAT

Bielanski P.*, Kowalska D.

National Research Institute of Animal Production, 32-083 Balice, ul. Krakowska 1, Poland
*Corresponding author: pbielans@izoo.krakow.pl

ABSTRACT

The aim of the study was to determine the effect of supplementing 3.4% additive linseed oil and antioxidant (vitamin E) on rabbit meat quality. 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 3% plus linseed oil; group III – fed a pelleted diet with 3% linseed oil and 100% greater vitamin E content (increased from 50 to 100 mg/kg). The linseed oil contained alpha-linolenic acid C18:3n-3.
The experiment was terminated by the slaughter of animals at 3 months of age (6 animals per group). Hind leg muscles were analysed for fatty acids, total cholesterol, vitamin E and malondialdehyde (TBARS) after 14 and 90 days of storage. 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. The overall sensory quality was also calculated.
It is concluded that the addition of linseed oil to rabbit diets had a favourable effect on the composition of the lipid fraction of rabbit meat, causing a significant decrease in total saturated fatty acids (SFA) and an increase in polyunsaturated fatty acids (n-3 PUFA). Vitamin E supplementation prevented lipid oxidation processes, which shows the effectiveness of the antioxidant used. A significant ($P \leq 0.01$) decrease in meat cholesterol content was found in the experimental groups.

Key words: Rabbit, Linseed oil, Fatty acids, Vitamin E, Meat.

INTRODUCTION

Fats are the basic, high energy components of food. The composition of dietary fatty acids, in particular the proportion of saturated to mono- and polyunsaturated acids are of special importance (Gibney *et al.*, 2002). Fats are also an important structural component of cell membranes (phospholipids, cholesterol).

Polyunsaturated essential fatty acids of the n-3 and n-6 series, known as vitamin F, cannot be synthesized by humans and need to be supplied in the diet (Kolanowski and Swiderski, 1997). The main of these acids are α-linolenic acid (C18:3) of the n-3 series, which is the precursor of eicosapentaenoic (EPA) and docosahexaenoic acids (DHA), and linoleic acid (C18:2) of the n-6 series, which is the precursor of arachidonic acid (AA). Supplementing these acids, especially those not synthesized endogenously, and ensuring the appropriate dietary composition of these acids may enhance population health.

This is why for many years, researchers have investigated functional food, which in addition to traditional nutritional value shows health-promoting effects on humans. The most favourable proportions between saturated, monounsaturated and polyunsaturated fatty acids are characteristic of fish meat, but its consumption in Poland is very low. This has prompted studies aiming to change the fatty acid profile of beef, pork and rabbit meat by adding vegetable oils to the diets of these animals. The high level of PUFA in feeds makes them susceptible to oxidation. Fat rancidity leads to the formation of free radicals, lipid peroxides, aldehydes and further oxidation products. Research has shown that these compounds have a negative effect on the dietetic value of fat and are harmful to the body. The rancidity process of fat in meat during meat storage adversely affects meat quality (stability, aroma, flavour, nutritive value), reduces the PUFA content and increases the amount of fat oxidation products and cholesterol. The aim of the study was to determine the effect of supplementing 3% added linseed oil and antioxidant on rabbit meat quality. The natural antioxidant vitamin E was added to the diet to protect fat from oxidation.

MATERIALS AND METHODS

Thirty New Zealand White female rabbits of the foundation stock and all of their offspring 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 3% linseed oil, group III – fed a pelleted diet with 3% linseed oil and 100% greater vitamin E content (increased from 50 to 100 mg/kg). The linseed oil used in the experiment was produced from linseed variety Linola and contained 17.5% linoleic acid C18:2n-6 and 50.9% alpha-linolenic acid C18:3n-3. 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. 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 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*.

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 higher fatty acids using gas chromatography, total cholesterol by the colourimetric method using a coloured reaction 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 at mild boiling in water (0.6% NaCl solution) at one part muscle to two parts water until the core 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. The 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 basic analysis of the complete pelleted diets used in the experiment. The addition of linseed oil increased the proportion of crude fat from 2.51 to 5.90%. Fraga *et al.* (1989) reported that the addition of 3-5% plant or animal fat to the feed gives good practical results as it enables the energy level to be increased without reducing the fibre content or excessively increasing the starch content of the diet. Table 2 presents the results of concentration of fatty acids in feed mixtures. Analysis of the results showed no significant differences in the final body weight of the rabbits (90 days of age) between the groups (group I – 2440 g, group II – 2536 g, group III – 2595 g).

Table 1: Nutrient content of the feeds (%)

Group	Dry matter	Crude ash	Crude protein	Crude fat	Crude fibre	N-free extractives
I	87.1	5.44	16.2	2.51	11.3	57.1
II	89.2	5.33	16.1	5.90	11.0	56.2
III	88.5	5.27	16.4	5.89	11.2	55.0

Carcass analysis showed that the nutritional factor used had no significant effect on carcass quality and did not influence the muscling of animals from the experimental groups. Analysis of the fatty acid composition of hind leg muscle lipids showed that a 3.4% supplement of linseed oil in the complete pelleted diet had a favourable effect on the dietetic value of rabbit meat (e.g. Table 3).

Table 2: The concentration of fatty acids (% of total acids) 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	0.10	0.00
C16:0	16.2	10.8	10.3
C16:1	0.22	0.17	0.12
C18:0	2.13	2.17	2.43
C18:1	20.2	25.8	20.6
C18:2n-6	52.8	37.5	35.3
C18:3n-3	6.74	22.4	30.4
C20:0	0.57	0.32	0.24
CLAc9t11	0.06	0.02	0.01
CLAt10c12	0.05	0.03	0.00
CLAc9c11	0.00	0.00	0.00
CLAt9t11	0.09	0.03	0.02
C20:4n-6	0.00	0.00	0.00
C22:1	0.10	0.12	0.05
C20:5n-3(EPA)	0.00	0.04	0.03
C22:6n-3(DHA)	0.00	0.00	0.00
SFA	19.6	13.8	13.4
PUFA	59.8	60.1	65.8
PUFAn-6	52.8	37.5	35.3
PUFAn-3	6.74	22.4	30.4
PUFA/SFA	3.04	4.35	4.91
PUFAn-6/n-3	7.83	1.67	1.16

Table 3: Level of fatty acids (% of total acids), total cholesterol (mg/100 g), vitamin E (mcg/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	0.01	0.02
C10:0	0.52a	0.21b	0.20b	0.18
C12:0	0.35ab	0.44a	0.14b	0.10
C14:0	2.41A	2.27AB	1.55B	0.11
C16:0	21.8A	18.2A	15.1B	0.34
C16:1	3.26a	1.86b	2.00b	0.45
C18:0	5.45	5.39	5.08	0.07
C18:1	21.8A	20.8AB	18.2B	0.82
C18:2n-6	38.5	36.9	36.9	1.28
C18:3n-3	2.12A	11.5B	18.7C	0.08
C20:0	0.09	0.08	0.07	0.01
CLAc9t11	0.05	0.04	0.06	0.02
CLAt10c12	0.01	0.04	0.01	0.01
CLAc9c11	0.01	0.01	0.01	0.02
CLAt9t11	0.50A	0.33AB	0.26B	0.03
C20:4n-6	1.77A	1.24AB	1.03B	0.19
C22:1	0.03AC	0.07B	0.01C	0.04
C20:5n-3(EPA)	0.13a	0.13a	0.23b	0.02
C22:6n-3(DHA)	0.93a	0.15b	0.29b	0.24
SFA	30.7A	26.7AB	22.1B	0.52
PUFA	44.2A	50.6AB	57.6B	1.61
PUFAn-6	40.4	38.3	38.0	1.38
PUFAn-3	3.18A	11.8BC	19.2BD	0.31
PUFA/SFA	1.44A	2.12AB	2.62B	0.07
PUFAn-6/n-3	13.0A	3.36Ba	1.97Bb	0.98
Cholesterol	66.3a	60.8b	60.5b	1.93
Vitamin E	1.73A	2.32AC	4.02BD	0.44
TBA-RS14	0.32	0.22	0.18	1.90
TBA-RS90	0.63	0.56	0.22	0.95

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

In group III, there was a highly significant decrease in total SFA and an increase in PUFA proportion. Compared to the control group, the n-3 PUFA content increased significantly in the experimental groups. Differences also occurred between the experimental groups, which shows the effectiveness of the antioxidant used. In all the groups receiving dietary linseed oil, the linolenic acid (C18:3) content increased highly significantly in meat lipids and the n-6 to n-3 PUFA ratio was found to decrease. In the human diet, they should account for 1/3 of the daily intake of fat, with the n-6 to n-3 ratio ranging from 5:1 to 3:1 (Kolanowski and Swiderski, 1997). The overconsumption of n-6 acids disturbs the metabolism of n-3 acids and hinders the physiological balance of compounds synthesized from these acids (Newton, 1996). 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).

Studies by Xiccato and Trocino (2003) on the effect of increased proportion of plant fat in balanced diets for rabbits showed that the use of essential unsaturated fatty acids characterized by appropriate relationship between individual types of acids can reduce the level of total cholesterol in muscles and depot fat. This effect occurs through stimulation or inhibition of the hepatic activity of the enzyme HMG-CoA reductase, which controls cholesterol synthesis. It was found that giving humans modified pork with reduced cholesterol causes a highly significant decrease in the concentration of total cholesterol and its atherogenic LDL fraction in the plasma lipid profile. For this reason, the nutritional and health aspects make the consumers increasingly interested in products with reduced cholesterol.

The amount of cholesterol in the analysed meat was found to decrease significantly ($P \leq 0.005$) in the experimental groups.

The addition of vitamin E to feed at 100 mg/kg had a beneficial effect on reducing the susceptibility of muscle lipids to oxidation during the frozen storage of meat, as evidenced by the lack of significant differences in the malondialdehyde (TBA-RS) content of meat samples stored frozen at 14 and 90 days. Moreover, a supposed effect of vitamin E was experienced, when analyzing EPA and DHA in the experimental groups.

In the sensory analysis of the *musculus longissimus dorsi*, cooking until the sample reached an internal temperature of 85°C was used as the meat preparation method (Table 4). No statistically significant differences were found between the groups in the overall sensory quality, which indicates that the linseed oil supplement had no effect on the sensory traits of meat. The only significant differences were found in meat tenderness, which was higher in the experimental groups.

Table 4: Sensory traits of meat (means)

Trait	Group I	Group II	Group III
Aroma intensity	4.8	4.6	4.8
Aroma quality	4.4	4.4	4.5
Tenderness	4.2a	4.9b	4.9b
Juiciness	4.2	4.6	4.6
Taste intensity	4.2	4.0	4.2
Taste quality	4.6	4.4	4.6
Overall sensory quality	4.40	4.48	4.60

CONCLUSIONS

In conclusion, the addition of linseed oil to rabbit diets had a favourable effect on the composition of the lipid fraction of rabbit meat, causing a highly significant decrease in total saturated fatty acids (SFA) and an increase in the tissue α-linolenic acid proportion. The vitamin E supplementation prevented lipid oxidation processes, which shows the effectiveness of the antioxidant used. A significant ($P \leq 0.005$) decrease in meat cholesterol was found in the experimental groups.

ACKNOWLEDGMENTS

This study was financed from the 2006-2009 budget for science as research project no. 2PO62 03 230

REFERENCES

Fraga M.J., Lorente M., Carabano R.M., De Blas J.C. 1989. Effect of diet and remating interval on milk production and milk composition of the does rabbit. *Animal Production, 48, 59-466.*

Gibney M.J., Vorster H.H., Kok F.J. 2002. Introduction to Human Nutrition. *Blackwell Science, Oxford*.

Kolanowski W., Swiderski F. 1997. Wielonienasycone kwasy tluszczowe z grupy n-3 (n-3 PUFA). Korzystne dzialanie zdrowotne, zalecenie spozycia, wzbogacanie zywnosci. *Zyw. Czlow. Metab., 2, 49-63.*

Newton J.S. 1996. Long chain fatty AIDS In health and nutrition. *J. Food Lipids, 31 (3), 233-249.*

Xiccato G., Trocino A. 2003. Role of dietary lipid on digestive physiology, immune system and growth in rabbits. *Cost 848, Agriculture and Biotechnology, Praga, Czech Republic, 48-57.*