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Fillet quality changes as a result of purging of common carp (*Cyprinus carpio* L.) with special regard to weight loss and lipid profile

Tomas Zajic [a,*], Jan Mraz [a], Sabine Sampels [a], Jana Pickova [a,b]

[a] University of South Bohemia in Ceske Budejovice, Faculty of Fisheries and Protection of Waters, South Bohemian Research Center of Aquaculture and Biodiversity of Hydrocenoses, Institute of Aquaculture, Husova tř. 458/102, 370 05 České Budějovice, Czech Republic
[b] Department of Food Science, Swedish University of Agricultural Sciences, PO Box 7051, S-750 07, Uppsala, Sweden

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ABSTRACT

Purging is a very important part of the rearing process for common carp (*Cyprinus carpio* L.) in Central Europe and is commonly conducted between October and December. Fish are kept in clear water without feeding in order to empty the gut, decrease the entrail proportion and eliminate possible tainted flavour. This leads to weight loss and stored fat mobilisation. This study investigated the effect of a purging period of up to 70 days on lipid content and quality of common carp flesh. Four-year-old, market-size carp (weight 1700–2600 g) from three different production systems (C: cereal supplemented; P: linseed/rapeseed pellet supplemented; N: natural feed) were sampled every 14 days for weight, fillet yield and lipid analysis. Fillet yield was highest after 14 days and decreased thereafter. Throughout the experiment, fillet fat content decreased continuously in groups C and P, but remained stable in group N. Initially, carp from groups C and P mainly metabolised monounsaturated fatty acids (MUFAs), but with prolonged starvation fish from all groups started to metabolise more polyunsaturated fatty acids (PUFAs). After 70 days of purging, all groups showed almost identical saturated FA (SFA), MUFA and PUFA values. Our conclusion is that carp are able to metabolise selected FA for their energy needs when they are in good condition and have surplus fat stores. However, when body fat content is low, they may metabolise all FA types equally to sustain metabolic functions.

1. Introduction

Common carp (*Cyprinus carpio*) is one of the most commonly reared fish globally, with a production volume of around 3 000 000 tons annually (FAO, 2010). Carp for consumption in Central Europe are traditionally harvested during late autumn and kept in concrete coated ponds with fresh water flow for some weeks before being sold, a process known as purging. During this time the fish are not fed, so that the digestive tract is emptied and unpleasant odours are eliminated (Einen et al., 1998). Purging is necessary to achieve good product sensory quality. Common carp in natural conditions decrease feeding and activity with decreasing water temperature in winter to save energy. The optimal temperature range for carp is 20–28 °C, and in general carp stop feeding in the range 12–4 °C and stop movement at water temperatures below 6–4 °C in natural conditions (Bauer and Schlott, 2004).

In preparation for the winter starvation period, carp naturally store fat as reserve energy in muscle and abdominal wall tissues, mainly in the form of energy-rich triacylglycerols (TAGs). During the winter starvation period these TAG reserves are metabolised gradually for maintenance of the organism (Csengeri, 1996).

Lipids have an important function as an energy source in the body (McCue, 2010). Different fatty acids (FAs) also have metabolically important functions in the body, and are involved in the determination of the physical and chemical properties and capacities of biological membranes (Wiseman, 1996). They also serve as precursors in the synthesis of several different chemical messengers and eicosanoid hormones, as well as other regulating factors (Horrobin, 1995; Kinsella, 1988). In general, TAG serves mainly as an energy source, whereas phospholipids (PLs) are mainly constituents of biological membranes (Sargent et al., 1999).

Under semi-intensive rearing conditions, carp have access to natural feed (plankton and benthos) in the pond and are also fed a supplement, often cereals. While cereals are rich in carbohydrates with moderate levels of fat and n−6 polyunsaturated fatty acids (PUFAs), plankton and benthos contain high amounts of n−3 PUFA (Bell et al., 1994; Domaizon et al., 2000). The carbohydrate-rich diet leads to a high muscle fat content (Mraz and Pickova, 2009), more than 10% in intensively reared carp (Keshavanath et al., 2002), by de novo synthesis of FA (Henderson, 1996). In addition, cereals contain n−6 PUFA, which are generally not present in the natural diet of fish in such amounts and therefore affect the lipid composition of fish tissues. Mraz and Pickova

Abbreviations: BF_3, boron trifluoride methanol complex; CF, condition factor; DHA, docosahexaenoic acid; EPA, eicosapentaenoic acid; FA, fatty acid; FFA, free fatty acid; FAME, fatty acid methyl ester; MUFA, monounsaturated fatty acid; PL, phospholipid; PUFA, polyunsaturated fatty acid; SFA, saturated fatty acid; TAG, triacylglycerol; TLC, thin layer chromatography.

* Corresponding author. Tel.: +420 387 772 739.
E-mail address: zajict00@frov.jcu.cz (T. Zajic).

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(2009) suggested that cereals cause an increase in n−6 PUFA in carp, while the proportions of n−3 PUFA decrease. Mraz et al. (2012) studied the effect of three different production systems (supplementation with cereals or pellets containing rapeseed cake, and a natural diet only) on lipid composition in common carp and found a significantly higher content of n−3 PUFA in fish fed rapeseed pellets compared with fish fed cereals. This and other studies (Pickova and Mørkøre, 2007; Runge et al., 1987; Schwarz, 1996) indicate the possibility of influencing fish lipid composition towards a higher content of n−3 PUFA, which is favourable from a human nutrition perspective (Calder and Yaqoob, 2009; Leaf and Weber, 1987; Simopoulos, 2002, 2008).

However, few previous studies have examined changes in lipid content and FA composition during the purging period of common carp. Csengeri (1996) and Vacha et al. (2007) observed some changes in FA composition during a long-lasting purging period in carp supplemented with different cereals. There was a slight increase in n−3 PUFA in the groups fed cereal, while n−3 PUFA decreased in the control group kept in natural conditions without supplemental feeding before purging. In a study on common carp, Csengeri (1996) concluded that monounsaturated fatty acids (MUFAs), especially oleic acid (18:1 n−9), are mainly utilised for energy production during prolonged starvation, while PUFAs are partly preserved. Similar results have been published for other fish species, for example channel catfish (*Ictalurus punctatus*; Luo et al., 2009), Atlantic salmon (*Salmo salar*; Einen et al., 1998), Murray cod (*Maccullochella peelii peelii*; Palmeri et al., 2008a, 2009a) and hybrid red tilapia (*Oreochromis mossambicus* × *O. niloticus*; De Silva et al., 1997). Different reduced feed ratio levels in rainbow trout (*Oncorhynchus mykiss*) were studied by Kiessling et al. (1989), who found that higher diet restriction resulted in higher n−3 PUFA percentage in fish flesh. Decreased muscle fat content has been reported in brown trout (*Salmo trutta*) starved for 2 months (Regost et al., 2001).

Previous studies suggest that the lipid content and composition of the edible parts of different fish species are affected during starvation (Palmeri et al., 2008b, 2009b; Thanuthong et al., 2012). In addition, previous nutrition most likely plays an important role in the changes (Tucker, 2000). The aim of the present study was to explore the effect of purging on fillet fat content and FA composition in common carp from three different production systems — supplementation with cereal; supplementation with rapeseed/linseed pellets; and natural feed only.

2. Materials and methods

2.1. Experimental design

Duplicate groups of 4-year-old, market-size common carp were reared in three different production systems for one season (April–September) in the experimental unit of the Faculty of Fisheries and Protection of Waters in Vodňany, Czech Republic. The production systems involved three different types of feed: natural feed only (N); supplementation with cereal (C) and supplementation with rapeseed/linseed pellets (P). Each treatment was carried out in two ponds to balance the effect of the pond environment.

After harvesting, 80 individuals were randomly chosen from each group, labelled by groups with visible implant elastomer (VIE, Northwest Marine Technology, Ltd., USA) and placed in a storage pond with continuous inflow of fresh river water. The pond was 8 m × 4 m × 1.3 m deep, with stony walls and gravel on the bottom. Water temperature measured with a temperature datalogger Minikin I (EMS, Brno, Czech Republic) decreased continually during the experimental period (18.5 °C at the beginning; 2.5 °C at the end; Fig. 1). Dissolved oxygen (O_2) concentration and pH were recorded regularly twice a week (O_2 varied between 6 and 8.5 mg L^{-1}; pH 7.1–7.6). Condition factor (CF) was calculated on each sampling day as the ratio of individual weight (W, grams) to body length (BL, cm = distance between edge of the head and base of tail fin) as:

$$CF = \left(W * BL^{-3}\right) * 100.$$

On days 0, 14, 28, 42, 56 and 70, a subsample of 10 fish from each group were weighed and 6 fish from each treatment (3 each from the two ponds of the same treatment) were killed for sampling. The fish were stunned by a blow to the head and then the gills were cut. A 4 cm wide strip of the fillet (containing white muscle, red muscle and adipose tissue with skin) was taken from each fish at the same position, in the fillet behind the dorsal fin. These fillet samples were packed in aluminium foil and immediately frozen in liquid nitrogen. All samples were stored at −80 °C until further analysis.

2.2. Lipid analysis

Strips of fillets with skin were minced in a table cutter to ensure that all edible parts were represented in the sample analysed. All chemicals and solvents were purchased from Merck (Darmstadt, Germany). Lipid extraction was performed according to Hara and Radin (1978) with minor modifications. Briefly, 1 g of sample was weighed and homogenised in HIP (hexane–isopropanol 3:2, v/v). The homogenate was transferred to a centrifuge tube and 6.5 mL 6.67% Na_2SO_4 was added to separate lipid and non-lipid phases. After centrifugation, the total lipid phase (upper phase) was transferred into pre-weighed tubes and evaporated under nitrogen (for about 1 h). Total lipid content was determined gravimetrically.

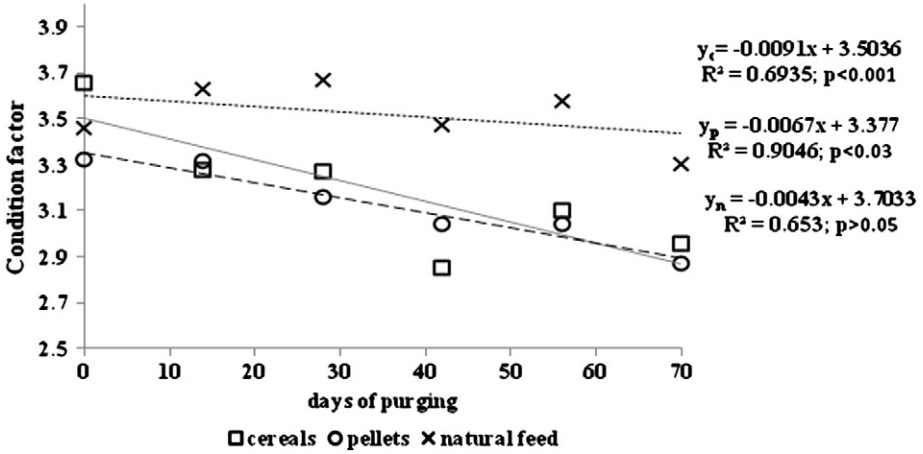

Fig. 1. Condition factor (CF) in carp in the group supplemented with cereals; the group supplemented with rapeseed/linseed pellets; and the group fed natural feed only during the purging period; P value indicates regression dependence within tested groups during purging period (mean values; n = 10).