Investigation of grass carp by-products from a fish farm in Vojvodina

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Abstract. The quantity of by-products obtained during grass carp primary processing and chemical characteristics of internal organs were investigated. The total average weight of by-products was 783.69 g (36.99%) in relation to live body weight which was cca 2118.5 g. The by-product contributing the largest quantity to total live body weight was the head with 458.22 g (21.63% of live body weight), followed by complete internal organs and tail and fins, with weights of 198.03 g or 9.35% and 57.93 g or 2.73%, respectively. The chemical composition of internal organs from the grass carp was mostly water (65.55%), followed by crude fats and crude proteins (17.47% and 13.35%, respectively). The low collagen content (13.43% of total crude protein) indicates the high nutritional quality of the protein content from internal organs. Nitrogenous complexes from the internal organs were predominantly proteins. Digestible nitrogen was approximately equal to total nitrogen (89.38%), indicating that all proteins of the internal organs had high biological value. Based on the results obtained, it can be concluded that carp internal organs could be important sources of proteins and fats, and thus, could be used in Serbia as a raw material for feed and technical fat production.

1. 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 [1]. The rapidly growing fish 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 [2].

Freshwater fish contain high levels of polyunsaturated fatty acids (PUFA), which makes them very important in human nutrition [3]. Since there are a number of biochemical interactions between the n-6 and n-3 series fatty acids, 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 [4]. Consumption of fish meat is increasing, due to its high content of PUFA, amino acids and lipid soluble vitamins which are important ingredients for human health. According to the latest data from FAO [5], the average...
consumption of fish in Serbia is 5-10 kg per capita per year, which is significantly below the European and global consumption [6].

Common carp is economically the most significant farmed fish species in Serbia [7], and the cyprinids are the most common species in the total world production of freshwater fishes (71.9%, 24.2 million tons in 2010) [5]. Grass carp was imported to the country as a regulator of hydro vegetation. It feeds on higher underwater plants and the meat is of good quality [8]. Manufacturing and development of fish products could increase the amount and contribute to better sales of fish, not only in traditional fish markets, but also in retail stores and supermarkets. However, technological processes, preservation and storage of fish meat differ from those for mammalian meat [9]. For proper manufacturing of fish products, knowledge of the chemical composition and characteristics of raw fish meat is very important in order to apply the most appropriate technology procedures that are adjusted to individual fish species.

Fish processing and new fish product development can produce novel sales of fish, not only in traditional fish markets, but also in all other consumer goods stores [10]. The demands of modern markets are increasingly directed towards processed fish, especially fillets. Larger quantities of edible and non-edible by-products are obtained in industrial conditions of primary fish processing [11]. Fish yield, expressed as the ratio of the weight of the carcass without the head, scales, fins and internal organs and whole fish weight, are essential parameters for all technological operations related to fish processing, since the economy of production is directly dependent on it [12].

By-products of grass carp processing contain valuable nutrients which can be sources for the food, pharmaceutical and feed industries [13]. In order to obtain more complete perception of the quality of animal by-products, 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 of its high usability, i.e. protein digestibility [14].

Inedible by-products obtained during grass carp slaughter belong to the third category of by-products [15], and are significant sources of proteins and fats that are convenient raw materials for processing into proteinaceous feeds for swine and pets. Due to the increasing industrial grass carp processing and need for complex utilization of the by-products obtained, the aim of this research was to investigate the quantity of by-products and nutritive value of internal organs of grass carp.

2. Materials and Methods
The quantity of by-products and quality of internal organs were monitored during the fish harvesting and processing of grass carp from fish ponds in Vojvodina in industrial conditions.

Grass carp (mean weight approx. 2100 g) from the Ečka Fish Farm were delivered live to the manufacturing plant where they were immediately sacrificed. Scales, gills and viscera, heads (flat transverse incision just behind the gill arch) and the fins were removed with a knife. The following tissues/organs were weighed: fish before cutting, scales, head, tail and fins and total internal organs. The internal organs were not separated because in industrial conditions it is standard procedure to treat them as one tissue mass.

Chemical characteristics of internal organs were determined at the Institute of Food Technology in Novi Sad. The entire internal organs from each fish were individually placed in plastic bags to be used as one sample, labelled and refrigerated at 4°C. Four hours after slaughter, samples were transferred to the chemistry laboratory. All samples (a sample was one set of internal organs from one fish) were ground with a homogenizer, then packed into aluminium foil bags and stored for 24 h at 4°C prior to examination.

The basic chemical composition was assessed by determining moisture [16], total protein [17], hydroxyproline (i.e. the relative content of connective tissue proteins) [18], free fat [19], and total ash [20]. Nitrogen fractions and digestible nitrogen were determined according the AOAC methods for free fat content [21].
Data were statistically evaluated [22] using arithmetic mean (\(\bar{X}\)), standard deviation (SD) and coefficient of variation (CV).

### 3. Results and Discussion

The quantities of by-products obtained from carp processing are presented in table 1.

| Table 1. Quantity of grass carp by-product, g and %*. |
|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| Live body weight            | 2118.50                    | 98.23                      | 4.64                       | 100.00                     |
| Scales                      | 69.51                      | 2.49                       | 3.58                       | 3.28                       |
| Head                        | 458.22                     | 31.65                      | 6.91                       | 21.63                      |
| Tail and fins               | 57.93                      | 5.11                       | 8.82                       | 2.73                       |
| Total internal organs       | 198.03                     | 12.22                      | 6.17                       | 9.35                       |
| Total by-products            | 783.69                     | 51.32                      | 6.55                       | 36.99                      |
| Fillet                      | 1001.19                    | 75.33                      | 7.52                       | 47.26                      |
| Bones and skin              | 305.85                     | 19.56                      | 6.40                       | 14.44                      |
| Carcass                     | 1307.04                    | 83.14                      | 6.36                       | 61.70                      |

* % according to grass carp live weight.

After cutting off the head, tail and fins and removal of complete internal organs, average carcass weight was 1307.04 g (61.70%) of total live body weight. Routine removal of skin, bones, spine and rib of carcass produced an average fillet weight of 1001.19 g (47.26%). Total average weight of by-products was 783.69 g (36.99%) in relation to live weight which was cca 2118.5 g. The by-product with the largest proportion of total live body weight was the head, with 458.22 g (21.63%), followed by the internal organs and the tails and fins which had weights of 198.03 g (9.35%) and 57.93 g (2.73%), respectively.

The head weight largely depends on the processing method (straight or round cut behind the gills). In the research of Tumbas and Petrović [23], the head, obtained with a circular cut, was 11% of the live body weight. The weight of tail and fins 99.15 g (5.11%) was smaller than the weight of heads. Total internal organs weighed 143.77 g (12.22%). According to Ristić et al. (1992), grass carp by-product percentages ranged from head 19.79%, tail and fins 3.09% and total internal organs 9.47%.

Results of the chemical composition of the internal organs are shown in table 2. This raw material, apart from water (65.55%), contained mostly crude fat (17.47%) and then crude proteins (13.35%). The low proportion of collagen (13.43%) in the total crude protein indicates the high nutritional quality of the protein. The fat content in grass 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% [3,24].

As seen in table 2, the nitrogen complex in grass carp internal organs was composed mostly of protein. The high digestibility of the protein (89.38%) indicates the high biological value of the internal organ proteins. Ristić et al. [13] studied a set of grass carp internal organs that contained a higher proportion of fat (31.64%), and also had protein with good digestibility (91.57%).
Table 2. Chemical composition of grass carp internal organs, %.

| Parameter                                | X   | SD  | CV  |
|------------------------------------------|-----|-----|-----|
| Moisture                                 | 65.55 | 13.83 | 21.10 |
| Crude protein                            | 13.35 | 1.83  | 15.94 |
| Relative content of connective tissue proteins | 13.43 | 0.60  | 4.47  |
| Crude fat                                | 17.47 | 2.35  | 13.45 |
| Ash                                      | 1.00  | 0.16  | 16.00 |
| N-free extract                           | 2.63  | 0.18  | 6.84  |
| Non-protein N                            | 0.46  | 0.08  | 17.39 |
| Protein digestibility                    | 89.38 | 3.30  | 3.69  |

4. Conclusion

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 1307.04 g (61.70% of the live weight).
• The total average weight of by-products was 783.69 g or 36.99% in relation to live weight (cca 2118.5 g).
• The head had the largest proportion of weight in relation to live weight, being 458.22 g (21.63% of live weight). Weights of tail and fins were much smaller, being 57.93 g (2.73%). The total internal organs weighed 198.03 g (9.35%).
• Biochemical analyses show that the internal organs, apart from water, contained significant amounts of crude fat (17.47%) and protein (10.68%), making them suitable for feed processing.
• The amount of digestible nitrogen in the internal organs was approximately equal to total nitrogen (89.38%), indicating that all proteins from the internal organs have high biological value.
• Inedible internal organs obtained during carp slaughter could be an important source of fatty acids and could be used as raw material for processing into feeds for use in animal nutrition.

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