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Examination of Fresh Water Carp By-Products

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Running title: **Carp By-products**

Abstract
The quantity of by-products obtained during carp primary processing and chemical characteristics of internal organs were investigated in this paper. The total average mass of by-products was 640.8 g (36.82%) in relation to livebody mass which was cca 1.740 g. Largest quantity in total live body weight was the head with 382.55 g (21.98%), followed by complete internal organs and tail and fins which mass were 143.77 g or 8.26% and 99.15 g or 5.70%, respectively
Chemical composition of the carp is basically composed of mostly water with a content of 68.56%, following by crude fats with a content of 15.93% and crude proteins percentage of 13.36%. Low content of collagen with a percentage of 3.25% in total crude protein indicates the high nutritional quality of protein content of internal organs. Nitrogenous complex of the examined raw material is predominantly composed of proteins. Digestible nitrogen is approximately equal with total nitrogen (92.04%), indicating that all proteins of the internal organs have high biological value.
Inedible internal organs obtained during carp slaughtering are essential sources of fatty acid and can be used as raw material for processing into feeds
Based on the obtained results it can be concluded that carp internal organs represent essential sources of proteins and fats, and thus, it can be used as a raw material for feed and technical fat production.

Practical applications
In feed production for poultry and pet food and technical fat production

Key words: carp, by-products, quantity, chemical characteristics, fatty acid

Introduction

The aquaculture industry has grown rapidly over the last decade. Likewise, mariculture is expanding worldwide thereby increasing the demand for feed ingredients to support production (FAO, 2014). The rapidly growing sector directly depends on the aquafeed industry, which in turn largely depends on fish meal as its primary protein source.

Over the last decade, the global supply of fish meal has been limited, and meeting the demands of a growing industry has become challenging. In addition, fish meal proteins experience periodic fluctuations in pricing and availability (Tacon and Metian, 2008).

Freshwater fish contain high levels of PUFA, which makes them very important in human nutrition (Vladau et al., 2008). Since there are a number of biochemical interactions between the n-6 and n-3 series fatty acid, a balanced ratio between these fatty acids in the food is important for the normal functioning of the body in humans, as well as in animals (Djordjevic et al., 2009) Consumption of fish meat is increasing, due to its high content of polyunsaturated fatty acids (PUFA), amino acids and lipid soluble vitamins which are important ingredients for human health. According to the latest data from FAO (2012), the Republic of Serbia is a country where the average consumption of fish is 5-10 kg per capita per year, which is significantly below the European and global consumption (Ćirković et al., 2011).

Carps represent one of the largest groups of cultured fish with around 70% of freshwater aquaculture production. The origin of carp is in central Asia, but it was spread east and west to China and the Danube. The majority of European of carp production with traditional semi-intensive techniques in ponds is placed in central Europe (Vandeputte et al., 2009).

Common carp is economically the most significant fish species on the fish farms in Serbia (Ćirkovic et al., 2012), and the cyprinids are the most common species in the total world production of freshwater fishes (71.9%, 24.2 million tons in 2010) (FAO, 2012).

Manufacturing and development of fish products could increase offer and contribute to better sale of fish, not only in traditional fish markets, but also in retail stores and supermarkets. Technological processes, preservation and storage of the fish meat differs from the mammalian meat (Okanović et al., 2015).

For proper manufacturing of fish products, knowledge about chemical composition and characteristics of raw fish meat is very important in order to apply the most appropriate technology procedures adjusted to certain fish species.

Fish processing and new fish products development can provide novel sale of fish, not only in traditional fish markets, but also in all other consumer good stores (Baltić et al., 2009). The demands of modern markets are increasingly directed for processed fish, especially fillets. Larger quantity of edible and non-edible by-products are obtained in industrial conditions of primary fish processing (Ristić et al., 2002).

Fish yield, expressed as the ratio of the weight of the carcass without the head, scales, fins and internal organs and whole fish mass, are essential parameters for all technological operations related to fish processing, since the economy of production is directly dependent on it (Ljubojević et al., 2012).

On the basis of earlier research (Vujković et al., 1993), it is known that byproducts of carp processing contain valuable nutrients which may be sources for the food, pharmaceutical and feed industry. In order to obtain more complete perception of quality animal by-product, it is necessary, in addition to knowledge of basic chemical composition, to obtain complete information on the quality of the most important nutritional components - proteins. However, the high crude protein content of some raw materials is not a guarantee for its high usability, ie. protein digestibility (Ristić et al., 2011).

Inedible by-products obtained during carp slaughtering belonging to the third category of by-products (Regulation EU, 2009), are significant sources of proteins and fats that represent convenient raw materials for processing into proteinaceous feeds for swine and pets.

Due to the increasing industrial carp processing and need for complex utilization of obtained by-products, aim of this research was to investigate the quantity of by-products and nutritive value of internal organs.

Materials and Methods

Experimental design

Quantity of carp by-products

The quantity of by-products and quality of internal organs were monitored during the overfishing and processing of carp from fish ponds Ečka in Vojvodina in industrial conditions.

The fish pond provided the flow of fresh water from 2.5 l / sec per unit area. Common carp has received feed in two portions. Morning meal was pelleted feed with extruded components (soybean and corn), with 25% protein and 6.7% fat, and in the afternoon the carp got corn.

Common carp were delivered live from fish farm in a manufacturing plant where they were immediately sacrificed. Mean values of carp mass were approximately 1.733 g. Scales, gills and viscera, heads (flat transverse incision just behind the gill arch) and the fins were removed with a knife.

The following values were measured:

- pre-slaughtering weight of fish
- head mass
- mass of the tail and fins
- total mass of internal organs

The total internal organs are not separated because it is the standard procedure in industrial conditions.

Analysis

Investigations of chemical characteristics of internal organs were performed in the laboratory of the Institute of Food Technology in Novi Sad.

Sample preparations

Slaughtered carps, according to the structure of the by-products, were used as one sample for further investigations. Samples, composed in such a way, were put in plastic bags, labeled and taken into refrigerator at about 4°C. Four hours after the slaughter, samples were transferred into the chemical laboratory.

Chemical composition

All samples were grounded with homogenizer prior to examination and used for determining the chemical parameters. Samples were packed into aluminium foil bags and stored for 24 h at +4°C.

The basic chemical composition was assessed by determining moisture content (SRPS ISO 1442:1998), total protein (SRPS ISO 937:1992), hydroxyproline content - the relative content of connective tissue proteins (SRPS ISO 3496:2002), free fat content (SRPS ISO 1444:1998) and total ash (SRPS ISO 936:1999).

Crude protein containing protein and non-protein nitrogen. The ability of the trichloroacetic acid (TCA) to precipitate a protein (polypeptide chains of a high molecular weight whose M is > 10,000), but not the other organic compounds of nitrogen (amino acids, peptides and polypeptides of lower molecular weight) is used for the determination of the share of non-protein nitrogen in the total nitrogen. After treatment with TCA, non-protein nitrogen is determined from the filtrate by Kjeldahl method (SRPS ISO 937:1992). The protein nitrogen was determined from the difference (crude protein – non protein).

For the determination of the protein digestibility *in vitro* method is applied by incubating the sample for 16 hours at 42-45 0 C in acid solution (HCl) pepsin (activity 1: 10,000). After protein hydrolysis with pepsin, the insoluble residue is separated by filtration and determined as the non digestible proteins by Kjeldahl method (SRPS ISO 937:1992). Digestible proteins are obtained from the difference between total and non digestible proteins. The share of total digestible crude protein is the "protein digestibility"

pH

The pH value of sausages was measured using a glass electrode pH meter (model Cyber Scan 510 pH Meter, EUTECH Instruments Europe, AB Landsmeer, The Netherlands). Calibration was carried out by standard buffers (Merck, Kenilworth, U.S.A.) at pH 4.0 and 7.0 (SRPS ISO 2917:2004). Measurements were performed in triplicate.

Fatty acid composition

Fatty acid analysis was performed by selected samples of homogenized meat mincing machine and from 1 gram of each sample was extracted fat from the prepared methyl esters of fatty acids with a solution of boron trifluoride in methanol. The resulting samples were analyzed on an Agilent 7890A gas chromatograph (Agilent Technologies, Inc., Wilmington, USA) equipped with a flame ionization detector and silica capillary column (DB-WAX 30m, 0.25mm, 0.50um, manufacturer Agilent Technologies, Inc., Wilmington, USA). Fatty acids were identified by comparison with standards from Supelco® 37 component FAME mix (Sigma-Aldrich Chemie GmbH, Taufkirchen, Germany) and data from PUFA No. 2, Animal source BCR-163 fat blend. Results are expressed as milligrams of fatty acids per 100 grams of tissue (mg/100g) and as a ratio between omega-6 and omega-3 fatty acids.

Statistical analysis

Five carp, in three replicates were examined and the mean values were calculated. With respect of right interpretation of the determined data, they were statistically evaluated with calculations of

arithmetic mean ($\bar{X}$), standard deviation (Sd) values and coefficient of variation (Cv).

Results and discussion

The quantities of by-products obtained during carp processing are presented in Table 1. After cutting off the head, tail and fins and removal of complete internal organs, average carcass weight was 1099.60 g (63.18%) of total live body weight. Routine removal of skin, bones, spinal and rib fillets were obtained an average weight of 853.17 g (49.02%) and the bones with the remains of the corresponding meat.

Total average mass of by-products was 640.8 g (36.82%) in relation to livebody mass which was cca 1.740 g. The largest quantity in total live body weight was head with 382.55 g (21.98%),followed by the whole internal organs including tail and fins which had mass 143.77 g (8.26%) and 99.15 g (5.70%), respectively. The share of head depends on the processing method (straight or round cut behind the gills). In the research of Tumbas (1978), the head share was 13.3% in a circular cutting.

The quantities of tail and fins were smaller than head quantities with the amount of 99.15 g (5.11%). Quantities of complete internal organs were 143.77 g (12.22%). According Ristić et al. (1992) carp by products quantities were ranged as head 21.1%, tail and fins 2.9% and total internal organs12.77%.

Results of the chemical composition of the internal organs are shown in the Table 2. Basic chemical composition showed that this raw material, apart from water (68.56%), contains mostly crude fat (15.93%) and then crude proteins (13.91%). Low share of collagen (3.25%) in total crude protein indicates high nutritional quality of protein.

The fat content in the fish carp ranges from 2.3 to 16.8%, while the protein content is less variable and generally is in the range of 14 to 18% (Vladau et al., 2008; Ljubojević et al., 2013).

As seen in Table 3, nitrogen complex of carp internal organs was composed mostly of protein (1.52%). The high digestibility of the protein (92.04%) indicates that high biological value of proteins of the internal organs.

Table 4 shows the fatty acid composition of carp internal organs. The analysis of fats included the classification and quantification of the fatty acids, and the sum of the SFA MUFA, PUFA, n-3 fatty acids, n-6 fatty acids, the ratio of n-6/n-3, PUFA/SFA, and the relationship USFA/SFA, which represent indicators of quality fats.

The total of the SFA was 29.03%, palmitic acid being the predominant SFA (21.69%). Results for the content of MUFA, PUFA and n6/n3 ratio amounted 49.64%, 2.43% and 21.33, respectively. The predominant PUFAs (and n-6) was linoleic acid (12.91%) and n-3 eicosatrienoic acid (2.12%).

The results obtained in this study were comparable with the results of other authors. In the research of Jankowska et al. (2004), the results for the content of MUFA, PUFA and the n3/n6 ratio amounted 40%, 35% and 2.31, respectively. According to data Bieniarz et al. (2000), carp meat contained 22% of the PUFA with the ratio of n-3 / n-6 2.39. Oleic acid is the predominant MUFA (36.06). When it comes to fatty acids n-3 series, carp is a good source of eicosapentaenoic acid (1.70%), docosapentaenoic acid (DPA) (5.46%) and DHA (13.0%).

The reason for the least favourable composition of fatty acid profile in lipids of common carp can be accounted to the type of food dominating in the diet. The traditional approach to the rearing of common carp in the Republic of Serbia is based on foods naturally occurring in ponds (zooplankton, benthos). The energy-producing component of their diet is supplemented with untreated cereals (corn and wheat). The feed rich in saccharides leads to an increase in the percentage of the oleic acid (C18:1n-9) in body lipids of the fish. At the same time, there is a decrease in the percentage of PUFA n-3 (Buchtová et al. 2010). According to research conducted by Buchtová et al. (2010) carp grown on natural food had a high content of both n6 and n3 fatty acids and Ćirković et al. (2011) observed that PUFA/SFA ratio was the most favourable in carp fed complete food, and the least in carp fed with maize and wheat.

The results show that the inedible by-products obtained from carp represent essential sources of fats and proteins. With processing of these by-products it is possible to obtain animal originated feed and technical fat (Ristić et al., 2002). With convenient combinations of the mentioned raw materials and using the corresponding technologies, it is possible to increase assortment of feeds.

Conclusions

Based on the results obtained in this study it is possible to conclude the following:

- After cutting off the head, tail and fins and removal of complete internal organs the average carcass weight was 1099.6 g (63.18%).

- The total average mass of by-products was 640.8 g or 36.82% in relation to livebody mass (cca 1740.4 g).
- The largest share in relation to the mass of live carp had head with 382.55 g (21.98%). Quantities of tail and fins were much smaller with the amount of 99.15 g (5.7%). Significant quantities complete internal organs were 143.77 g (8.26%).
- Biochemical characteristics show that the internal organs, apart from water, contain significant amounts of crude fat and protein suitable for feed processing.
- Digestible nitrogen is approximately equal with total nitrogen (92.04%), indicating that all proteins of the internal organs have high biological value.
- Inedible internal organs obtained during carp slaughtering is a essential sources of fatty acid and can be used as raw material for processing into feeds and can be utilize in animal nutrition.

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Table 1. Quantity of carp by-product, g and %*

	$\overline{X}$	Sd	Cv	%
Carp	**1740,40**	**98,23**	**5,67**	**100**
Scales	15.33	2.49	16.24	0.88
Head	382.55	31.65	8.27	21.98
Tail and fins	99.15	5.11	5,15	5.70
Total internal organs	143.77	12.22	8.50	8.26
Total by-products	**640.80**			**36.82**
Fillet	853.17	75.33	8.83	49.02
Bones and skin	246.43	19.56	7.94	14.16
Carcass	**1099.60**			**63.18**

* on carp in live weight

Table 2. Chemical composition of carp internal organs, %

Item	$\overline{X}$	Sd	Cv
Moisture	68.56	4.27	6.22
Crude protein	13.36	1.18	8.82
Collagen in crude protein	3.25	0.16	4.92
Crude fat	15.93	2.35	14.75
Ash	1.51	0.18	11.92
N-free extract	1.07	0.09	8.41
pH	6.68		

Table 3. Nitrogen fractions and protein digestibility in internal organs of carp, %

Item	$\overline{X}$	Sd	Cv
Protein N	1.52	0.08	5.26
Non-protein N	0.79	0.03	4.28
Protein digestibility	92.04	0.37	0.41

Table 4. Fatty acid composition of carp internal organs, (mg/100 g)

	$\overline{X}$	Sd	Cv
Myristic acid (C14:0)	1,30	0,10	7,34
Pentadecylic acid (C15:0)	0,35	0,05	13,37
Palmitic acid (C16:0)	21,69	0,81	3,75
Sapienic acid (C16:1)	7,26	1,57	21,67
Stearic acid (C18:0)	5,35	1,10	20,48
Oleic acid (C18:1n9c)	36,06	0,36	1,01
Linoleic acid (C18:2n6c)	12,91	1,45	11,22
Eicosenoic acid (C20:1n9)	6,24	1,27	20,28
α-Linolenic acid (C18:3n3)	1,65	0,24	14,33
Eicosadienoic acid (C20:2)	0,28	0,03	9,45
Behenic acid (C22:0)	0,34	0,07	20,38
Erucic acid (C22:1n9)	0,08	0,02	19,92
Eicosatrienoic acid (C20:3n3)	2,12	0,46	21,65
Arachidonic acid (C20:4n6)	0,64	0,16	24,69
Docosadienoic acid (C22:2n6)	1,36	0,23	17,29
Eicosapentaenoic acid (C20:5n3)	1,70	0,36	21,17
Docosahexaenoic acid (C22:6n3)	0,67	0,21	30,88
SFA	29,03	0,62	2,15
MUFA	49,64	2,13	4,30
PUFA	21,33	1,81	8,47
USFA	70,97	0,62	0,88
PUFA/SFA	0,73	0,06	7,83
ω6	14,91	1,11	7,43
ω3	6,14	0,72	11,76
ω 6/ ω 3	2,43	0,12	4,82