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SUITABILITY OF MODIFIED PIG BRISTLES FOR EXTRUDED FEED MIXTURES FOR CARP FRY

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ABSTRACT. Tests were performed with four extruded feed mixtures balanced at an isonitrogen and isoenergetic level. The experimental feeds contained modified pig bristle, added at the rate of 5%, 10% and 15% in place of fish meal.
Value of the feeds was estimated using chemical methods and growth performance in a feeding test carried out in experimental fish ponds. It was found that carp fry used in a most efficient way these feeds which contained 15 % of prepared pig bristles. The prepared pig bristles used in the experiment proved to be a valuable source of proteins and can be added instead of fish meal to carp fry feeds.

Key words: CARP, FRY, MODIFIED PIG BRISTLES, FEEDS, EXTRUSION

INTRODUCTION

The need to meet the increasing demand for animal protein resulted in growing interest in the tissues that might become the source of keratin, e.g. in pig bristles. Keratin belongs to proteins which are not well digested by the warm-blooded animals (Pezacki 1987), so it is of little use in the feeds for poultry and pigs (Uchman, Konieczny 1982). This material can be, however, utilised in fish feeds as cold-blooded animals can more effectively use scleroproteins. Utilisation of this substance in the feeds for rainbow trout was studied by Gropp et al. (1981), Przybył et al. (1995) and Madziar and Przybył (1995).

This study had two objectives:

- to work out a method of preparing pig bristles based on texturization techniques,
- to determine the suitability of modified and pre-prepared pig bristles as a substitute of fish meal in carp fry feeds.

MATERIAL AND METHODS

Experiments were carried out in the Experimental Department of Feed Production Technology and Aquaculture in Muchocin. Twelve concrete reservoirs of 40m^2

area, 1.2 m deep were used. Their slopes and bottoms were lined with a 10 cm layer of gravel. The feeding experiment lasted for 60 days, from July 4 to August 31, 1995. It was conducted in four experimental groups (variants), in three replications, the type of feeds used being the only variable factor.

Sorted carp fry was used, of fairly uniform body weight of about 80 g. Each experimental group was composed of 45 fish.

The feeds tested were spread manually over „tables", in three doses, from 7.00 to 18.00 hours. Daily feeding rates were calculated according to the standards presented by Schreckenbach et al. (1987) in relation to water temperature and fish weight.

Composition of the experimental diets was established using a computer programme based on the aim recorded in form of linear programming with the Simplex method, in Turbo Pascal 5. The tested feeds were produced in the Feed Laboratory of the Experimental Department in Muchocin.

Feed composition is presented in table 1. Basic diets were supplemented with a mineral-vitamin mixture Polfamix C, produced by Polfa Pharmaceutics in Kutno, as well as limestone and choline chloride.

TABLE 1

Composition of the experimental feeds (%)

Components	Experiment variants			
	A	B	C	D
Fish meal	15,0	10,0	5,0	-
Poultry meal	8,0	8,0	7,0	7,0
Pre-prepared pig bristles	-	5,0	10,0	15,0
Yeast *Candida utilis*	4,0	4,0	4,0	4,0
Soybean meal	20,0	17,0	14,0	10,5
Rapeseed cake	5,0	6,0	9,0	9,5
Wheat	25,0	27,0	27,0	30,0
Wheat bran	19,0	19,0	19,0	19,0
Limestone	2,0	2,0	3,0	3,0
Polfamix C	1,8	1,8	1,8	1,8
Choline chloride	0,2	0,2	0,2	0,2
Total	100,0	100,0	100,0	100,0

Feed mixtures B, C and D contained prepared pig bristles, added at the rate of 5%, 10 % and 15 % respectively. Pig bristles used in fish feeds were first washed to remove blood and dirt, dried, cut into small pieces with a cutter having 0.2 mm interval between the knives and rotating at the speed of 1440 rot./min.

The bristle pieces were then hydrolysed in an alkaline environment, and subject to barothermal treatment in a single-screw extruder KMW, type 40. The bristle preparate was then dried and powdered in an electric mill.

Content of the following exogenous amino acids (in g per 100 g of protein) was determined: treonine - 5.80, alanine - 4.23, valine - 5.23, isoleucine - 3.41, leucine - 7.73, tyrosine - 2.82, phenylalanine - 3.48, histidine - 2.01, arginine - 8.91, lysine - 3.00, and methionine with cystine - 8.84.

Other components were also powdered. Pre-mixtures were prepared of wheat bran, limestone, Polfamix C and choline chloride. All components were mixed in proportions resulting from diet recipes, in a mixer with an active knife, and 8 % of hot water was added. These mixtures were subject to thermobaric treatment in an endogenic single-screw extruder N-60 produced by Metalchem Gliwice, having the head with 4.15 mm openings.

The best extrusion conditions were achieved applying the following technological parameters:

- cylinder temperature in the area of growing pressure - 92°C;
- cylinder temperature in the region of high pressure - 114°C;
- head temperature - 128°C;
- screw rotation speed (rot./min) - 47.

The extrudate was cut with a knife into 10 mm pieces, and dried on sieves in hot air stream.

The following components were determined in the experimental feeds:

- total protein, with Kjeldahl's method, using a Danish apparatus Foss Electric, multiplying the amount of nitrogen by 6.25;
- crude fibre, using the Weenden method and an apparatus Fibertec System produced by Tecator;
- dry weight, crude ash and crude fat - with the methods described by Gawęcki (1994);
- mineral components: P and Ca after sample digestion in a mixture of concentrated nitric, perchloric and sulphuric acids, using flame photometer Flapho 4, produced by Carl Zeiss, Jena (Gawęcki 1994);
- amino acids, after sample hydrolysis in 6N HCl in 105°C for 23 hours, using an analyser type AAA 339 produced by Microtechna;

– tryptophan with the method described by Opieńska-Blauth et al. (1963), and sulphuric amino acids - after their oxidation and preservation with performic acid (Szram et al. 1954).

Based on amino acid composition, a chemical score (Cs) after Block and Mitchell (1946) was calculated; it was treated as an index of essential amino acids (EAAI) according to Oser (1951), assuming egg white composition as a standard.

Digestible energy of the model diets was calculated in kcal from their chemical composition, using the standards of digestible energy for fish: extruded carbohydrates - 2.5 kcal, protein - 5.2 kcal, fats - 8.5 kcal (Havler 1988).

The following indices were used to assess zootechnical results of the feeding tests:

– mean individual fish weight, calculated dividing weight of the fish stocked into or caught from the pond by their number,
– mean daily weight gains (SGR - specific growth rate) in %,
– increment of individual fish weight (%),
– fish survival rate (%),
– food conversion ratio (FCR),
– protein efficiency ratio (PER) (AONC 1975).

Economic effectiveness of the experimental feeds was also calculated.

The following parameters were controlled daily throughout the experiment;

– water temperature, measured at 9.00 and 18.00 hours,
– oxygen content (mg/dm) using Winkler's method (Just and Hermanowicz 1964).

Final mean body weight of the fish was analysed statistically with the variance method, within the confidence limits of Scheffe, as described by Elandt (1964).

RESULTS

CHARACTERISTICS OF THE FEEDS

The experimental feeds were prepared at an isoactove and energy level. Differences in the content of crude protein were very small, from 3.19 % (feed A) to 32.38% (feed B), and the level of crude fat was within the range of from 5.64 % (feed B) to 5.93% (feed C). Content of crude fibre ranged from 4.86 % (feed A) to 5.12 % (feed D). Ash content ranged from 8.33 % (feed D) to 9.34 % (feed A). Energy to protein ratio was from 9.57 (feeds B and C) to 9.59 (feed A) (tab. 2).

TABLE 2

Chemical composition of the experimental feeds (%)

Components	Experiment variants			
	A	**B**	**C**	**D**
Dry weight	90,78	90,68	90,70	90,60
Crude protein	32,19	32,38	32,40	32,33
Crude fat	5,68	5,63	5,93	5,76
ZBAW	38,71	38,50	38,42	39,06
Crude fibre	4,86	4,99	5,02	5,12
Ash	9,34	9,18	8,93	8,33
P	1,14	1,02	0,90	0,78
Ca	1,99	1,74	1,84	1,58
Digestible energy in kcal/g	3124,4	3124,8	3149,4	3147,3
Energy/protein	9,59	9,57	9,57	9,58

Levels of exogenous (essential) amino acids were more or less uniform. The limiting amino acids were: methionine with cystine for feed A, for which CS amounted to 51.16, followed by isoleucine and valine; isoleucine for feeds B, C and D, for which CS reached the lowest level of 60.57, followed by valine and methionine with cystine (feed B) and lysine (feeds C and D) (tab. 3). Values of EAAI ranged from 74.49 (feed D) to 80.19 (feed C) (tab. 3).

TABLE 3

Content of essential amino acids in the experimental feeds (g/100 g of protein)

Amino acid	Experiment variants			
	A	B	C	D
Arginine	6,344	6,664	6,979	7,295
Histidine	2,764	2,450	2,140	1,826
Lysine	6,401	5,737	5,086	4,416
Tryptophan	2,932	2,294	1,667	1,038
Phenylalanine + tyrosine	7,948	7,730	7,507	7,288
Methionine + cystine	2,967	3,750	4,518	5,311
Treonine	3,794	3,905	4,017	4,127
Leucine	6,941	7,005	7,070	7,133
Isoleucine	4,139	4,156	4,179	4,195
Valine	4,646	4,698	4,744	4,799
CS	Methionine + cystine - 51,16 Isoleucine - 59,99 Valine - 62,78	Isoleucine - 60,23 Valine - 63,49 Methionine + cystine - 64,66	Isoleucine - 60,57 Valine - 64,11 Lizyna - 75,91	Isoleucine - 60,80 Valine - 64,85 Lizyna - 65,91
EAAI	78,50	79,72	80,19	74,49

Water stability of the feeds, expressed as % of weight loss, and oxidability indices are presented in table 4.

TABLE 4

Estimation of water stability of the experimental feeds

Item	Experiment variants			
	A	B	C	D
Weight loss in %	20,7	24,5	27,9	29,4
Estimate	dobra	dobra	dobra	dobra
Oxidability mg O_2/dm^3	37,2	49,2	54,3	68,2
Estimate	very good	very good	good	good

Weight losses of the tested feeds ranged from 20.7 % to 29.4 %. According to the classification by Szumiec-Stanne (1975), the highest stability in water was observed in the case of feeds A and B, slightly lower - for feeds C and D. As regards oxidability, feeds A and B were ranked as very good, and C and D - as good.

ENVIRONMENTAL CONDITIONS AND THE RESULTS OF FEEDING

Mean daily temperatures ranged in course of the experiment from 15.9 to 25.0^{0}C. Content of dissolved oxygen was from 1.4 to 8.4 mg O_2/dm^3. The highest final body weight was attained by the fish in the experimental group D, the lowest - in group A (tab. 5).

Mean weight gains ranged in particular experimental groups from 304.5 (feed A) to 343.9 % (feed D). Differences in the growth rate were also confirmed by daily weight gains SGR (tab. 5).

Fish survival during the experiment was very high and amounted to 97.8 % in groups A, C and D, and to 95.6 % in group B.

Mean values of food conversion rates in particular variants of the experiment ranged from 1.43 (group A) to 1.33 (groups C and D).

Protein efficiency ratios (PER) were very high, from 2.31 (group B) to 2.04 (group A).

It was proved that the feed D, containing 15 % of prepared pig bristles, was characterised by the highest economic efficiency (tab. 6).

Analysis of variance (significance level < 0.05) showed that mean fish body weights in variants D and A differed in a significant way. No statistically significant differences were found between the other groups.

TABLE 5

Results of carp fry feeding with the experimental diets

Item	Experiment variants			
	A	B	C	D
Initial fish number	45	45	45	45
ŚMean individual body weight in g	84,30	84,54	81,18	80,43
Total weight of the fish stock in kg	3,79	3,80	3,65	3,62
End results				
Final fish number	44	43	44	44
Total weight of the fish stock in kg	15,01	14,86	15,87	15,71
Mean individual weight in g	341,03	345,65	349,32	357,01
Individual weight increment in %	304,5	308,8	330,3	343,9
SGR in %	1,01	1,02	1,06	1,08
Total increase of fish stock weight in kg	11,22	11,06	11,72	12,09
Gross production in kg/ha	1250	1238	1280	1309
FCR	1,43	1,41	1,33	1,33
PER	2,04	2,06	2,28	2,31
Survival in %	97,8	95,6	97,8	97,8

TABLE 6

Economic indices for the experimental feeds

Index	Experiment variants			
	A	B	C	D
Carp fry production from 1 ha (kg)	1250	1238	1280	1309
Value of the fish produced (zł)*	8125,0	8050,9	8321,3	8508,5
Cost of feeds used (zł)	2271,2	1975,1	1739,7	1554,1
Total value of the fish minus feed costs	5853,8	6071,9	6580,3	6954,4

**Fish price 6,50 zł/kg*

DISCUSSION

Water temperature and saturation with oxygen belong to the most important abiotic factors affecting fish feeding intensity, food digestion and assimilability. Optimal temperature range for carp fry and yearlings, which ensures the best use of feeds, is from 14 to 28^{0}C (Szumiec and Szumiec 1979). Water temperatures in course of the experiment were within this range.

According to Kijastorin (1982) level of dissolved oxygen in culturing carp should not drop below 5 mg O_2/dm^3. In course of the experiment lower levels were observed on cloudy days, sometimes as low as 1.4 mg O_2/dm^3.

Protein level in the experimental feeds should be regarded as sufficient for carp yearlings. The feeds were fairly uniform in this respect (protein levels from 32.19 to 32.40 %), with protein levels slightly exceeding optimal range suggested for this age group (28-32 %, Wilson 1991).

Water stability of the feeds, assessed using Hastings-Hepher test, was very high. The feeds were ranked as good and very good. In the experimental conditions, when the feeds were applied three times daily by spreading them upon „tables", water stability would not have affected the results of the feeding test.

In Lovell's opinion (1979), properly balanced fish feeds should not contain more than 8 g of phosphorus per 1 kg. In the experimental feeds A, B and C phosphorus levels slightly exceeded this limit. Increased level of phosphorus resulted from the use of local fish and poultry meals which are characterised by high ash content.

The experimental feeds A and B were characterised by some deficiency of methionine (2.967 and 3.750 % respectively), and the feed D - by a deficiency of lysine (4.416). According to Nose (1971) protein in fish diet should contain at least 3.9 % of methionine and 5.7 % of lysine.

Total fat content of the experimental diets was sufficient to meet energy requirements of the fish. Energy to protein ratio (E/P) ranged from 9.57 to 9.59 which ensured optimal utilisation of protein for body weight gain (FAO/WHO 1973).

Based on growth rate of the fish and evaluation of nutritive diet components it can be concluded that nutritive value of the experimental feeds for carp fry was not uniform. Taking into account PER values and food conversion rates (FCR), which are used to characterise nutritive value of feeds, the C and D feeds were most effectively used by the fish. These feeds contained, respectively, 10 % and 15 % of prepared pig bristles.

In view of the obtained results, the experiment confirmed the suitability of thermobaric processing of pig bristles, both to modify them as well as to manufacture pellets for fish feeding.

There were some successful attempts made in the recent years to use modified pig bristles in extruded feeds for rainbow trout and carp (Przybył et al. 1995, Madziar and Przybył 1995, Przybył and Madziar - in print). Results of these studies seem to correspond to the opinion of Uchman and Konieczny (1984) that materials containing kera-

tin, in this also pig bristles, are more effectively used by the animals if subjected to modification procedures.

Growth of carp fry in course of the experiment, as well as FCR and PER values suggest that diets containing 15 and 10 % of modified pig bristles can be well used by fish farmers.

This suggestion is confirmed by economic effectiveness of the experimental feeds. Calculating per 1 ha, the highest economic effectiveness was obtained for feed D; it was 1100.6 zł higher than of feed A which had been produced using fish meal.

CONCLUSIONS

1. Carp fry readily consumed feeds containing modified pig bristles, this being reflected in satisfactory growth rate and good utilisation of nutritive components.
2. Carp fry used in a most effective way the extruded feed containing 15 % of modified pig bristles.
3. Pre-prepared pig bristles by their modification in course of hydrolysis and extrusion can become a valuable source of proteins in the feeds for carp fry, and can be used instead of fish meal.

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STRESZCZENIE

BADANIA NAD PRZYDATNOŚCIĄ PREPARATU MODYFIKOWANEJ SZCZECINY ŚWIŃSKIEJ W EKSTRUDOWANYCH MIESZANKACH PASZOWYCH DLA KROCZKA KARPIA

Celem badań było określenie wartości żywieniowej preparatu modyfikowanej szczeciny świńskiej jako substytutu mączki rybnej w mieszankach paszowych dla narybku karpia. Test żywieniowy przeprowadzono w stawkach doświadczalnych o powierzchni 40 m^2. W trakcie doświadczenia średnia dobowa temperatura wody wahała się,od 15,9 do 25,0 ^oC. Do badań użyto narybku karpia o średniej początkowej masie jednostkowej ca. 80 g/szt. Test żywieniowy trwał 60 dni. Badaniami objęto 4 mieszanki paszowe, zbilansowane jako diety izokaloryczne i izoazotowe. W paszach doświadczalnych zamiennikiem mączki rybnej był preparat modyfikowanej szczeciny świńskiej, na poziomie 5, 10 i 15 %. Mieszanki paszowe uformowane zostały metodą obróbki barotermicznej. Wartość pasz doświadczalnych oceniano metodami chemicznymi i wzrostowymi. Badania wykazały, że preparat szczeciny świńskiej jest dobrym źródłem białka i może być w paszach dla kroczka karpia substytutem mączki rybnej. Kroczek karpia najefektywniej wykorzystywał mieszankę paszową zawierającą 15 % preparowanej szczeciny.

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