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THE EFFECT OF DIFFERENT AMOUNTS OF KRILL ADDED TO FEED ON THE PHYSICOCHEMICAL PROPERTIES OF DEPOT FAT OF LARDHOG

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Key words: full ration mixtures, krill meal, back fat, hard fat, unsaturated fatty acids, linoleic acid, linolenic acid.

The study concerns the possibility of a partial or complete feed replacement of animal origin by shelled krill in an amount of 1.2% to 4.8% in pigs full ration feed mixtures. The influence of krill meal on the changes of the physicochemical properties of back fat and hard fat was determined. Experiments showed, that the addition of 1.2% to 1.6% krill meal to pig diet did not cause any changes in depot fat physicochemical properties. Higher amounts (2.4%-4.8%) of krill meal in pig ration increased in back fat outer layer and hard fat the content of polyunsaturated fatty acids and fatty acids with an odd carbon atom number in chain.

INTRODUCTION

The chemical composition of krill, especially the high content of nitrogen substances and mineral salts and the comparatively high amount of fat with a specific composition suggest that it could be used for feed purposes [4, 6, 12]. The industrial utilisation of krill in feeding seems to be most promising in production of meal [6, 8, 12]. Researches of many authors [6, 8, 12] showed that krill meal used in limited amounts may replace the expensive and deficit protein fodders used in the fattening pigs. When new kinds of protein feeds in animal nutrition are used, not only the production effects but the chemical composition and the nutritional value of the final products are important. The effect of the composition of fatty acids lipids in the diet on the physicochemical properties of depot fat are well known [5, 10, 14]. The composition of fatty acids and the degree of their unsaturation determine the technological and nutritional properties of fatty tissues [4, 10].

Taking into account the complicated composition of krill meal compared with other commonly used feed mixtures, especially the high content of mineral components and specific lipids, it seemed useful to undertake the investigations of physicochemical properties of back fat and suet of fattening pigs fed with mixtures comprising different levels of krill meal.

MATERIAL AND METHODS

The experiment was conducted on 80 pigs of White Large (Polish) breed with an initial body weight approx. 30 kg. The animals were divided into four experimental groups (10 ♀ and 10 ♂ in each group). The experimental fattening was conducted until the animals achieved a body weight approx. of 110 kg.

The full-ration mixtures used in the pigs during the first period of fattening, contained an addition of standard concentrate "Prowit" (16% in the 1 st period of fattening and 12% in the 2nd period) and of barley ground grain mixed with 0.5% feed salt (Table 1).

Table 1. Composition of „Prowit" concentrate

Components (%)	Groups			
	I	II	III	IV
Fish meal	20	10	—	—
Meat-bone meal	5	5	5	—
Blood meal	5	5	5	—
soybean oil cake	15	15	15	15
groundnut oil cake	40	40	40	40
Feed yeast	5	5	5	5
Chalk feed grade	2	2	2	2
Fodder phosphate	6	6	6	6
Micro TA-wit	2	2	2	2
Krill meal	—	10	20	30
Total	100	100	100	100

The physicochemical properties of fatty tissues were determined in 48 pigs (selected at random, 6 gilts and 6 hogs from each group). Samples of back fat and hard fat were collected from the right side. After accurate skinning back fat samples were separated along the line of connective tissue onto the outer layer adjoining the skin and inner layer adjoining the meat. The content of dry matter in both layers of back fat and suet were determined by the drying method [1], fat content by the extraction method of Weibull-Stoldt [1]. In the fat obtained by the melting method at 95°C in studied tissues, dried by anhydrous sodium sulphate [11], determinations of the melting temperature according to Rutkowski were made [11]. The iodine number of fat was estimated by Hanus method [11], the per cent content of various fatty acids and triglicerides was determined by the method of gas chromatography. The methyl esters of fatty acids were prepared acc. to Peisker [9]. The distribution of methyl esters was made on a gas chromatograph (PYE Unicam) equipped with a flame-ionisation detector. The following conditions for fatty acids separation were used: a glass column 270 cm×0.4 cm) filled 10% BDS on Gas-chrome Q 100/120 mesh, column temperature — 215°C, carrier gas — argon with a flow rate of 50 ml/min. Triglicerides were obtained by the method of thin layer chromatography on glass plates covered with a layer of silicon gel G (Merck), using for development the following mixture: petroleum benzin — ethyl ether — acetic acid (90:10:1).

The isolated triglicerides were extracted with ethyl ether and separated on a gas chromatograph with a flame — ionisation detector (PYE Unicam) in a glass column (60 cm×0.4 cm) filled with 3% OV-1 on Diatomit CQ 100/120 mesh at 200-325°C. The statistical calculations were performed by a two-factor variance analysis in an non-orthogonal and orthogonal arrangement [2].

RESULTS

THE FAT AND DRY MATTER CONTENT

Results of fat and dry matter content in the back fat and suet (Table 2) have shown that the outer layer of back fat in pigs of group IV fed with the highest amount of krill meal in full ration mixtures contained a statistically significant lower percentage of fat and dry matter in comparison with corresponding layer of back fat in pigs of control group. A lower percentage of dry matter in the outer layer of back fat compared with the control group was also observed in pigs of group III. However no differences were observed in the content of dry matter and fat in the inner layer of back fat and suet in pigs of all experimental groups.

MELTING TEMPERATURE AND IODINE NUMBER

The melting temperature and iodine number of fat in the outer and inner layers of back fat and suet are presented in Table 2.

Table 2. Melting point, iodine value, content of fat and dry matter in back fat and suet

Experimental groups \ Investigation indexes	Melting point (°C)	Iodine value	Fat content (%)	Dry matter content (%)
Outer back fat				
I	42.42	53.67	90.05^{A}	91.74^{A}
II	41.82	53.25	89.55^{AB}	91.63^{A}
III	41.65	55.13	88.82^{AB}	90.32^{B}
IV	41.09	53.93	88.53^{B}	90.08^{B}
Inner back fat				
I	45.07	50.33	92.13	93.70
II	43.96	49.26	91.96	93.93
III	44.91	51.13	91.38	93.42
IV	43.35	48.91	91.41	93.27
Suet				
I	48.14	46.87	93.20	95.22
II	47.61	46.24	92.60	94.46
III	48.33	47.11	92.12	94.53
IV	46.61	46.94	92.73	94.54

A, B — $P \leq 0.01$

As it is shown by the data obtained, the feeding of pigs with full-ration mixtures containing various amounts of krill meal had no effect on the consistency of the outer and inner layers of back fat and suet. The slight drop of melting temperature of the outer layer of back fat in all experimental groups was not statistically significant. The iodine number as a total index of the level of unsaturated fatty acids in both layers of back fat and suet was not influenceed by full-ration mixtures used.

FATTY ACIDS COMPOSITION

Most significant changes in fatty acids quantitative composition were observed in the outer layer of back fat (Table 3). The total amount of poly-unsaturated fatty acids in the outer layer of back fat of pigs of groups II and III was similar to that observed in the control group. In pigs of group IV fed with mixtures comprising krill meal in amount of 3.6% in the first fattening period and 4.8% in the second, the outer layer of back fat contained a statistically significant higher level of poly-unsaturated fatty acids than the control group. The increase of the level in poly-unsaturated fatty acids was due both to an increased level of linoleic acid and of a highly statistically significant amount of linolenic acid. It is interesting to note the statistically significant increase in the amount of acids with seventeen carbon atoms in molecule in the outer layer of back fat in pigs of

T a b l e 3. Percent fatty acids content in back fat and suet

Fatty acids	$C_{12:0}$	$C_{14:0}$	$C_{16:0}$	$C_{16:1}$	$C_{17:0}$	$C_{17:1}$	$C_{18:0}$	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$	Total saturated fatty acids	Total monounsaturated fatty acids	Total polyunsaturated fatty acids
Experimental groups													
Outer back fat													
I	tr.	1.53	29.13^{A}	3.23	tr.^{A}	tr.^{A}	12.60^{A}	47.91^{A}	5.36	tr.^{A}	43.27	51.29	5.43^{A}
II	tr.	1.45	28.48^{AB}	3.68	tr.^{A}	tr.^{A}	12.54^{A}	48.15^{A}	5.85	tr.^{A}	42.54	51.83	5.52^{AB}
III	tr.	1.47	29.33^{A}	3.23	tr.^{A}	tr.^{A}	13.22^{AB}	47.98^{A}	5.51	tr.^{A}	43.35	51.33	5.51^{AB}
IV	tr.	1.66	26.35^{B}	3.72	0.262^{B}	0.244^{B}	14.56^{B}	45.86^{B}	6.63	0.452^{B}	42.87	50.04	7.08^{B}
Inner back fat													
I	tr.	1.57	28.70	2.62	tr.	tr.	15.70	45.70	5.05	tr.	46.63	48.33	5.05
II	tr.	1.68	29.49	2.66	0.096	0.096	14.85	46.36	4.46	0.161	46.23	49.11	4.62
III	tr.	1.55	29.63	2.78	0.042	tr.	16.00	45.17	4.79	0.174	47.28	47.94	4.83
IV	tr.	1.64	29.13	2.85	0.087	0.078	15.65	45.42	5.09	0.222	46.52	48.35	5.13
Suet													
I	tr.	1.39^{A}	31.22	2.32	tr.^{a}	tr.^{a}	19.83	41.68	3.23^{A}	tr.	52.39	44.01	3.59^{A}
II	tr.	1.69^{AB}	31.16	2.59	tr.^{a}	tr.^{a}	19.90	39.96	4.70^{B}	tr.	52.74	42.55	4.70^{AB}
III	tr.	1.82^{B}	30.13	2.69	0.118^{b}	0.056^{b}	19.72	40.20	5.18^{B}	0.085	51.78	43.04	5.27^{B}
IV	tr.	1.72^{B}	29.83	2.74	0.113^{b}	0.064^{b}	19.78	40.95	4.89^{B}	0.165	51.13	43.66	5.20^{B}

A, B — P 0.01
a, b — P 0,05

group IV as compared with the remaining experimental groups. As the experiments have shown, the inner back fat layer was characterized by lower lability than the subcutaneous outer back fat layer (Table 3). From the Table 3 it can be shown that similar amounts of saturated fatty acids contained the suet of pigs of all experimental groups. Statistically significant differences were observed in the amount of unsaturated fatty acids in this tissue. In pigs of groups III and IV fed with mixtures containing 2.4% to 4.8% krill meal a highly statistically significant content of the total amount of poly-unsaturated fatty acids was observed in suet comparing with control group. These results suggest that the higher amount of poly-unsaturated fatty acids in the suet of pigs of groups III an IV was mostly due to the highly statistically significant amount of linolenic acid. The suet of pigs of groups III and IV contained higher content of $C_{17:0}$ and $C_{17:1}$ as compared with the level of these acids found in the suet of pigs of groups I and II.

COMPOSITION OF TRIGLICERIDES

The composition of triglicerides of the outer and inner layers in back fat and suet is illustrated in Table 4. In the tested fatty tissues occurrence of triglicerides comprising 42 to 56 carbons in one molecule was observed.

In all the experimental groups similar amount of these triglicerides was observed in both layers of back fat and suet. No significant differences, between the amount of triglicerides and the topographical location of the tested fatty tissue were found.

DISCUSSION

The results of experiments and their analysis have shown that the addition of krill meal to full ration mixtures influences the physicochemical properties of the depot fat of pigs. The intensity of these changes is proportional to the amount of krill meal in the fed rations. The data obtained have shown that when the krill meal replaced only 50% of fish meal in "Prowit" concentrate no changes in the physicochemical properties of depot fat occurred. These results are in agreement with the observations of Lewicki and Tywończuk [6]. In their studies the best fattening results were achieved in the range within 30-60 kg body weight when 50% of fish meal in "Prowit" concentrate was replaced by krill meal. Higher amounts of krill meal in the diet, i.e. a complete replacement of fish meal in "Prowit" by krill meal had an effect on the percentage content of fatty acids in suet.

Table 4. Triglycerides composition of back fat and suet (weight percentage)

Experimental groups \ Triglycerides	42C	44C	46C	48C	50C	52C	54C	56C
Outer back fat								
I	0.033	0.178	0.511	2.49	19.91	64.68	11.76	0.064
II	0.075	0.185	0.533	2.77	20.09	64.68	12.24	0.033
III	0.059	0.244	0.559	2.73	18.88	66.47	11.46	0.065
IV	0.098	0.219	0.441	2.67	18.18	66.38	12.52	0.033
Inner back fat								
I	0.029	0.208	0.507	3.19	19.55	66.01	10.14	0.118
II	0.052	0.196	0.471	3.04	19.91	65.66	10.37	0.068
III	0.135	0.223	0.511	2.31	19.09	65.33	11.79	0.050
IV	0.099	0.279	0.476	3.03	19.56	65.11	11.68	0.108
Suet								
I	0.033	0.233	0.576	2.75	20.48	66.59	8.50	0.030
II	0.077	0.229	0.460	3.00	21.17	65.85	8.89	trace
III	0.106	0.354	0.564	3.01	19.77	65.30	9.81	trace
IV	0.060	0.230	0.517	2.96	19.64	66.57	9.91	trace

However in triglicerides the percentage composition of fatty acids was changed only when fish meal, blood meal and meat-bone meal in "Prowit" were replaced by krill meal; these changes took place mostly in the outer layer of back fat. Changes in the composition of fatty acids in the outer layer of back fat and the suet of pigs fed on a diet comprising krill meal additives to an amount of 2.4% to 4.8% concerned mainly poly-unsaturated fatty acids and fatty acids with an odd number of carbons in the chain. Similar results were obtained by other authors [5, 7, 13, 14] who have observed that the amount of linolenic acid and of higher poly-unsaturated fatty acids is determined by the type of lipids in the diet.

As it is known, krill meal comprises substantial amounts of long-chain poly-unsaturated fatty acids. Taking into account the mechanism of lipids transport and distribution in the organism of mammals in can be assumed that a part of the long-chain poly-unsaturated fatty acids in the lipids of krill meal has been built into the triglicerides of adipose tissues of experimental pigs. Tove [14] has demonstrated that the administration of linolenic acid to rats causes an estrification of a considerable amount of this acid with first-order hydroxyl glycerol groups which has an effect on the fatty acids composition. Whereas, such acids like the palmitic, oleic or stearic acids, acc. to Leat and collaborators [5] may be synthetized in the organism also from endogenic sources.

It can be assumed that not only specific krill meal lipids but also its rich mineral composition may influence the level of fatty acids in the triglicerides of the fatty tissues of pigs fed with full ration mixtures with krill meal additives (2.4% to 4.8%). There is well-known effect of a considerable increase of the unsaturated fatty acids level and proportional decrease of suitable saturated fatty acids in the depot fat of pigs fed on a diet comprising a copper additive (250 mg/kg of feed [7, 13].

Taking into account the fact that new types of feeds may influence not only the production effects but also the technological and nutritional properties of the food products obtained, it should be assumed that the results obtained in the present study should constitute an additional indication for use feed rations with a krill meal additive.

CONCLUSIONS

1. An addition of krill meal to full ration mixtures in an amount of 1.2% in the first period of fattening and 1.6% in the second period of fattening, i.e. replacement of 50% of fish meal in the "Prowit" concentrate, had no effect on the physicochemical properties of the outer and inner layers of back fat and suet.

2. An addition of krill meal to full ration mixtures in an amount of

2.4% in the first period of fattening and 3.2% in the second period, i.e. replacement of 100% of fish meal in the "Prowit" concentrate had the effect on:

a) reduction of dry matter content in the outer layer of back fat,

b) increase of linoleic acid content ($C_{18:2}$) and of total content of poly-unsaturated fatty acids in suet,

c) increase of fatty acids level with an odd number of carbons in one molecule ($C_{17:0}$ and $C_{17:1}$) in suet.

3. An addition of krill meal to full-ration mixtures in an amount of 3.6% in the first period of fattening and 4.8% in the second period of fattening, i.e. a complete replacement of feed of animal origin in the "Prowit" concentrate had the effect on:

a) reduction of the content of fat and dry matter in the outer layer of back fat,

b) increase of the level of poly-unsaturated and 17-carbon fatty acids in the outer layer of back fat,

c) increase of the level of poly-unsaturated and 17-carbon fatty acids in suet.

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WPŁYW RÓŻNEGO UDZIAŁU MĄCZKI Z KRYLA W DAWCE POKARMOWEJ TUCZNIKÓW NA WŁAŚCIWOŚCI FIZYKOCHEMICZNE TŁUSZCZU ZAPASOWEGO

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Streszczenie

Badano możliwość częściowego lub całkowitego zastąpienia pasz pochodzenia zwierzęcego w mieszankach pełnoporcjowych dla tuczników mączką z kryla nieodskorupionego w ilości od 1,2% do 4,8% oraz wpływ mączki z kryla na zmiany cech fizykochemicznych słoniny i sadła. W zewnętrznej i wewnętrznej warstwie słoniny oraz w sadle doświadczalnych tuczników oznaczano temperaturę topnienia, liczbę jodową, poziom tłuszczu i suchej masy oraz procentową zawartość kwasów tłuszczowych i trójglicerydów.

Wykazano, że dodatek mączki z kryla do diety tuczników w ilości od 1,2% do 1,6% nie powodował zmian cech fizykochemicznych tłuszczu zapasowego. Wyższe ilości mączki z kryla w dawce dla tuczników miały wpływ na zmniejszenie zawartości tłuszczu i suchej masy oraz na zwiększenie zawartości wielonienasyconych kwasów tłuszczowych i kwasów tłuszczowych o nieparzystej liczbie węgli w łańcuchu w zewnętrznej warstwie słoniny i sadle.