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EVALUATION OF PIG BRISTLE AS A COMPONENT OF CARP PELLETED FEEDS

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A B S T R A C T. Four extruded feed formulas were tested. The feeds were isocaloric and of similar nitrogen content, formulated with a 10 % addition of processed hog's bristle meal. Pellets were evaluated using chemical methods and growth test carried out in experimental ponds. The studies revealed highest efficiency of the feed with bristle meal processed by keratolysis (thermal hydrolysis with 1% ammonia solution). Pig bristle processed this way turned out to be a valuable source of protein and may replace other animal meals in commercial carp feeds.

Key words: CARP, FEED, EXTRUSION, HOG'S BRISTLE, FATTENING

INTRODUCTION

Most fish feeds are expensive because of high content of total protein (25-50%). Various meals of animal origin: fish, poultry, blood, or meat-and-bone meal are most frequently used as a protein source. These meals, and especially fish meal, are expensive and hardly available components which considerably affect prices of fish feeds.

For these reasons replacing these meals with other components of similar nitrogen content is an important issue.

No data were found in the literature on the application of pig bristle in carp feeds. However, studies were carried out on the evaluation of bristle meal as a component of rainbow trout feeds (Koops et al. 1981, Przybył, Madziar 1995, Madziar, Przybył 1995).

Keratin containing materials such as horn sheaths, hooves, and pig bristle are still poorly utilised, and according to Pezacki (1977) easily available in Poland. Pig bristle alone is produced at a rate of 5400 tons per year and this corresponds to about 4000 tons of pure protein.

Energetic value of keratin containing materials is low but they are biologically valuable as supplementary sources of sulphuric amino acids for plant feeds.

Keratin belongs to the proteins poorly digested by warm blooded animals due to its physic-chemical complexity (Pezacki 1987). Thus, keratin processed using traditional methods, for example in Hartman's decomposers, is poorly utilised by poultry and swine (Uchman, Konieczny 1984). Keratin materials may be, however, more applicable in fish feeds as fish are able to utilise more efficiently this protein source.

The aim of the present study was working out an effective method of hydrothermal processing of hog's bristle to obtain high degree of keratin protein degradation. Nutritive value of processed bristle used instead of traditional animal meals in extruded carp pellets was also assessed.

MATERIAL AND METHODS

The study was carried out in the Experimental Station in Muchocin near Międzychód, in twelve concrete ponds $40m^2$ in area and 1.2 m deep, with bottom and sides lined with a 10 cm layer of gravel.

During the experiment water temperature (°C), and O_2 content (mg $O^2 \cdot dm^{-3}$) were monitored daily.

The ponds were stocked with 2 years old common carp of similar individual body weight of about 230 g . The fish were divided into 4 experimental groups, 33 individuals in each, in 3 replicates. Type of feed was an experimental factor. The experiment lasted 60 days, from June 24 to August 24, 1994.

Daily feed doses were calculated according to water temperature and fish weight. The pellets were supplied manually into the feeding grounds three times a day, from 7 a. m. to 6 p. m.

The experimental feed formulas were calculated using a computer program according to linear programming with the Simplex method, in Turbo Pascal 5.

The experimental feeds were produced in the Experimental Station in Muchocin.

Composition of the experimental diets is shown in Table I. The following components were used: fish meal, poultry meal, hydrolysed feather meal, rape seed meal, wheat grain, and wheat brain. In B, C, and D diets feather meal was substituted with hog's bristle processed using various methods.

The bristle was supplied by the Meat Processing Factory in Poznań. The material was rinsed with water and left until the next day to dry. The bristle was then cut in a blender to particles of less than 2 mm. The raw material was subjected to keratolysis. The bristle was processed after a preliminary test using:

– thermal hydrolysis at 132°C, during 3 h (with 40% of bristle and 60% of water),
– thermal hydrolysis with ammonium solution (0.5%), at 132°C, in 3 h (40% of bristle, 60% of water).

Diet B was formulated using bristle subjected to keratolysis catalysed with NH_4OH.

Diet C was produced with bristle hydrolysed thermally in saturated steam.

For D diet the bristle was dried and ground in a high-revolution disintegrator into particles of less than 1 mm.

All components were mixed according to the recipe and ground in a percussion mill into particles of less than 1.25 mm. The mixture was conditioned with supersaturated steam up to 20.3-23.7% of water content, and then extruded using single-worm extruder for foodstuffs, type N-60, made by „Metalchem" Gliwice. Extrusion took place under the following conditions:

– temperature of section I - 110°C, of section II - 120°, and of the head 140°C,
– rotation speed 90 rot../min.,
– extrusion time 35-40 s.,
– hole diameter 4.15 mm.

The extruded product was cut using a rotary blade into 10 mm long pieces, placed on sieves, and dried in heated air steam. Diameter of dry pellets was 5.3-5.7 mm.

Basic analysis of the experimental feeds was done according to the methods by Skulmowski (1974). Amino acid composition (except tryptophan) was assessed following the hydrolysis of the samples in 6N hydrochloric acid for 26 h, using the AAA-881 analyser. Tryptophan content was determined according to Opieńska-Blauth et al. (1963), and sulphur containing amino acids - according to Schram et al. (1954). Chemical score (Cs) according to Block, Mitchell (1946), and essential amino acid index (EAAI) according to Oser (1951) were calculated assuming amino acid composition of chicken egg as a standard (FAO/WHO 1973).

Mineral phosphorus and calcium content in the diets were evaluated using atomic absorption spectrophotometer AAA 3 (Carl Zeiss Jena), according to Gawęcki (1988).

Digestible energy of the diets was calculated in Kcal from the chemical composition, using coefficients of digestible energy for fish: extruded carbohydrates 2.5 kcal, protein 5.2 kcal, fat 8.5 kcal (Halver 1988). Water stability of the pellets was evaluated using Hastings-Hepher method (Hepher 1968).

In addition to this, an organoleptic test of the fish flesh was done, according to Baryłko-Pikielina (1975). After the experiment, 6 randomly harvested fish of each group were killed and cooked in 0.6% NaCl. Taste and flavour of fish were evaluated and scored using a 4 point scale (from 2 to 5).

Efficiency of fish culturing was assessed using the following parameters:

- average final body weight of fish (g per ind.)
- increment of average individual weight (%)
- survival rate
- mean value of food conversion rate
- protein efficiency ratio (PER), according to AOAC (1975).

Average final fish weight was analysed statistically using the variance analysis ANOVA and Scheffe confidence limits.

RESULTS

The level of total protein in the diets ranged from 26.7 to 26.9%, and the level of crude fat - from 3.8 to 3.9%. Crude ash content in all the formulas was uniform - 5.3%, and the level of digestible energy ranged from 2915.9 kcal/g (formula C) to 2945.9 kcal/g (formula B), at constant energy-protein (E/P) ratio from 10.91 to 10.93 (Tab. 1).

Table 2 shows considerable differences of exogenous amino acid levels, most pronounced in the case of sulphur amino acids (methionine and cystine). Methionine and cystine were the limiting amino acids in formula A (44.46%), and isoleucine in B, C, and D diets (from 57.75 to 57.81%). Biological value of protein was higher in B, C and D diets (essential amino acid index EAAI 75.6%) comparing to the A diet (69.0%).

The results on water stability of the feeds, measured as percent of weight loss, and oxidation coefficient are given in Table 3. Weight loss of the pellets ranged from 29.18 to 48.72%. The data revealed that formula A was most stable (good), and B and D diets were evaluated as unsatisfactory (Szumiec, Stanny 1975).

Basing on oxidability, all tested formulas were evaluated as good (coefficients from 56.9 to 64.5 mg $O2 \cdot dm^{-3}$). Diet A was scored very good (30 mg $O_2 \cdot dm^{-3}$).

ENVIRONMENTAL CONDITIONS DURING THE FEEDING TEST

Mean daily temperatures during the experiment fluctuated from 16.9 to 26.7°C, and DO content from 3.3 to 8.45 mg $O_2 \cdot dm^{-3}$.

TABLE 1

Ingredients, chemical composition, and caloric value of the experimental feeds.

Ingredients	Feed meal			
	A	B	C	D
Fish meal	3.0	3.0	3.0	3.0
Poultry meal	7.0	7.0	7.0	7.0
Feather meal	10.0	-	-	-
Ammonium-treated bristle meal (NH_4OH)	-	10.0	-	-
Hydrolysed bristle meal (H_2O)	-	-	10.0	-
Crude bristle meal	-	-	-	10.0
Rapeseed meal	10.0	10.0	10.0	10.0
Wheat grain	40.5	40.5	40.5	40.5
Wheat husks	28.3	28.3	28.3	28.3
Polfamix WK	1.0	1.0	1.0	1.0
Choline chloride	0.2	0.2	0.2	0.2
Chemical composition				
Dry weight	89.8	89.9	89.6	89.8
Crude protein	26.7	26.9	26.7	26.8
Crude fat	3.9	3.9	3.8	3.9
Fibre	5.7	5.7	5.7	5.7
ZBAW	48.2	48.1	48.1	48.1
Ash	5.3	5.3	5.3	5.3
P	0.75	0.85	0.85	0.85
Ca	0.59	0.62	0.62	0.62
Digestible energy Kcal/g	2926.5	2945.9	2915.9	2922.6
E/P	10.95	10.91	10.91	10.93

TABLE 2

Exogenous amino acid content (in g per 100 of protein), chemical nutritive value of the experimental diets.

Amino acids		Experimental diets			
		A	B	C	D
Arginine		6.067	6.965	6.949	6.953
Histidine		1.786	1.876	1.880	1.880
Lysine		3.906	4.249	4.253	4.252
Tryptophan		3.851	2.263	2.275	2.273
Phenyloalanine + Tyrosine		6.698	6.603	6.603	6.603
Methionine + Cystine		2.579	4.851	4.817	4.822
Treonine		3.535	3.735	3.724	3.726
Leucine		6.604	6.771	6.762	6.763
Isoleucine		3.953	3.989	3.985	3.985
Valine		5.009	4.636	4.631	4.632
CS	I	Met+Cys44.46	Ileu57.81	Ileu57.75	Ileu57.75
	II	Ileu57.29	Wal62.65	Wal62.58	Wal62.59
	III	Liz58.29	Liz63.47	Liz63.46	

TABLE 3

Evaluation of water stability of the experimental diets.

Parameter	Experimental diets			
	A	B	C	D
Water content in %	8.96	8.70	9.56	9.55
Weight loss in %	29.18	47.78	37.32	48.72
Score	good	unsahisfactory	fair	unsahisfactory
Oxidability in mg $O_2 \cdot dm^{-3}$	30.0	64.5	56.9	64.1
Score	very good	good	good	good

TABLE 4

Fishery results of carp feeding with the experimental diets.

Specification	Experimental variants			
	A	B	C	D
Stock				
Initial number of fish	33	33	33	33
Average individual fish weight g/ind.	227.3	230.3	236.4	240.9
Average total fish weight in g	2500.3	2533.3	2600.4	2649.9
Final results				
Final number of fish	33	31	29	32
Average total fish weight in g	6483.4	6839.6	6050.4	6193.1
Average individual fish weight g/ind	589.4	661.9	625.9	580.6
Increment of individual body weight in %	159.3	187.4	164.7	141.0
Total increase of fish weight in g	3983.1	4306.3	3450.0	3543.2
Gross production in kg/ha	1620.9	1709.9	1512.6	1548.3
Feed conversion rate	1,75	1.63	1.71	1.88
PER	1.47	1.66	1.50	1.34
Survival	100.0	93.94	97.88	96.97

TABLE 5

Average score of organoleptic evaluation of the fish flesh.

Experimental group	Small	Taste	Comments
A	4.00±0.25	4.00±0.25	
B	3.501770.25	3.35±0.40	distinct ammonia off flavor
C	3.80±0.25	3.45±0.40	
D	4.00±0.25	3.95±0.40	
Control group	4.50±0.25	4.25±0.50	

FISH GROWTH, SURVIVAL, AND FOOD CONVERSION RATE

Final body weights of the fish fed B, C, and D diets were similar: from 580.6 to 661.9 g per individual. The fish fed diet A (without bristle) weighed 589.4 g/ind. (Tab. 4.). Fish fed feed B containing ammonium-treated bristle were the heaviest.

Average final body weight increment ranged from 141.0% (group D) to 187.4% (group B).

ANOVA revealed that average final body weight of the fish fed A and D diets differed from that in group B ($p<0.05$).

Fish survival was high in all the groups: from 87.88% in group C to 100% in A (Tab. 4.).

Average food conversion rate varied from 1.88 for D diet to 1.63 for diet B.

Table 5 shows the results of the organoleptic test. Carps receiving barley were used as the control. It was found that diets B, C, and D had an adverse effect on flavour and taste of the fish flesh. Diet B, in which ammonium-treated bristle was used, resulted in a distinct ammonia flavour of the fish.

DISCUSSION

Total protein level of the experimental diets did not differ in a significant way and could be defined as sufficient (Cowey 1992). Phosphorus content in the feeds did not exceed 8.5 g which seems advantageous in terms of water quality (Wiessman et al. 1988).

Not all the diets, however, were positively evaluated in Hastings-Hepher test, although this did not affect the final results in a significant manner.

Fish growth rate and feed conversion rate indicated that nutritional value of the feeds was different. Routine indices (for example PER) showed that diet B was most efficiently conversed, and diet C slightly less so.

PER value varied according to the level of nutrients, mainly protein, and energy content in the diet, as well as to the duration of rearing, fish age, sex and race.

In the present study PER value of the most efficiently conversed feed B was equal to 1.66, and was considerably lower comparing to casein - 2.22 (Nose 1971).

Dried and ground bristle was tested as a component of trout diet (Gropp et al. 1981). Also modified bristle processed by keratolysis turned out to be a valuable component of trout feeds (Przybył et al. 1995, Madziar, Przybył 1995).

Present data seem to confirm the data of Uchman and Konieczny (1984) which revealed that keratin-containing materials were more efficiently utilised in hydrolysed form, as polypeptides and amino acids. Keratin hydrolysis in water environment is very slow so catalysers are necessary, such as strong acids , bases, or proteolytic enzymes. In the present study the best fish growth was obtained using pellets containing 10% of ammonium-treated hydrolysed bristle. Application of bristle subjected to high pressure thermal hydrolysis resulted in lower fish production.

Experimental factors affected flavour and taste of the fish flesh. Ammonium-treated bristle caused a distinct off-flavour in fish. Flesh taste and flavour are important for market value of fish, so further studies on the effect of feeds on flesh quality seem necessary.

CONCLUSIONS

1. The experimental feeds differed in terms of nutritional value and usefulness for carp rearing.
2. Pig bristle meal processed by keratolysis is a valuable protein source and may substitute other animal meals.
3. Formula B containing ammonium-treated hog's bristle was most efficiently conversed by the fish.

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STRESZCZENIE

BADANIA NAD PRZYDATNOŚCIĄ SZCZECINY ŚWIŃSKIEJ W MIESZANKACH PASZOWYCH DLA KARPIA

Celem badań było określenie wartości żywieniowej mączki z modyfikowanej szczeciny świńskiej, jako zamiennika tradycyjnie stosowanych mączek zwierzęcych w ekstrudowanych mieszankach paszowych dla karpia. Eksperyment żywieniowy wykonano w stawkach doświadczalnych o powierzchni 40 m^2. W trakcie doświadczenia średnia dobowa temperatura wody wahała się od 16,6 do 26,7°C. Do badań użyto karpi o średniej początkowej masie jednostkowej 230 g. Test żywieniowy trwał 60 dni. Badaniami objęto cztery mieszanki paszowe, zbilansowane jako diety izokaloryczne i izoazotowe. Do sporządzenia pasz wykorzystano jako źródła białka szczecinę świńską spreparowaną różnymi metodami. Mieszanki paszowe uformowano metodą ekstruzji w endogennym ekstruderze. Wartość pasz doświadczalnych oceniano metodami chemicznymi i wzrostowymi. Badania wykazały, że mączka ze szczeciny świńskiej modyfikowanej w procesie keratolizy z NH_4OH jest wartościowym źródłem białka i może być ekwiwalentnym zamiennikiem mączek zwierzęcych w paszach tuczowych dla karpia. Szczecina amoniakowana miała jednak wpływ na pogorszenie walorów smakowo-zapachowych mięsa ryb.

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