Acta Veterinaria (Beograd), Vol. 49. No. 1, 57-64, 1999.

UDK 619:636.087.63

PROTEIN MEAL OBTAINED FROM SMALL FISH BY EXTRUSION

RISTIĆ M.*, RADENKOVIĆ BRANA, ** FILIPOVIĆ S.,* SAKAČ MARIJANA*, RADANOV-PELAGIĆ VESELINA***, ĐORĐEVIĆ M.**

*The Faculty of Technology, The Feed Technology Department, Novi Sad, **The Department of Zoohygiene, The Faculty of Veterinary Medicine, University of Belgrade, ***The Faculty of Agriculture, The Institute of Animal Breeding, Novi Sad

(Received, 4. January 1999.)

Whole fish, as well as by products of fish processing, contain very important nutrients - amino acids, fatty acids, mineral matter and vitamins indispensable in animal diets. Their high quality makes them one of the most suitable materials to be processed into protein meal.

The main objective of this study was to obtain data about the possibility of processing freshwater fish affals by extrusion, by comparing the quality of the original raw material and that of the obtained end product.

High quality protein meal was produced by extrusion of fish with soybean meal. Both the quality of the obtained end product and the technological, economic and ecological aspectis were highly fawourable.

A statistically very significant difference for all the studied parameters in acid pepsin was found between the composite material, consisting of fish and soybean meal, prior to extrusion and the end product after extrusion ($p<0.01$). Statistically very significant differences were also found between the contents of essential and half essential amino acids of the composite material prior to extrusion and the contents in the end product after extrusion ($p<0.01$).

Key words: extrusion, fish, soybean meal, protein meal

INTRODUCTION

The world today and we as part of it are faced, on the one hand, with an increasing shortage of food for the rapidly growing human population, and, on the other hand, with the problem of how to use waste materials and preserve the environment. The lack of high quality protein feedstuffs puts a strain on animal production with every passing day, particularly on fish and poultry breeding.

Therefore, special attention has been paid to the utilization of by - products of animal and plant origin, as prospective animal feed, i. e. to be used directly or indirectly in the manufacture of protein meal intended for animal nutrition.

Whole fish, as well as by - products of fish processing, contain very important nutrients- amino acids, fatty acids, mineral matter and vitamins indispensable in animal diets (Ristić et al., 1990 a; 1990 b; 1992; Vujković, 1996). Its high quality makes it one of the most suitable materials to be processed into protein meal.

In order fully to utilize by - products of freshwater fish breeding and processing, it is necessary to abandon the traditional methods used in the manufacture of fish meal by rendering, (which involves expensive processing equipment, too much energy for the processing of raw material and the running of machines for the purification of waste water and cleaning of the air) and to introduce a new, simple and ecologically acceptable method known as - extrusion.

Numerous investigations on processing material of animal origin for animal feed (Lavel, 1980; Ristić, 1981; Jackson et al., 1984; Fajvi sevskij and Liberman, 1984), Rot et al., (1991), Harvey (1992), Blake et al., (1990). Ristić et al., (1995; 1996) have shown that the processing of fish by - products into quality protein meal by extrusion is possible.

There fore we undertook a study to obtain the necessary data that would demonstrate the possibility of processing freshwater fish offals by extrusion, by comparing the quality of the original raw material with that of the obtained end product.

MATERIAL AND METHODS

The material used for the production of protein meal by extrusion, consisted of waste small fish from fish ponds and soybean meal. Two technological procedures were used:

1. Processing after drying the basic material
2. Processing urthout a prior drying step

1. The procedure with a previous decrease in moisture content

Waste fish, was cut up in small pieces in a chopping machine, and then conveyed to the continual disk - dryer with recycling air. Once in the dryer the material was further fragmented and dried at a temperature ranging from 95^{0}C to 100^{0}C until the desired moisture percentage was achieved (cca 35%). The partially dehydrated material was then conveyed to the mixer where soybean meal was added (60% dehydrated fish and 40% soybean meal). The composite material was homogenized and subsequently put into the cylinder of the extruder. In the extruder the material was cooked and sterilized at 135 ^{0}C. The obtained protein meal was cooled, chopped up and packed in bags.

2. The procedure without a previous decrease in the moisture content

Waste fish was cut up in small pieces in the chopping machine, and subsequently conveyed into the mixer in combination with soybean meal (20% fish and 80% soybean meal), homogenized, and put into the cylinder of the extruder. In the extruder the material was cooked and sterilized at 135^{0}C. The obtained protein meal was cooled, cut up into small pieces and packed.

The basic chemical composition, composition of nitrogen fractions and protein digestibility in acid pepsin were determined, by applying AOAC techniques (1984). The amino acid content of the tested samples was determined on an amino acid analyser (Biotronic LC 5001).

Protein was hydrolysed in 6 mol 1^{-1} HCl during 23 hrs at 110^{0}C. Cystine and methionine had previously been oxidized by performic acid (15 hrs at 2^{0}C) (Moore, 1963). Tryptophan was determined by spectrophotometry (Graham et al., 1947).

The following mathematical - statistical parameters were calculated 1. The measure of central tendency ($\bar{X}$); 2. Measures of variability, i. e. the standard deviation (SD), standard error (Sy); the coefficient of variance (CV) and interval of variability (IV); 3. the analysis of variance (group F - test) and, one individual test, i. e. LSD - test.

RESULTS AND DISCUSSION

The process used in the technology of treating inedible by - products of the slaughter industry, is based on the so called HT - ST (high temperature - short time) principle, (Rot et al., 1991; Harvey, 1992 and Ristić et al., 1996). As a result of friction forces and pressure within the extruder cylinder a rise in temperature up to 135 ^{0}C occurs and the material is cooked for 30 seconds. The resulting temperature of 135 ^{0}C sterilizes the product. An abrupt decrease in the pressure upon leaving the extruder enables additional evaporation of water from the material. In order to achieve a successful extrusion it is necessary for the moisture percentage in the material to remain within the range from 20% to 26% (Davies, 1990; Blake et al., 1990; Ristić et al., 1996).

As fish contains a high percentage of water, it is necessary to reduce its moisture by pressing and drying it prior to mixing it with drier matter in order to meet the necessary technological requirements for successful extrusion. The choise of second component and its percentage depend on the moisture percentage and fat content in the basic material and also on the desired end product.

Some data obtained for the composite material, consisting of partially dried fish and soybean meal in the ratio of 60:40 and fresh fish and soybean meal in the ratio of 20:80 are presented in Tables 1 and 2.

The higher protein content and higher fat content of the composite material, containing previously partially dried fish (55.56% d.m.), results from the higher percentage of fish dry matter in the material prepared for extrusion compared to the material composed of fresh fish and more soybeean meal (Table 1).

Table 1. The basic chemical composition, nitrogen fractions and protein digestibility in acid pepsin of the composite material made up of fish and soybean meal

Chemical parameters	The ratio of the mixed substances			
	60% partially dried fish and 40 % soybean meal I		20% fresh fish 80% soybean meal II	
	In sample	In dry matter	In sample	In dry matter
Basic chemical composition				
Moisture (%)	25.00*	–	23.13	–
Crude protein (%)	41.67	55.56	37.83	49.21
Crude fat (%)	7.11	9.48	2.41	3.14
Crude fiber (%)	3.62	4.83	6.08	7.91
Mineral matters (%)	7.34	9.79	5.02	6.53
Nitrogen free extract (%)	15.26	20.35	25.53	33.21
Nitrogen fractions				
Protein nitrogen (%)	5.876	7.83	5.46	7.11
Non-protein nitrogen (%)	0.796	1.06	0.59	0.77
Protein digestibility (%)	94.58		92.63	

*Each value represents the mean for 10 samaples

The essential and half essential aminoacid contents found in the proteins of the composite materials (Table 2) correspond to the expected aminoacid contents of waste fish, (Ristić et al., 1997), and soybean meal.

The heat treatment, both during drying (Ristić et al., 1997 b) and extrusion with a plant carrier, has a key role in the production process. In the course of extrusion, due to the high temperature rise, the structure of proteins, fats and carbohydrates is changed. According to Estelecki (1990), the reactions that diminish the nutritive value of lipids during extrusion are: oxidation, hydrolysis, cis - trans isomerization or polymerization. Moreover, there is a decrease in carbohydrates of low molecular weight while the carbohydrates of high molecular weight (starch) undergo physico - chemical changes, which increase the digestibility and utilization of this source of energy.

The quality of the protein meal obtained was determined mainly by the process of preparation of the material, as well as by the process of extrusion, i. e. the end- product quality is influenced by the original material and heat treatment (Tables 3 and 4).

The protein meal, produced from partially dried fish and soybean meal contained 5.84 g ($p>0.01$) more protein, 6.47 g ($p<0.01$) more fat, and 3.369 g ($p<0.01$) more mineral matter in 100 g of dry matter, and 2.76 g ($p<0.01$) less cellulose and 12.91 g ($p<0.01$) less nitrogen - free extract than protein meal II manufactured from fresh fish and soybean meal.

The relative contents of individual aminoacids present in both feedstuffs are adequate. Protein meal I contained more lysine.

Table 2. The contents of essential and half essential aminoacids in the composite material prior to extrusion

Aminoacids	The ratio of the mixed substances			
	60% partially dried fish and 40% soybean meal I		20% fresh fish 80% soybean meal I	
	% in sample	% in dry matter	% in sample	% in dry matter
Lysine	3.26*	7.82	2.51	6.63
Histidine	1.09	2.62	1.06	2.80
Arginine	3.28	7.87	2.84	7.51
Threonine	1.78	4.27	1.52	4.02
Valine	1.95	4.68	1.85	4.89
Methionine	0.80	1.92	0.57	1.51
Isoleucine	1.14	2.74	1.81	4.78
Leucine	3.01	7.22	2.91	7.69
Phenylalanine	2.06	4.94	1.01	2.66
Tryptophan	0.51	1.22	0.53	1.40
Cystine	0.55	1.32	0.57	1.51
Tyrosine	1.60	3.84	1.35	3.57
Total aminoacid content	21.03	50.46	18.53	48.98

*Each result represents the mean value for 10 samples.

Table 3. The basic chemical composition, nitrogen fractions and protein digestibility in acid pepsin of the end product after extrusion

Chemical parameters	The ratio of the mixed substances			
	60% partially dried fish and 40 % soybean meal I		20% fresh fish 80% soybean meal II	
	In sample	In dry matter	In sample	In dry matter
Basic chemical composition				
Moisture (%)	12.50*	–	11.79	–
Crude protein (%)	47.88	54.72	42.72	48.88
Crude fat (%)	8.61	9.84	2.97	3.37
Crude fiber (%)	4.52	5.16	6.99	7.92
Mineral matters (%)	8.87	10.14	5.98	6.78
Nitrogen free extract (%)	17.62	20.14	29.55	33.05
Nitrogen fractions				
Protein nitrogen (%)	6.545	7.410	6.035	6.897
Non-protein nitrogen (%)	1.116	1.215	0.800	0.914
Protein digestibility (%)	94.58		92.63	

* Each result represents the mean value for 10 samples

Table 4. The contents of essential and half essential aminoaacids in the end product after extrusion

Aminoacids	The ratio of the mixed substances			
	60% partially dried fish and 40% soybean meal I		20% fresh fish 80% soybean meal II	
	% in sample	% in dry matter	% in sample	% in dry matter
Lysine	3.65*	7.62	2.74	6.41
Histidine	1.27	2.65	1.19	2.78
Arginine	3.45	7.20	3.17	7.42
Threonine	2.08	4.34	1.77	4.14
Valine	2.28	4.76	2.12	4.96
Methionine	0.95	1.98	0.66	1.54
Isoleucine	1.33	2.78	2.08	4.86
Leucine	3.51	7.33	3.34	7.81
Phenylalanine	2.41	5.03	1.16	2.71
Tryptophan	0.61	1.27	0.60	1.40
Cystine	0.67	1.40	0.59	1.38
Tyrosine	1.87	3.90	1.55	3.63
Total aminoacid content	24.08	50.26	21.01	49.14

* Each result represents the mean value for 10 samples

The most important changes brought about during extrusion of fish with soybean meal are those that a affect proteins. Due to the temperature changes, cleavage of protein peptide bonds occurs, accompanied by an increase in the content of lower molecular weight polypeptides, as well as by an increase in free aminoacids. The small decrease in protein nitrogen and accompaniing increase in non protein nitrogen fractions confirm this (Tables 1 and 3). It is possible to analyse the changes in the nitrogen complex of the material if extrusion is performed at temperatures below 149°C with a moisture percentage of 20% to 26% (Ormai et al., 1987). Extrusionof the material at 135°C did not result in any significant degradation of proteins until the water level of the end product, immediately after extrusion had droppeed below 10%. That corresponds to a water content in the basic material of not less than 20%. A low water content in can seriously endanger the quality of proteins, due to overheating. Ormai et al., (1988) refer to the data of Pougor and Matroi 1976 showing that during the extrusion of soybean at 154°C there was a loss of lysine up to 31% and a loss of methionine up to 13%. In our experiment the lysine loss in protein meal I was 4%, whereas in protein meal II it was 5%.

The analysis of variance established a statistically very significant difference for all the observed parameters in acid pepsin between the composite material prior to extrusion and the end - product after extrusion ($p<0.01$). The same analysis showed statistically very significant differences in the contents of essential aminoacids and half essential aminoacids of the material prior to extrusion and the contents in the end product after extrusion ($p<0.01$).

As the differences in the quality of the proteins in the basic material and those in the manufactured protein meals (Tables 1, 2, 3 and 4) were small, it can be concluded that the applied technological procedure of extrusion was suitable for the carrier protein. Thus production of this protein meal is justified both from the aspect ofthe quality of obtained end product and from technological, economoc and ecological aspects.

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PROUČAVANJE PROIZVODNJE PROTEINSKOG HRANIVA OD SITNIH "KOROVSKIH" RIBA PROCESOM EKSTRUDIRANJA

RISTIĆ M., RADENKOVIĆ BRANA, FILIPOVIĆ S., SAKAČ MARIJANA, RADANOV PELAGIĆ VESELINA, ĐORĐEVIĆ M.

SADRŽAJ

Riba i sporedni proizvodi dobijeni preradom riba sadrže veoma značajne hranljive sastojke - aminokiseline, masne kiseline, mineralne materije i vitamine neophodne za ishranu životinja. Kvalitet ove sirovine svrstava je u jednu od najpovoljnijih sirovina za preradu u proteinska hraniva.

Osnovna ideja istraživanja obuhvaćenih ovim radom je bila da se dođe do podataka koji će ukazati na mogućnost i opravdanost prerade ribljeg otpada iz slatkovodnog ribarstva ekstrudiranjem kroz kompariranje kvaliteta polazne sirovine i finalnog proizvoda.

Kompletno sagledavanje procesa proizvodnje proteinskog hraniva ekstrudiranjem ribe sa sojinom sačmom i njegovog kvaliteta, u okviru ovih naših istraživanja, upućuju nas na opravdanost proizvodnje ovog proteinskog hraniva, kako sa aspekta kvaliteta dobijenog finalnog proizvoda, tako i sa tehnološkog ekonomskog i ekološkog aspekta.

Analizom varijanse ustanovljena je statistički vrlo značajna razlika između svih posmatranih parametara u kiselom peptinu komponovane sirovine od riba i sojine sačmme pre ekstrudiranja u odnosu na finalni proizvod nakon ekstrudiranja ($p<0.01$). Takođe su analizom varijanse ustanovljene statistički vrlo značajne razlike u sadržaju esencijalnih i poluesencijalnih aminokiselina kombinovane sirovine pre ekstrudiranja i njihovih sadržaja u finalnom proizvodu nakon sektrudiranja ($p<0.01$).