

Peter SPURNÝ

Aquaculture

**ESTIMATION OF DIGESTIBILITY OF NUTRIENTS IN FEED MIXTURES  
FOR CARP (*CYPRINUS CARPIO* L.) FRY WHEN USING CHROMIUM  
OXIDE AS AN INDICATOR**

**OKREŚLENIE STRAWNOŚCI SKŁADNIKÓW MIESZANEK  
PASZOWYCH DLA NARYBKU KARPIA (*CYPRINUS CARPIO* L.)  
Z ZASTOSOWANIEM TLENKU CHROMU JAKO WSKAŹNIKA**

**Institute of Fisheries and Hydrobiology, Brno, Czech Republic**

In years 1990–1991, laboratory experiments were carried out to estimate values of coefficients of apparent digestibility in two genetic lines of carp fry: a scaly form (HoS) with initial weight of 37 g and a scattered form (HoL) with initial weight of 49 g. Experiments were carried out at the water temperature of 20°C. Two feeding mixtures were tested, viz. S<sub>1</sub> and S<sub>2</sub> with 19 and 34% of protein. The obtained coefficients of apparent digestibility of crude protein, crude fat, N-free extract and crude fibre ranged from 75.6 to 87.2%, from 32.2 to 67.8%, from 58.2 to 67.8% and from 0.9 to 14.3%, respectively. Better values of food conversion were found in the scaly form of carp fry (proteins, fat and carbohydrates by 5.9 and 29.4 and 8.23%, respectively).

**INTRODUCTION**

Under climatic conditions of the Czech Republic, fresh-water fish farming is traditionally based on pond management with carp as the major fish species. At present, carp yields equal approximately up to 90% of commercial catches of our ponds. With regard to the intensification of carp production, it is necessary to emphasise the importance of a high efficiency of feeding because it appears that, in spite of a relatively high consumption of feedstuffs, it is still not possible to obtain an adequate production effect in pond fish farming. Shortcomings associated with unsuitable composition, nutrition value, and digestibility of individual feed components represent some of the possible causes of a wrong feed conversion. Finding a solution to these problems was the objective of a series of experiments carried out at the Department of Fisheries and Hydrobiology of the Mendel University of

Agriculture and Forestry Brno in years 1990 and 1991. In these experiments, the effect of genotype on the digestibility of various diets was studied using selected lines of carp fry.

An application of methods of farm animal nutrition in physiological studies on fish nutrition is associated with considerable theoretical, methodological and also practical difficulties. In fishes as animals living in an aquatic environment, it is very difficult to estimate not only the consumed amount of feed but also to measure the total amount. The evaluation of different methods used for the estimation of feed digestibility was published by Austreng (1978). In these studies, an indirect method of estimation based on the use of chromium oxide as an indicator had been used more and more frequently. There are different opinions of different authors about the most suitable method of collection of fish excrements. The indirect method of digestibility estimation does not require a quantitative method of excrement collection; in fish, however, it cannot be used in studies on digestibility of natural food. Dąbrowski (1986) studied absorption of amino acids in individual segments of carp intestine using  $\text{Cr}_2\text{O}_3$  as an indicator. This author used fish with the average body weight of 200 g which were fed on a diet containing a supplement of 1% of chromium oxide at the temperature of 20°C. Hanley (1987) used chromium oxide as an indicator in studies on the estimation of nutrients in feed for the species *Oerochromis niloticus*. Kirchgessner et al. (1986) tested digestibility of 23 different feed mixtures for carp using 0.5% chromium oxide in the diet as an indicator. Eid and Matty (1989) developed an *in vitro* method of digestibility estimation which simulated conditions existing inside the digestive tract of carp. Pongmaneerat and Watanabe (1991) studied the nutritional value of various sources of protein in 6 different diets for carp containing 10 to 52% of protein and 0.5% of  $\text{Cr}_2\text{O}_3$  as an indicator.

## MATERIAL AND METHODS

In years 1990–1991, a series of 4 laboratory experiments was carried out with the aim to estimate the digestibility of nutrients in experimental feed mixture  $S_1$  and  $S_2$  for one-year-old carp. Two genetic lines of carp fry were used in these experiments, viz. “Hodonin scaly carp” (HoS) and “Hodonin scattered carp” (HoL) with average body weights of  $37.06 \pm 1.05$  and  $49.53 \pm 1.86$  g, respectively.

The experiments were carried out in aquaria within the periods of 6 to 17 November 1990 (with feed mixture  $S_1$ ) and 5 to 15 January 1991 (with feed mixture  $S_2$ ). For these experiments a special facility was developed which consisted of two 70-litre aquaria in which fish were used for the collection of excrements. These Zügel incubators enabled a continuous flow of water which was supplied from an equalising tank with the capacity of 150 litres in which water was aerated with an aquarium aerator. Waste water was not recycled. Both in feeding aquaria and in Zügel incubators, the water temperature was maintained at the

Table 1

Composition of feed mixtures used for the estimations of nutrient digestibility

Components	S <sub>1</sub>	S <sub>2</sub>
Fish meal	—	24
Meat and bone meal	10	12
Extracted crushed soybean	8	15
Dried yeast	2	2
Wheat bran	7	7
Wheat sprouts	2	2
Wheat flour	68	35
Supplement of biofactors	2	2
Cr <sub>2</sub> O <sub>3</sub>	1	1
Total	100	100

level of  $20 \pm 1^\circ\text{C}$ . At the beginning of the conical part Zügel incubators were partitioned with a plastic grid which prevented fish to penetrate into the lower part of this jar and to swirl sedimented excrements there (Fig. 1). Prior to the beginning of the experiments, the health condition of the fish was checked and 20 individuals were adapted to environmental conditions in each variant for a period of 10 days. The feeding of the fish with a pelleted feed mixture containing 1% of Cr<sub>2</sub>O<sub>3</sub> started three days before the collection of excre-

ments; the feed mixture was prepared in our laboratory (Tab. 1).

The whole experimental group was fed *ad libitum* for one hour with feed mixture containing chromium oxide. Thereafter, the experimental fish were caught in the manipulation reservoir (to eliminate a random transfer of non-consumed feed) and put into the modified jar incubator where they were left overnight. Immediately after the removal of fish, the feeding aquarium was cleaned up and an exchange of its water content was carried out. On the following day, fish kept in the Zügel jar were placed back into the feeding aquaria, the sedimented excrements were drawn off and the collecting jar was cleaned up to be ready for a further use. During the whole collection period, carp fry did not show neither symptoms of a worsened health condition nor of stress load caused by this manipulation. Quite on the contrary, within several days of this manipulation fish get so accustomed to the time regime described above that they even "waited" to be transferred from the manipulation reservoir to the feeding aquaria (obviously in expectation of food). The collected excrements were filtered to remove excessive water. Thickened excrements were put every day into a freezing box and stored at the temperature of  $-18^\circ\text{C}$ . This procedure was repeated several times to obtain the necessary amount of 100–150 g of fresh matter of excrements required for analyses.

#### Method of estimation of digestibility coefficients

Coefficients of apparent digestibility of individual nutrients (i.e. crude protein, crude fat, nitrogen-free extract and crude fibre) in fed mixtures were estimated by means of a Cr<sub>2</sub>O<sub>3</sub>-indicator methods (Castell and Tiews 1980) recommended by a commission of FAO. For analyses of nutrients present in the experimental feed mixtures and in the fish excrements common routine methods were used. The content of chromium was estimated after the mineralisation of the samples by means of AAS method.

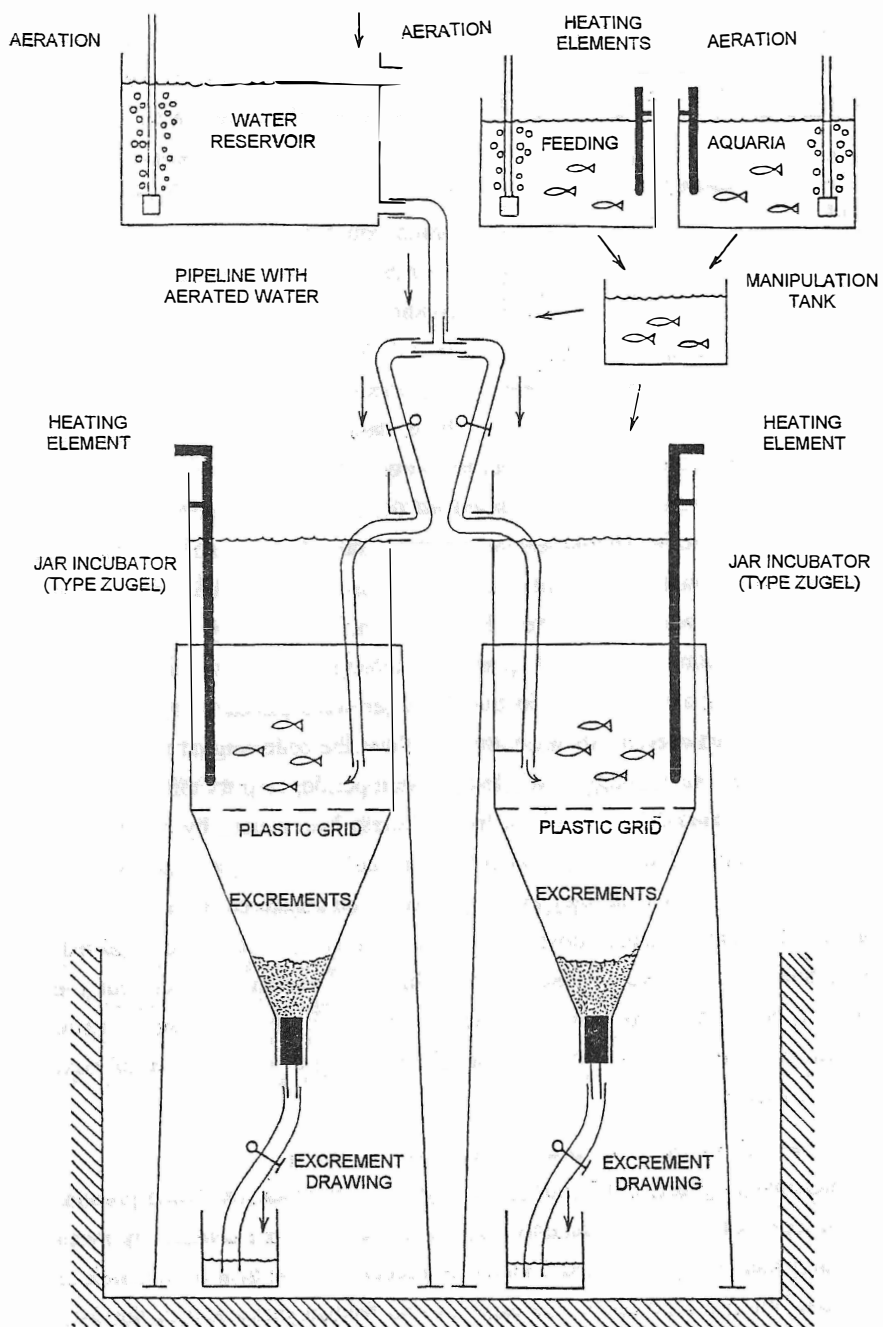


Fig. 1. Diagrammatic presentation of the technical equipment for the collection of excrements

## RESULTS AND DISCUSSION

The results obtained are presented in Tab. 2.

Table 2

Survey of coefficients of apparent digestibility of nutrients in two lines of carp ( $K_1$ ) fry under study

Line $K_1$	Treatment	Crude protein			Crude fat			N-free extract			Crude fibre		
		Feed	Excr.	ADC	Feed	Excr.	ADC	Feed	Excr.	ADC	Feed	Excr.	ADC
HoS	$S_1$ (0.79/2.45)*	19.2	7.6	87.2	4.5	4.5	67.8	63.7	64.3	67.5	4.8	12.7	14.3
HoS	$S_2$ (0.88/2.37)*	33.9	17.9	80.4	6.0	8.4	48.0	44.1	47.7	59.8	4.6	11.0	11.2
HoL	$S_1$ (0.79/1.76)*	19.2	10.3	82.1	4.5	6.7	33.2	63.7	58.6	58.7	4.8	10.6	0.9
HoL	$S_2$ (0.88/2.17)*	33.9	20.4	75.6	6.0	7.6	48.6	44.1	45.5	58.2	4.6	11.2	1.3

\* The content of Cr=indicator is given parentheses as:

% of Cr in DM of feed/% of Cr in DM of excrements

Feed - % of nutrients in dry matter of feed

Excr. - % of nutrient in dry matter of excrements

ADC - apparent digestibility coefficient.

## Digestibility of crude protein

In fish, the digestibility of crude protein is high and, according to different authors, the values of ADC range from 70 to 95%. The value of digestibility coefficients, however, is closely correlated with the source of protein and with the technology of processing of feed components. Cowey and Sargent (1977) and Takeuchi and Watanabe (1977) agreed that the coefficient of digestibility of crude protein ranged from 80 to 95% and emphasised that its requirement in feed should be covered up to 10–15% by fish meal. Kirchgessner et al. (1986) carried out digestibility experiments with carp of the average body weight of 850 g at the water temperature of 20°C. They found out that coefficients of digestibility ranged in this category from 70 to 90% with the average value of 83%. In their experiments, the value of ADC of fish meal were as much as 95%. Pongmaneerat and Watanabe (1991) studied digestibility of different sources of protein and estimated at the water temperature of  $22 \pm 2^\circ\text{C}$  and for carp fry with the individual body weight of 3–5 g, coefficients of digestibility of meat-and-bone meal and white fish meal to be 54 and 87%, respectively. Bergot (1981) found in carp with the average body weight of 270 g that the value coefficient of digestibility of crude protein was 88% at the water temperature of 20°C. Coefficients of digestibility as estimated in our experiments (ranging from 75.6 to 87.2%) corresponded well with these literary data. In scaly (HoS) carp fry, the average coefficient of protein digestibility of our experimental feed mixtures was 83.8% (i.e. 87.2 and 80.4% for mixtures  $S_1$  and  $S_2$ , respectively). On the other hand, on case of the scattered carp fry (HoL), the average value of protein digestibility coefficient was 78.85% (viz. 82.1 and 75.6% for mixtures  $S_1$  and  $S_2$ , respectively). It results from these data that in HoL fry the average digestibility of

protein from experimental feed mixtures was lower by 5.9% than in HoS fry. The digestibility of protein from  $S_1$  feed mixture was lower by 5.85% while that from  $S_2$  by 6.0%. It seems that relatively lower value of ADCs, as observed in case of  $S_2$  containing 24% of fish meal could be associated with a lower quality of this component. In the Czech Republic, the composition and quality of feed mixtures manufactured for fish did not correspond with the present knowledge on fish nutrition and could not be compared with the European standards.

### Digestibility of crude fat

In HoS fry, the average value of coefficients of apparent digestibility of crude fat contained in feed mixtures under study was 57.9% (67.8 and 48.0% for mixtures  $S_1$  and  $S_2$ , resp.). In HoL fry, the corresponding average value was 40.9% (33.2 and 48.6% for mixture  $S_1$  and  $S_2$ , resp.). This means that in HoL fry the average efficiency of crude fat digestibility was lower by 29.4%. In case of  $S_1$  feed mixture, this efficiency was lower by 51.0% while in  $S_2$  it was practically the same as in HoS fry or by 24.9%.

As far as lipids were concerned, many authors mentioned a high degree of their digestibility for fish and the published values ranged from 75 and 95%. Leva (1981) mentioned the value of 85% of lipid digestibility for fish. Kirchgessner et al. (1986) found the values of fat digestibility ranging between 75 and 95% in carps of the weight category 850 g at the water temperature of 20°C. Many authors were of the opinion that fish oil is the best source of lipids for fishes because its digestibility ranged from 85 to 96%. Léger (1981), Austreng (1978) and Nose (1967) mentioned that the digestibility of fat in fish food decreased with the increasing melting point of fat. On the other hand, it increased with the increasing degree of unsaturation of fatty acids as well as with the length of their chain. As compared with these data, the values of fat digestibility found in our experiments were markedly lower and ranged from 33.2 to 67.8%. Obviously, the main cause of this difference was a changing quality of individual components used for the formulation of feed mixtures for fish.

### Digestibility of N-free extract

N-free extract and/or carbohydrates present in feed mixtures under study were in average digested to 63.65 % in HoS fry (67.5 and 59.8% for feed mixtures  $S_1$  and  $S_2$ , respect.). In the group of HoL fry, the average digestibility of carbohydrates was 58.45% (58.7 and 58.2% for feed mixtures  $S_1$  and  $S_2$ , resp.). The estimated coefficients of digestibility of N-free extract were once again lower in the group of HoL fry. The digestibility of carbohydrates present in the feed mixtures under study ranged in experimental carp fry from 58.2 to 67.5%. Leva (1981) mentioned that in fish the digestibility of carbohydrates was approximately 45%. This author also wrote that in fish the digestibility of these carbohydrates



was much lower if more complex compounds were given to fish and presented as an example digestibilities of 19 and 40% for glucose and starch, respectively. Schwarz and Kirchgessner (1982) observed in fish fed on mixtures with a high content of cellulose a rapid impairment of digestibility of carbohydrates compounds from 89 to 48%. In our experiments, wheat flour was used as the main source of carbohydrates and the results obtained (i.e. coefficients of digestibility) corresponded with this fact.

### Digestibility of crude fibre

In HoS fry, the average value of the coefficient of apparent digestibility of crude fibre was 12.75% (14.3 and 11.2% for feed mixtures  $S_1$  and  $S_2$ , resp.). In HoL fry, the average value of this coefficient was 1.1% (0.9 and 1.3% for feed mixtures  $S_1$  and  $S_2$ , resp.). Basing on these results, it can be concluded that the digestibility of crude fibre present in the experimental feed mixtures was very low and that it was nearly indigestible for HoL fry. In our experiments, values of coefficients of apparent digestibility ranged from 0.9 to 14.3%. There are some very different literary data about digestibility of crude fibre in fish. Bergot (1981) studied this problem in carp and trout. He found out that it was indigestible for both species. On the other hand Leva (1981) mentioned that cellulose could be partly digested by fish and that the values of digestibility coefficient were lower than 10%.

## CONCLUSIONS

The evaluation of experiments with the estimation of coefficients of apparent digestibility of two different feed mixtures ( $S_1$  and  $S_2$  with 19 and 34% of protein) revealed that scaly carp fry (HoS) showed better parameters than scattered carp fry (HoL). Digestibility of feed mixture  $S_1$  was better and the feed conversion was higher in HoS carp fry. As compared with HoL carp fry, the values of digestibility coefficients were higher by 5.9%, 29.4% and 8.2% for protein, fat and carbohydrates, respectively. It is not possible to however, draw explicit conclusion on the base of the obtained results because this was the first experiment of this type in the Czech Republic and it was oriented, above all, to the methodologic aspects of the estimation of coefficients of apparent digestibility in carp fry as well as to the method of excrement collection. It can be concluded that these results indicated, above all, an unbalanced quality of feed mixtures manufactured for fishes in the Czech Republic in the period of our experiments. However, they also indicated potential genetic differences in efficiency of digestion and, therefore, in feed conversion on different lines of carp fry.

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Peter SPURNÝ

OKREŚLENIE STRAWNOŚCI SKŁADNIKÓW MIESZANEK PASZOWYCH  
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STRESZCZENIE

W latach 1990–1991 przeprowadzono badania laboratoryjne dla określenia wartości wskaźników strawności pozornej dla dwóch genetycznych linii narybku karpia: pełnołuskiej (HoS) i lustrzenia (HoL) o średniej masie jednostkowej odpowiednio: 37,06 ± 1,05 i 49,53 ± 1,86 g. Badania przeprowadzono w specjalnie skonstruowanych urządzeniach laboratoryjnych w temperaturze wody 21 ± 1°C. Testowano dwie mieszanki paszowe oznaczone jako S<sub>1</sub> i S<sub>2</sub> zawierające odpowiednio: 19 i 34% białka. Określono następujące wskaźniki strawności pozornej: białka ogólnego, tłuszczu ogół-



nego, bezazotowych związków wyciągowych i włókna ogólnego, których zakresy wynosiły odpowiednio: 75,6–87,2, 32,2–67,8, 58,2–67,8 oraz 0,9–14,3%. W porównaniu do lustrzenia dla formy pełnołuskiej narybku karpia uzyskano wyższe wskaźniki wykorzystania paszy (białka, tłuszczu i węglowodanów odpowiednio o: 5,9; 29,4 i 8,23%).

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Authors' address:

Assistant Professor Petr Spurný, Ing DSc  
Institute of Fisheries and Hydrobiology  
Mendel University of Agriculture and Forestry  
Zemědělská 1, 613 00 Brno, Czech Republic