Development of Technology for Producing Beef With A Modified Fatty Acid Composition

Ruslan Omarov, Ivan Gorlov, Marina Slozhenkina, Natalia Mosolova, Sergei Shlykov

Abstract*: *The article presents the results of an assessment of the effect of making oil (Echium vulgare) rich in 18: 4 n-3 PUFAs on the fatty acid composition and qualitative indicators of beef. The introduction of this oil suggested an increase in the deposition of C18: 3n-3 and the long chain fatty acids C20 and C22, eicosapentaenoic acid (EPA), docosapentaenoic acid (DPA) and docosahexaenoic acid (DHA) in muscle lipids. It was found that the introduction of echium oil or linseed oil in the diet of cattle contributed to the improvement of the profile of long-chain C20 fatty acids in beef, but had a negligible effect on its quality indicators.

Keywords : beef, functional nutrition, fatty acids, herbal fattening

I. INTRODUCTION

Food quality is becoming increasingly important in the modern world and is directly dependent on the quality of food. Much attention is paid to increasing the content of n-3 PUFAs in foods, since increased consumption of long-chain n-3 PUFAs has a beneficial effect on human health and reduces the incidence rate. C18: 3n-3 rich green fodder is an important tool to increase the delivery of n-3 PUFAs through ruminants to meat (and milk).

Our previous studies have established that seasonal and environmental factors play a significant role in the phenotypic variation in the content of fatty acids, which in turn will require adjustment of the fatty acid composition of the feed during the growing process. However, the instability of the fatty acid composition of forage grasses requires studying the possibility of additional enrichment of the cattle diet with PUFA sources.

A study of the effect of grass-fed fattening on the productivity and quality of meat of beef cattle has shown the effectiveness of using alfalfa extract in diets for feeding cattle to enrich PUFA meat. An assessment of the formation of organoleptic characteristics of beef showed that the least effect on the taste of beef has the use of a diet based on straw, feed containing 25% alfalfa extract and vitamin E (~ 300 mg / kg) significantly improves the fatty acid composition of meat.

The next stage of the experiment was to assess the effect of adding echium oil rich in 18: 4 n-3 PUFAs on the fatty acid composition and qualitative indicators of beef. The introduction of this oil suggested an increase in the deposition of C18: 3n-3 and the long chain fatty acids C20 and C22, eicosapentaenoic acid (EPA), docosapentaenoic acid (DPA) and docosahexaenoic acid (DHA) in muscle lipids.

II. MATERIALS AND METHODS

Evaluation of the effect of introducing rich C18: 4n-3 PUFAs into the diets of vegetable oils on the productive qualities of beef cattle was carried out in the conditions of the SPK Plodovitoye, Maloderbetovsky District, Republic of Kalmykia. For the experiment, thirty-two calves of the Kalmyk breed were distributed into 4 groups of 8 animals each, a specific diet was compiled for each group. The average age of the animals at the beginning of the experiment was 506 days. Feeding animals was carried out "ad libitum." The rations consisted of:

1) grass silo (TS) according to the system "ad libitum" (control),
2) TS herbal silage + 1.5% bruise oil per 1 kg of dry solids taken (manufacturer Northstar Lipids Ltd., Great Britain),
3) grass silo + 3.0% bruise oil per 1 kg of dry matter taken
4) grass silo + 3.0% linseed oil per 1 kg of dry solids taken.

The oils were mixed with sugar beets, mixing was carried out immediately before feeding. Measurement of live weight was carried out every 14 days, and the average number of days on experimental diets was 95 ± 8 days. Slaughter of animals was carried out when reaching the fatness class 3L according to the British system for assessing the fatness of cattle.

To determine the quantitative content of fatty acids and the qualitative characteristics of beef from each carcass of an animal, the longest muscle of the back M. longissimus was selected from each group.

The fatty acid composition of beef was evaluated in neutral lipids and phospholipid fractions. The fatty acid content was determined in 1 g of lyophilized material using gneinosanoic acid methyl ester (C21: 0) (according to the methodology of Sigma-Aldrich Co, St Louis, MO, USA) and one-stage transesterification extraction. Fatty acid methyl esters were separated and quantified using gas chromatography.

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Identification of the individual conjugated linoleic acid (CLA) isomers was achieved using high pressure liquid chromatography with silver ions.

Shelf life characteristics were analyzed by quantifying vitamin E and the substances that react with the thiobarbituric acid (TBARS) present in meat after storing steaks in a modified gas environment (MGS) (O2: CO2 75:25).

The color of the meat was determined on a Simulated retail display unit immediately after slaughter and when stored in the MGS, and was calculated using the coordinates L *, a * and b *.

Evaluation of taste was carried out on heat-treated steaks (frying to a temperature in the center of 74 ° C), which were previously kept for 14 days in vacuum packaging at 1 ° C.

Assessment of taste was based on linear scales of 0-100 (0 - zero, 100 - extreme intensity) or on an 8-point scale of intensity of beef taste (1 - extremely weak, 8 - extremely strong), juiciness (1 - extremely dry, 8 - extremely juicy) and textures (1 - extremely hard, 8 - extremely soft).

III. RESULTS AND DISCUSSION

The results obtained indicate that the addition of echium oil or linseed oil did not affect the total content of lipids, neutral lipids, phospholipids, saturated fatty acids, MUFAs or PUFAs compared to grass-fed fattening only (table 1). In addition, the ratio of fatty acids n-6: n-3, and polyunsaturated to saturated (P: S) was also not dependent on the diet, as well as the concentration of EPA + DHA in total lipids of M. longissiumus.

Table- I: Fatty acid composition of M. Longissimus from experimental animals

Indicators	Diet			
	Control	Echium oil 1.5%	Echium oil 3%	Linseed oil 3%
Mg / 100 g muscle concentration				
Total lipids	3138.0	4034.4	3964.3	3378.4
The total number of neutral lipids	2678.4	3553.8	3495.8	2912.3
The total amount of phospholipids	459.6	480.6	468.4	466.1
Saturated Fatty Acids [A]	1328.4	1785.5	1717.9	1454.4
MUFA[B]	1311.6	1648.8	1643.8	1359.4
PUFA[C]	164.7	175.3	173.3	175.3
Amount n-6[D]	78.2	85.5	85.3	83.7
Amount n-3[E]	86.5	89.7	88.0	91.6
Health indicators				
P:S[G]	0.06	0.06	0.06	0.07
n-6:n-3	0.91	0.95	0.97	0.92
EPA+DHAG	23.4	23.1	20.8	24.6

[A] Saturated Fatty Acids, (12:0 + 14:0 + 16:0 + 18:0).

[B] MUFA, (16:1 + t18:1 + 9c18:1 + 11c18:1 + 20:1).

[C] PUFA, (18:2n-6 + 18:3n-3 + 18:4n-3 + 20:3n-6 + 20:4n-6 + 20:4n-3 + 20:5n-3 +22:4n-6 + 22:5n-3 + 22:6n-3).

[D] n-6 PUFA (18:2n-6 + 20:3n-6 + 20:4n-6 + 22:4n-6).

[E] n-3 PUFA (18:3n-3 + 18:4n-3 + 20:4n-3 + 20:5n-3 + 22:5n-3 + 22:6n-3).

[F] P:S, (18:2n-6 + 18:3n-3)/(12:0 + 14:0 + 16:0 + 18:0).

[G] mg / 100 g muscle.

The diet with added oils also slightly affected fractionated lipid components. Adding 3% echium oil to the diet improved the deposition of C18: 1 trans and cis-9, trans-11 CLA in both neutral and phospholipid fractions, and also increased C18: 4n-3 in the neutral lipid fraction (table 2).

Table- II: Concentration of fatty acids (mg / 100 g muscle) in the lipid fractions of M. Longissimus

Fatty acid	Diet			
	Control	Echium oil 1.5%	Echium oil 3%	Linseed oil 3%
Neutral lipids				
C14:0	86.8	130.3	127.0	104.8
C16:0	761.1	1030.4	1003.3	818.5
C16:1	120.0	164.1	158.4	127.3
C18:0	375.5	514.8	480.6	428.0
C18:1 *trans*	37.9	71.7	112.4	73.7
C18:1 *cis-9*	993.8	1237.2	1203.9	1002.6
C18:2n-6	18.6	23.6	22.9	20.1
C18:3n-3	13.2	16.0	15.3	14.1
CLA[A]	9.2	14.8	23.1	14.3
C18:4n-3	1.1	1.6	2.3	1.9
Phospholipids				
C14:0	0.889	0.993	1.110	0.834
C16:0	60.899	63.302	60.824	57.610
C16:1	11.732	13.318	12.155	10.849
C18:0	41.298	42.832	42.206	42.308

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C18:1*trans*	1.880a	2.782b	4.572c	2.972
C18:1n-9	106.095	114.144	106.280	102.652
C18:2n-6	32.383	34.357	36.250	35.496
C18:3n-3	18.069	18.927	19.688	20.440
CLA[A]	0.770	1.091	1.642b	1.081
C18:4n-3	0.244	0.226	0.225	0.219
C20:3n-6	4.519	4.342	4.382	4.425
C20:4n-6	19.978	20.118	18.602	20.880
C20:4n-3	3.822	3.526	3.918	3.639
C20:5n-3	18.979	18.410	16.899	19.806
C22:4n-6	1.215	1.278	1.342	1.149
C22:5n-3	23.346	22.358	21.898	23.069
C22:6n-3	3.664	3.747	3.110	3.757

Other major fatty acids, including long chain fatty acids of C20 phospholipids, were diet independent (Table 2). The study of individual CLA isomers of M. longissiumus revealed an increased content of 6 out of 13 detected CLA isomers, including cis-9, trans-11 CLA, when 3% echium oil was added compared to the control, which have a healing effect on human health. The addition of 1.5% echium oil or linseed oil increased the deposition of trans-7, trans-9 CLA and trans-11, trans-13 CLA. For all other CLA isomers, the addition of 1.5% echium oil or linseed oil had an intermediate effect on their concentration compared to adding 3% echium oil or control. It is suggested that a higher concentration of C18: 1 trans CLA in the muscles may indicate that the fatty acids of both echium and flaxseed oil were prone to strong biohydrogenation in the rumen.

Shelf life, sensory characteristics, color saturation of meat from all animals, as expected, decreased over time. In the course of the study, it was not possible to find any effect from the diets on the color saturation of the meat, nor the interaction between the diet and the shelf life. All diets maintained a color saturation level above the threshold for an acceptable meat color for at least 15 days, but by day 18, beef from all groups had a color saturation of <18. It was also not possible to establish the effect of diets on oxidative stability according to TBARS, color on the 10th day, or the content of vitamin E in the muscles (table 3).

Table-III: Oxidative stability of M. Longissimus steaks depending on rations

Indicators	Diet			
	Control	Echium oil 1.5%	Echium oil 3%	Linseed oil 3%
TBARS, days 10[A]	0.62	0.52	0.44	0.46
Chroma, days 10	22.1	22.7	22.4	22.2
Vitamin E[B]	5.88	6.18	5.92	6.03

[A] mg madonnaldehyde / kg meat.

[B] mg / kg muscle.

The diets used also had a slight effect on taste indices, significant differences were noted only in terms of “vegetable / herbal” and “milk” flavor. A flaxseed oil-based cattle diet intensified the manifestation of the “vegetable / herbal” flavor, and a diet based on 3% echium oil increased the “milk” flavor attribute (Table 4). However, the overall taste indices were similar between the diets used.

Table-IV: Taste indices of fried steaks from experimental animals, with a final temperature in the thickness of 74 ° C

Indicators	Diet			
	Control	Echium oil 1.5%	Echium oil 3%	Linseed oil 3%
8 point scale				
Texture	5.14	4.77	4.75	5.22
Juiciness	5.41	5.42	5.42	5.34
Beef Flavor Intensity	5.23	5.05	5.19	5.20
Abnormal aroma intensity	2.47	2.69	2.47	2.80
Thickness 100 mm				
Greasiness	19.08	20.02	19.66	17.39
Bloodyness	15.05	14.39	14.08	14.13
Hepatic aftertaste	11.25	11.64	13.14	12.08
Metallic aftertaste	15.58	14.59	16.30	17.48
Astringency	7.73	7.02	6.77	9.00
Sweetness	16.09	13.55	16.73	14.77
Rancidity	0.75	0.86	0.44	0.55
Fish flavor	2.92	3.19	2.69	2.97
Acidity	9.84	11.09	10.11	11.38
Taste of paper	11.89	13.11	13.45	14.39
Vegetable / Herbal Flavor	12.47	13.63	13.11b	15.81
Milk flavor	26.72	23.55	29.86	25.02
Hedonism				
General taste	57.59	55.00	58.02	54.58

The introduction of echium oil or linseed oil into the diet of cattle helped to improve the profile of long-chain C20 fatty acids in beef, but had a negligible effect on its quality indicators.

IV. CONCLUSION

The European Food Safety and Labeling Authority (EFSA) has introduced a standard for levels of long-chain PUFAs in products that allows labeling them as a source of n-3 PUFAs. They concluded that this standard should be based on the needs of the body at the rate of 25 mg per day EPA + DHA or 2 g per day C18: 3n-3, in order to be labeled as "source" or "high content" the product should contain 25 to 40 mg EPA plus DHA per 100 g (European Food Safety Authority, 2009). The results obtained in the framework of research data aimed at modifying the fatty acid composition of beef indicate that the levels of EPA and DHA ranged from 11 to 25 mg / 100 g of muscle, with higher values observed in beef, supplemented with oils. The results obtained fit into the range of recommended parameters, which makes it possible to mark this product as a source of n3 PUFA.

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