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Preliminary results on the somatic and body compositional changes in juvenile common carp during long-term starvation

D. Varga, Cs. Hancz, T. Molnár, R. Romvári, A. Szabó
Kaposvár University, Faculty of Agricultural and Environmental Sciences, H-7400 Kaposvár, Guba S. str. 40.

ABSTRACT

The aim of our study was to analyse the body compositional changes in common carp juveniles during 12-week-long starvation. Food restriction had a significant impact on every parameter. Hepatosomatic index, viscerosomatix index and condition factor decreased linearly, while in case of body composition parameters a slight fluctuation can be observed. Body fat and dry matter content decreased, protein and ash increased due to 12-week-long starvation. It can be concluded that body lipids constituted the major energy source for starved carp juveniles and 12-week-long starvation did not induce proteolysis in tissues.
(Keywords: common carp, juveniles, body composition, starvation)

INTRODUCTION

Most of the fish species are exposed to short-term or long-term starvation during their lifespan in natural and artifical conditions also. Purging (feed restriction in clear water for flesh quality improvement) is a very important part of the rearing process for common carp (*Cyprinus carpio* L.) in Central Europe and leads to weight loss and stored fat mobilisation (*Zajic et al.,* 2013). The intermedier metabolism of nutrients in the starving organisation changes significantly. In addition, condition factor may decrease due to starvation and body composition can be modified significantly.

Starvation, as a stress factor may alter the biochemical processes of the fish, and catabolism is intensified. During short-term starvation catecholamines (e.g. adrenaline) are excreted, which has a direct effect on stored carbohydrate (glycogene) by glycogenolysis. If starvation is longer than 5 days, synthesis of cortisol starts and due to this process glycogenilysis is replaced by glyconeogenesis. (*Janssens and Waterman.*, 1988).

Effects of starvation in fish were investigated in case of commercial fish species (*Álvarez et al*., 2008; *Caruso et al*., 2012; *Einen et al.,* 1998; *Zajic et al*., 2013) which are important in human consumption, and necessary to provide a good and constant quality. Aim of our recent study was to analyse the body metabolic changes in common carp (*Cyprinus carpio*) juveniles during 12-week-long starvation in warm temperature.

MATERIAL AND METHODS

Experimental animals and design

Common carp (*Cyprinus carpio*) fingerlings (4 g) were introduced into a recirculation system in the Fish Laboratory of the Kaposvár University (Hungary). Fish were reared in fish tanks until they reached 25 g liveweight. Feeding of carps during this period was ad libitum with a commercial fish feed (Aller Aqua; *Table 1*). Fish were adapted to the artifical conditions and feed, so that the effects of stress and disturbing environmental circumstances can be excluded.

Table 1.

Proximate composition of the feed fed prior to starvation

Crude protein (1) (%DM) (2)	45
Crude fat (% DM) (3)	15
Nitrogene-free extract (% DM) (4)	21.9
Crude ash (%DM) (5)	6.9
Crude fiber (%DM) (6)	3.3
Gross energy (MJ/kg) (7)	20.8

After the rearing of fingerlings 200 common carp juveniles were randomly chosen for further experiment. They were stocked into 60 l fish tanks (20 x 10 fish) in a small recirculation system. Feeding was totally restricted for 12 weeks. Water temperature was measured daily (n=84).

Sampling and analyses

Sample collection was carried out initially and every two weeks during the experiment. In all sampling time points 15 randomly selected individuals were over-anaesthetized with clove oil (N_{total} = 7 x 15 = 105).

Weight and standard lenght were measured. 10 fishes were dissected, viscera and liver were measured. Somatic indices, such as viscerosomatic index (VSI) and hepatosomatic index (HSI), and also condition factor (CF) were calculated:

$$VSI = V / W \times 100 \qquad HSI = H / W \times 100 \qquad CF = W \times L^{-3} \times 100$$

V – weight of viscera; H – weight of liver; W – bodyweight; L – standard lenght

Another 5 individuals were analysed for body composition after homogenisation. Dry matter content was determined after drying at 50 ºC till constant weight. Protein content was determined by Kjeldhal analysis (ISO 5983). The crude fat content was determined according to ISO 6492. Ash was analysed by burning oven-dried samples in a muffle furnace at 550 ºC (ISO 5984).

Statistical analysis

The basic data were tested for normality (Shapiro-Wilk test). For the analysis of the effect of starvation on body composition and somatic indices one-way ANOVA was used, followed by Tukey *post hoc* test. SPSS 10 for Windows (1999) was used for the statistical analysis.

RESULTS AND DISCUSSION

The average water temperature was 18.3±1.5 ˚C during the starvation period. No mortality was recorded.

Table 2.

Approximate body composition and somatic indices of common carps during 12-week-long starvation

	Weeks (1)							
	0	**2**	**4**	**6**	**8**	**10**	**12**	**Sig.**
	Mean ± SD							p
Dry matter (%) (2)	23.12 ± 0.55^{a}	23.57 ± 0.33^{a}	23.3 ± 0.22^{a}	21.44 ± 0.33^{b}	21.98 ± 0.19^{b}	19.92 ± 0.37^{c}	21.54 ± 0.32^{b}	0.000
Crude protein (%) (3)	13.28 ± 0.22^{ab}	13.98 ± 0.2^{bc}	13.68 ± 0.25^{bc}	13.8 ± 0.32^{bc}	13.84 ± 0.43^{bc}	13.04 ± 0.26^{a}	13.38 ± 0.36^{abc}	0.000
Crude fat (%) (4)	6.06 ± 0.72^{cd}	6.33 ± 0.2^{d}	6.68 ± 0.31^{d}	4.7 ± 0.19^{ab}	5.38 ± 0.13^{bc}	4.04 ± 0.30^{a}	5.6 ± 0.32^{c}	0.000
Crude ash (%) (5)	2.22 ± 0.08^{a}	2.42 ± 0.31^{b}	2.38 ± 0.05^{b}	2.62 ± 0.13^{b}	2.68 ± 0.41^{b}	2.72 ± 0.19^{a}	2.58 ± 0.15^{b}	0.019
HSI[1] (6)	2.46 ± 0.59^{a}	1.30 ± 0.57^{b}	1.05 ± 0.44^{b}	0.92 ± 0.27^{b}	0.77 ± 0.17^{b}	0.79 ± 0.18^{b}	0.79 ± 0.27^{b}	0.000
VSI[2] (7)	10.62 ± 1.04^{a}	7.07 ± 1.01^{b}	7.78 ± 1.38^{b}	7.35 ± 1.20^{b}	7.21 ± 0.86^{b}	6.86 ± 0.72^{b}	6.70 ± 0.67^{b}	0.000
CF[3] (8)	3.10 ± 0.31^{a}	2.80 ± 0.19^{ab}	2.70 ± 0.23^{bc}	2.60 ± 0.18^{bc}	2.46 ± 0.71^{bc}	2.54 ± 0.21^{c}	2.41 ± 0.13^{c}	0.000

[1]Hepatosomatic index; [2]Viscerosomatic index; [3]Condition factor
Means bearing different small superscript letters are significantly different (P<0.05).

Table 2 shows the results of body composition and somatic indices of carps during the 12-week-long period. Food restriction had a significant impact on every parameter. HSI, VSI and CF decreased significantly and linearly, while in case of body composition parameters a slight fluctuation can be observed. Body fat and dry matter content decreased, protein and ash increased due to 12 weeks starvation.

Most obvious effects of starvation are decrease of live weight, condition factor and somatic indices. The decrease of VSI and HSI is attributable to the decrease of liver and visceral fat. During long term starvation fishes complement the lacking energy by catabolism of several tissues. Main metabolizable tissues are visceral fat and the stored fat in the liver.

Decrease of VSI and HSI in our study is excessive in the fist two weeks than it slowed down. Firstly, digestive tract became empty. Secondly, in the beginning of the starvation period the excreted adrenaline enhanced the glycogene mobilisation, and activity of liver increased. After some weeks fishes were adapted to the starvation stress and lipid mobilisation increased (as can be shown in *Table 2*) contrary to the mobilisation of carbohydrates. These results are consonant with other studies (*Falahatkar* 2012; *Caruso et al*. 2012).

Several authors reported significant decrease of body lipids due to starvation. Fish store lipids in several places: intramuscularly, visceral, in the liver and under the skin.

Fish species utilize stored lipids differently in case of food restriction. Atlantic salmon (*Salmo salar*) prefers the mobilization of intramuscular lipids (*Einen et al*. 2008), while white sturgeon (*Acipenser transmontanus*) mobilizes the visceral fat instead (*Hung* 1998). Therefore, decrease of lipid content affected by starvation can be described by the total body lipid content (*Falahatkar*, 2012).

In our study body fat content decreased significantly during 12-week-long starvation. No decrease of body protein content was observed (conversely, a significant increase was detected), the 12-week-long starvation did not induce proteolysis. *Friedrich and Stepanowska* (2001) published similar results in common carp: 12-week-long starvation does not significantly affect the vital functions.

CONCLUSIONS

Results indicate that body lipids constituted the major energy source for starved carp juveniles. If carps are in good condition (as in our case), 12 week long starvation do not induce proteolysis in muscle. Considering the significant decrease of condition factor in our data gained on carp juveniles we can suspect that purging period (starvation) should be long enough to eliminate possible unpleasant odours and flavours in adult carps as well, but as short as possible from a practical handling point of view to avoid the extreme weight loss and decrease of nutritive value.

For the better understanding of the mechanism, further analyses will be carried out. Blood clinical chemical parameters will be determined to analyse the metabolic changes. In addition, fatty acid composition (phospholipid and triacylglycerol fractions separately) of the liver and fillet will be defined to explore the potential selective fatty acid metabolism due to long term starvation.

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Corresponding author:

Varga Dániel
Kaposvár University, Faculty of Agricultural and Environmental Sciences
H-7400 Kaposvár, Guba S. str. 40.
Tel.: +36-82-505-800
e-mail: varga.daniel@ke.hu