The effect of starvation on chemical composition of Common carp *Cyprinus carpio* L.

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Abstract

The experiment was conducted using 48 fish, common carp *Cyprinus carpio* (average weight 41.51 ± 3.51 gm), The fish were distributed on 6 aquaria each one contain 8 individuals, after two weeks acclimatization on commercial diet (35% protein) to reduce individual differences in nutritional status, fish were exposed to starvation, fish weighed and body composition (moisture, protein, lipid and ash) was analyzed using 5 specimens every two weeks. Fish weight decreased noticeably as a result of consumption of some components of the body to sustain essential activities, fish showed significant decrease ($P < 0.01$) in carcass dry matter, protein and lipid, while moisture increased significantly ($P < 0.01$), fish used 91.8% of carcass lipid and 20.1% of carcass protein during the experiment period, no significant ($P > 0.05$) effect of starvation on carcass ash except the last two weeks of experiment.

Introduction

Under natural conditions, numerous fish species endure long periods of starvation، associated mainly with seasonal changes in food availability, spawning migrations, preparation for spawning or seasonal changes in water temperature (Stepanowska *et al.* 2006). Starvation can take place in fish culture as well. At the final stage of rearing, fish farmers frequently stop administering food for a few days, subjecting the fish to the so-called depuration. At that time the fish regain their physiological equilibrium, cleanse their alimentary tracts from faeces, and get rid of skin and gill impurities. The properly depurated fish are regularly colored, viable, and importantly for the consumer flavor qualities of their meat improve (Friedrich and Stepanowska 2001). Avariety of strategies for surviving to different periods of food deprivation have been adopted by fish, including metabolic, hormonal and behavioral responses. As a rule, fish appear to use catabolic energy conservation strategies which meet their caloric needs but minimize their tissue energy loss. However, the nature of metabolic changes in starvation depends on the species and duration of the fasting period (De Pedro *et al.* 2003). In cod (*Gadus morhua*), carp (*Cyprinus carpio*), and roach (*Rutilus rutilus*), if hepatic lipids are present in significant amounts، they are the first reserves used during starvation, muscle lipids are next to be used, followed by liver and muscle glycogen, in these species, muscle protein is the last reserve to be mobilized during starvation (Dabrowski and Guderley 2002). The objective of the present study was to investigate the effects of long starvation up to10 weeks on the condition of the common carp *Cyprinus carpio* via changes in body composition.

Materials and methods

Experimental procedure

The starvation experiment was conducted in the Marine Science Center laboratories, involved 48 common carp (initial average weight 41.51 ± 3.51 gm), the fish were kept in 6 (60 L capacity) constantly aerated glass aquaria equipped with mesh net to prevent them from jumping, each aquarium was stocked with 8 individuals. Prior to experimentation, fish were acclimatized for two weeks fed *ad libitum* on commercial diet (5.94% moisture, 30.21% protein, 43.73% carbohydrate, 12.56% lipid and 7.56% ash) to minimize the nutritional differences between them. The experiment took 10 weeks during which time the fish were not fed. The fish were weighed and 5 specimens were taken to analyze the chemical carcass composition at the onset of the experiment as well as every two weeks from the begging of starvation.

Analytical procedures

At the end of each starvation period, five fish were sampled, killed by a blow on the head and weighed. Chemical composition was analyzed using the analytical procedures described in Olvera-Novoa *et al.* (1994). moisture content was determined by drying samples in an oven at 105°C for at least 12 h. Crude protein was measured using the Kjeldahl technique which evaluates the total nitrogen content of the sample after it has been digested in sulphuric acid with a mercury or selenium catalyst and multiplying N by 6.25. Crude lipid was extracted with chloroform/methanol (2 : 1, v/v) by the Soxhlet method according to the method of Folch *et al.* (1957). Ash was determined after burning the samples in a muffle furnace at 550°C until a stable weight was obtained.

Statistical analysis

All data were expressed as Mean ± SD. Data were analyzed by ANOVA followed by Duncan's multiple range test for multi-group comparisons. A probability level of $P < 0.05$ was considered statistically significant. The SPSS (Statistical Package for the Social Sciences) version 16.0 was used.

Results

There were no mortalities encountered during the experimental period but body weight was gradually decreased as a direct consequence to starvation (Table 1). Starvation was found to have a substantial affect on carcass composition in carp as shown in Table (2).

There was highly significant ($P < 0.01$) effect of starvation on moisture content of the fish body (Fig. 1), the water content increase from 74.92% to 83.06% during the starvation period, minimum insignificant ($P > 0.05$) moisture increase was noticed at the last two weeks of the experiment.

Starvation led to highly significant ($P < 0.01$) drop in fish carcass lipid content which reduce from 5.67% at the beginning of the starvation period to 0.47% at the end of it (Fig. 2), this reduction equal about 91.8% of primarily carcass lipid content, lowest insignificant ($P > 0.05$) reduce was observed through the last two weeks of the experiment too (from 0.98% to 0.47%) reflected to the reduction in moisture increase (Fig. 3).

Protein was less affected by starvation compare with lipid, the decrease in fish carcass protein content was slowly, and during ten weeks of starvation only 20.10% was used, decreasing protein content from 16.28% to 13.01%.

Fish carcass ash percent was not affected by starvation, its level was almost constant (Fig. 4) excluding the last two weeks of the experiment were attend a significant ($P < 0.01$) increase from 2.66% to 3.23%.

Table 1. Changes in carcass weight (gm) in starved common carp during experiment period

Aquarium no.	Beginning of experiment	Starvation time (weeks)				
		2	4	6	8	10
I	364.42	-	-	-	-	-
II	309.02	281.05	-	-	-	-
III	324.02	303.20	279.43	-	-	-
IV	326.06	309.07	292.52	268.75	-	-
V	368.08	347.30	327.66	310.65	308.29	-
VI	301.11	284.10	265.72	246.08	240.72	229.33
Mean	332.12	304.94	291.33	275.16	274.51	229.33

Table 2. Effect of starvation on proximate carcass composition (%) of Common carp

Carcass Composition	Beginning of experiment	Starvation time (weeks)				
		2	4	6	8	10
Dry matter	25.05[a] ±0.73	22.78[b] ±0.73	20.90[c] ±0.55	19.85[c] ±0.74	17.14[d] ±0.73	16.94[d] ±0.53
Moisture	74.95[d] ±0.73	77.22[c] ±0.73	79.10[b] ±0.55	80.15[b] ±0.74	82.86[a] ±0.73	83.06[a] ±0.53
Lipid	5.67[a] ±0.45	4.69[b] ±0.57	3.44[c] ±0.03	2.60[d] ±0.26	0.98[e] ±0.16	0.47[e] ±0.17
protein	16.28[a] ±0.41	15.19[b] ±0.37	14.59[bc] ±0.31	14.05[cd] ±0.59	13.37[de] ±0.62	13.01[e] ±0.61
Ash	2.76[a] ±0.10	2.77[a] ±0.10	2.77[a] ±0.55	2.77[a] ±0.06	2.66[a] ±0.19	3.23[b] ±0.10
Used lipid (%)	0	17.2	39.3	54.1	82.6	91.8
Used protein (%)	0	6.7	10.4	13.7	17.9	20.1

Values are Means + SD, (n = 5)
Means with different superscripts in each row are significantly different ($P < 0.05$).

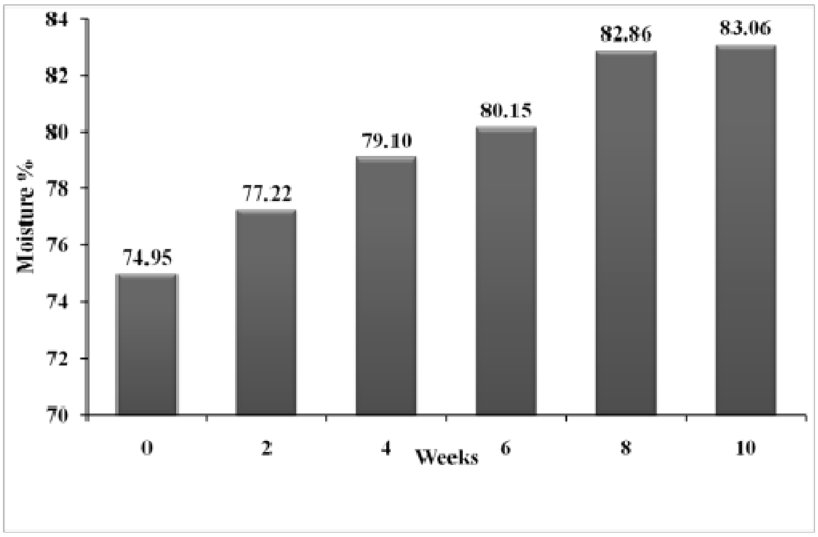

Figure 1. Changes in body moisture during starvation of common carp *Cyprinus carpio*

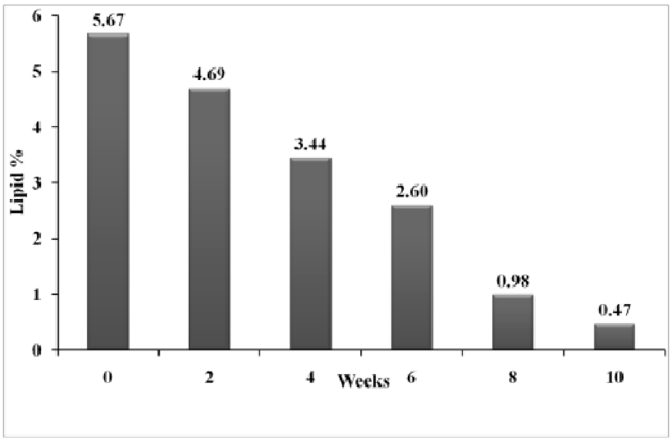

Figure 2. Changes in body lipid during starvation of common carp *Cyprinus carpio*

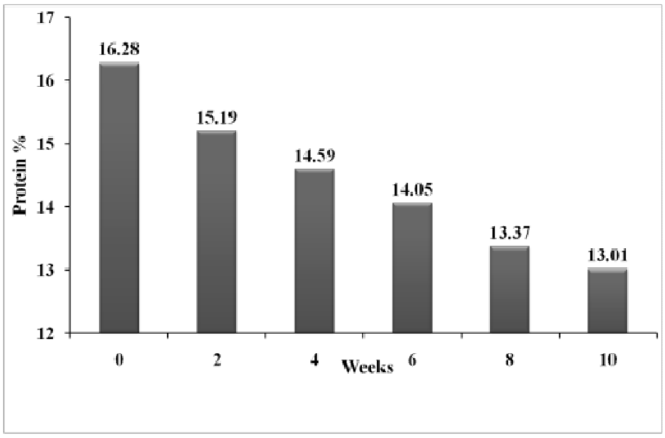

Figure 3. Changes in body protein during starvation of common carp *Cyprinus carpio*

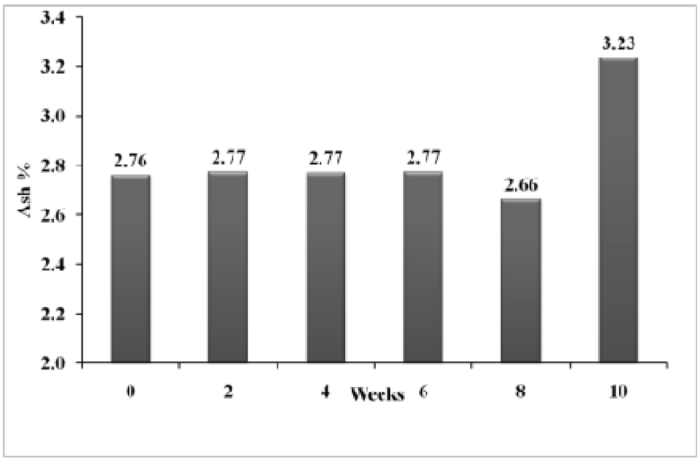

Figure 4. Changes in body ash during starvation of common carp *Cyprinus carpio*

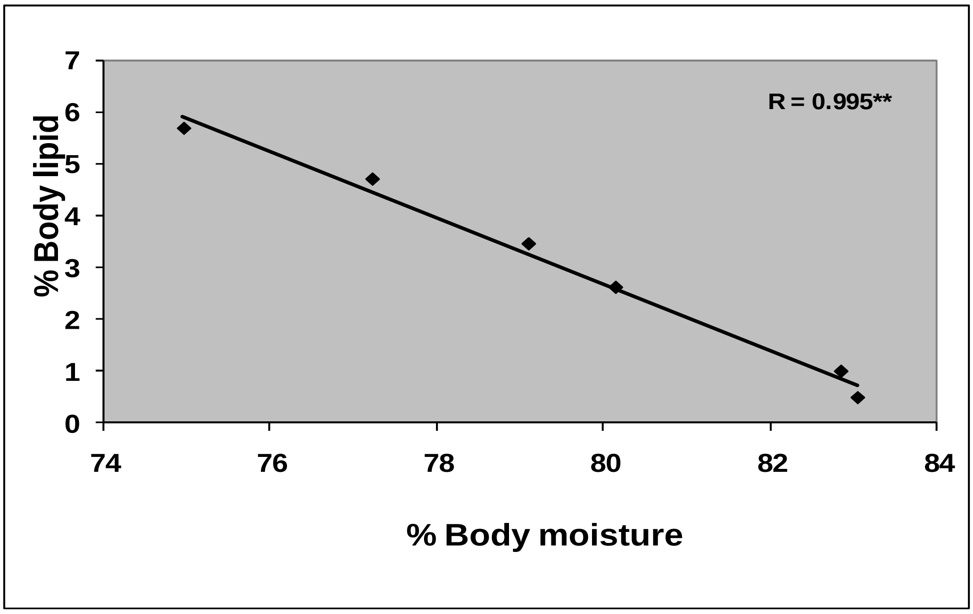

Figure 5. The relation between body moisture and lipid percentage during starvation of common carp *Cyprinus carpio*

Discussion

Food deprivation has diverse effects on tissue and plasma components; the duration of deprivation has an important influence on the way in which energy reserves are utilized and metabolic processes are altered (Mehner and Wieser 1994). The effect of food deprivation on the use of reserve protein, lipid or glycogen as a metabolic fuel seems to be species-specific, two principal groups of fish have been identified on the basis of their metabolic response to starvation; (1) those that use primarily muscle protein as the principal fuel, e.g. eel, *Anguilla anguilla* L., *cursian* carp, *Carassius aurantus* L., plaice, *Pleuronectes platessa* L. (2) those that use primarily lipids, e.g. pike, *Esox lucius* L., *Rutilus rutilus* L., however, such a distinction is artificial as endogenous and exogenous factors may influence the choice of metabolic fuel (Salam *et al.* 2000).

The results of the current study indicate that carcass lipid level on a wet weight basis was decreased rapidly during starvation period; we could notice that 91.8% of original carcass lipid was consumed after 10 weeks of food deprivations. Thus the study provides further evidence that common carp depend greatly on body lipid storages as alternative source of energy during starvation, which agreed with the results obtained by Friedrich & Stepanowska (2001) and Nagai & Ikeda (1971). Furthermore, similar results have been observed in other fish species including Antarctic fish

(Stepanowska *et al.* 2006), thaila (Salam *et al.* 2000), *Liza abu* (Yesser *et al.* 1999), sturgeon (Hung *et al.* 1997) and trout (Heming & Paleczny 1987). Significant ($P < 0.01$) negative correlation (-0.995) was identified between lipid and moisture levels in the body as a result of replacing lipid consumed by water (Fig. 5), such results have been found in Arctic Chare (Miglavs & Jobling 1989), trout (Denton & Yousef 1976) and carp (Nagai & Ikeda 1971).

The reduction in carcass protein content (20.1% of original carcass protein) was much slower than that for carcass lipid, these results could be assigned to the ability of common carp to conserve body tissues as a final source of energy by depending on lipids reserves firstly, such results have been also reported in other works (Mahdi 2006, Salam *et al.* 2000, , Yesser *et al.* 1999, Hung *et al.* 1997 and Reinitz 1983). Larsson & Lewander (1973) mentioned that one cannot exclude the possibility that the fish also utilize protein as energy source during the starvation period due to an increase in gluconeogenesis but to a lower extent comparing with lipid. On the other hand, Some researchers (Friedrich & Stepanowska 2001 and Heming & Paleczny 1987) found that carcass protein level does not decline during starvation, on the contrary, the body protein concentration was even found to have increased (Stepanowska *et al.* 2006), However, it is assumed that the observed tissue protein increase is an artifact produced by a change in fish body dry mass, not accompanied by any loss of tissue protein. However, it should be noted that in current study when making the calculations of carcass composition on dry weight basis, the protein and ash levels were increased and lipid level decreased which make the results unclear.

No significant ($P > 0.05$) effect of starvation on carcass ash was observed except the last two weeks of experiment, during this period ash level was increased significantly ($P < 0.01$), this may due to retardation in other components (lipid and protein) levels without compensate them by adequate quantity of water (Stepanowska *et al.* 2006 and Salam *et al.* 2000).

The present study pointed out that common carp is able to withstand relatively long periods of starvation, reached in the current study up to 10 weeks without leading to any mortalities, also showed that fish had resorted to use lipid primarily as an alternative source of energy during starvation, while relying less on protein as long as the body contains enough lipid to exploit.

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دراسة تأثير التجويع على التركيب الكيمياوي للجسم في اسماك الكارب الشائع *Cyprinus carpio* L.

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الخلاصة

استخدمت في التجربة 48 سمكة كارب شائع *Cyprinus carpio* (معدل الوزن 41.51 ± 3.51)، وزعت الأسماك على ستة أحواض بمعدل ثمانية اسماك لكل حوض، بعد فترة أقلمة لمدة أسبوعين غذيت خلالها الأسماك لحد الإشباع على عليقة تجارية (35% بروتين) لتقليل الفروقات الفردية في الحالة التغذوية بين الأسماك قبل بدء التجربة، عرضت بعدها الأسماك للتجويع، وزنت الأسماك كل أسبوعين مع اخذ عينة (5 اسماك) لقياس التركيب الكيمياوي للجسم (الرطوبة والبروتين والدهن والرماد). أظهرت الدراسة انخفاض أوزان الأسماك بشكل ملحوظ نتيجة استهلاك بعض مكونات الجسم لإدامة الفعاليات الحيوية، فضلا عن ذلك أظهرت الأسماك انخفاض ملحوظ ومعنوي ($P< 0.01$) في نسبة المادة الجافة وبروتين ودهن الجسم، بينما في المقابل ارتفعت نسبة الرطوبة في الجسم وبشكل معنوي ($P<0.01$) أيضا. اعتمدت الأسماك بشكل اكبر على مخزون الدهن في الجسم خلال فترة التجويع إذ بلغت الكمية المستهلكة منه نسبة إلى الكمية الأصلية في الجسم عند بداية التجربة إلى 91.8%، بينما اعتمدت بشكل اقل على بروتين الجسم اذ بلغت النسبة المستهلكة منه 20.1% خلال نفس الفترة، أظهرت نسبة الرماد تقاربا في مستوياتها خلال فترة التجربة ولم تتأثر معنويا ($P>0.05$) إلا خلال الفترة الأخيرة من التجربة، تم تعويض النقص في دهن وبروتين الجسم من خلال زيادة نسبة الرطوبة فيه.