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Effect of maturation degree on fatty acid profile of different tissues in wild and farmed rohu (*Labeo rohita*)

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RESUMEN

Efecto del grado de maduración en el perfil de ácidos grasos de diferentes tejidos de rohu (*Labeo rohita*) salvaje y criado.

Durante la época de reproducción numerosos cambios fisiológicos ocurren en el cuerpo de los peces que guían a cambios anatómicos y de comportamiento. Para evaluar el impacto de la etapa de reproducción en la composición de los peces, ensayos para determinar el perfil de ácidos grasos fueron conducidos en peces salvajes y criados, en dos categorías de peso, maduro (booder) o inmaduro (non-brooder). Las muestras fueron analizadas por cromatografía de gases usando un detector de ionización de llama. No hubo diferencias significativas en la cantidad de ácidos grasos saturados e insaturados en peces salvajes o criados non-brooder mientras que en el caso de los brooder sí hubo diferencias significativas. Los peces brooder criados contienen más ácidos grasos saturados; en gónadas aproximadamente el doble que los salvajes con el C16:0 como el ácido graso dominante. C18:2n-6 y C20:5n-6 fueron los ácidos grasos insaturados dominantes en las gónadas. Los peces non-brooder contienen más ácidos grasos insaturados en la carne que los peces brooder y los peces criados contienen mayores cantidades de ácidos grasos saturados en comparación con los peces salvajes. Los ácidos grasos C18:1n-9 y C20:4n-6 fueron encontrados en cantidades más altas y entres los saturados el C16:0 fue uno de los principales. Resultados más o menos similares fueron encontrados en el caso del perfil de ácidos grasos de hígados de peces en etapas de reproducción y no reproducción. Los peces de la categoría de pesos más bajos contienen más ácidos grasos insaturados y son mejores para el consumo y permite la cría de peces de peso más alto.

PALABRAS-CLAVE: Ácido graso – Criado – Labeo *– Maduración –* Rohita *– Salvaje.*

SUMMARY

Effect of maturation degree on fatty acid profile of different tissues in wild and farmed rohu (*Labeo rohita*).

During the breeding season, lots of physiological changes occur in the bodies of fish which lead to other phenotypical, anatomical and behavioral changes. To evaluate the impact of breeding on the bodily composition of fish, tests were conducted to determine the fatty acid profile of the brooder and Non-brooder wild and farmed fish. Samples were analyzed by gas liquid chromatography using a flame ionization detector. There are non significant differences in the amount of saturated and unsaturated fatty acids in wild and farmed non-brooder fish whereas in case of brooder there are significant differences. Brooder farmed fish contained more saturates in gonads approximately twice that of wild fish with C16:0 as the dominating fatty acid. C18:2n-6 and C20:5n-6 were the dominating unsaturated fatty acids in the gonads. Non-brooder fish contained more unsaturated fatty acids in the meat as compared to the brooder fish and farmed fish contained higher amounts of saturated fatty acids as compared to wild fish. C18:1n-9 and C20:4n-6 fatty acids were found in higher quantities and among the saturated acids, C16:0 is the dominating one. More or less similar results were found in the case of the liver fatty acid profile of breeding and non-breeding fish. Fish of lower weight categories contained more unsaturated fatty acids and so better for consumption to leave the brooders of higher weight categories for the breeding of future generation.

KEY-WORDS: Farmed – Fatty acids – Labeo *– Maturation –* Rohita *– Wild.*

1. INTRODUCTION

Fish, whether, from the sea or from freshwater has been historically regarded as a simple and dependable quality food because it is an appropriate source of animal protein for more than half of the global population (Ling, 1977). Cultured fish is currently considered one of the most promising sources of animal protein. During recent years, the potential and prolific nature of cultured fish has been directed towards its large scale adoption and promotion in Asian countries. Traditionally, Indian major carps, viz, *Catla catla, Labeo rohita* and *Cirrhina mrigala* are commonly cultured in freshwater ponds (Mahboob, 1992). Fish has long been recognized as a valuable source of high quality food in the human diet. In recent years, fish lipids have also assumed a great nutritional significance owing to their protective role against the development of cardiovascular diseases and rheumatoid arthritis (Shahidi and Boota, 1994). Coronary heart diseases have been identified as a leading cause of death in various parts of the world including Pakistan, with mortality rates increasing every year. Although fish is widely consumed by people in Pakistan, its consumption is still low (0.6Kg/

person/year) compared to that of developed countries (Mahboob, 1992).

Labeo rohita is extensively cultured in ponds and is one of the most preferred fish in the Indian Subcontinent (Misra and Samantaray, 2004). Rohu along with two other Indian major carps (*Catla catla and Cirrhina mrigala*) contribute to the bulk of fish farm production with over 1.8 million tones (FAO 2003). Fish lipids are rich in polyunsaturated fatty acids (PUFA), which are essential for fish health and growth. In comparison with terrestrial animal meat, the lipids of fish flesh are recognized as beneficial to human health by decreasing cardiovascular and inflammatory disorders (Piclet, 1987; Nettleton, 1991; Klor *et al*., 1997). In fish nutrition, lipids as a non-protein energy source allow protein sparing by effectively reducing organic matter and nitrogen loss (Lee and Putnam, 1973) and currently salmonid aquaculture uses high fat diets. There is, however, a concern that a high level of dietary lipids may lead to increased fat deposition, depending upon species and age, and its ability to modify flesh quality in terms of storage stability, transformation, yield and organoleptic and physical properties (Austreng *et al*., 1987; Fauconneau *et al*., 1993). The liver and viscera (pyloric caecum and mesenteria) constitute the location for fat depots in all species. Fats are also encountered in the meat tissue, the skin, milt and roe. In flat fish, it was found that the skeleton and the liver were rich in fats and the viscera and flesh were poor in this respect (Love, 1980). With the increasing demand, the population of fish in different areas of the world has decreased drastically due to over fishing by modern techniques. The present project is aimed at evaluating the difference in the fatty acid profiles of mature breeding and immature non-breeding fish in farmed and wild habitats so that future human generations may enjoy a high protein and lipid profile diet.

2. MATERIALS AND METHODS

2.1. Obtaining of Fish

Freshwater carp, *Labeo rohita* (*L. rohita*) of two weight categories (mature designated as Brooder and immature designated as Non-brooder), both farmed and wild, were analyzed for the estimation of the fatty acid profile of three selected tissues: gonads, meat and liver.

The farm raised *L. rohita,* designated as Non-brooder (501-800g) and Brooder (1301-1600g) were obtained from the Fish Hatchery, Satiana Road, Faisalabad. Concurrently, wild *L. rohita* of two weight categories designated as Non-brooder (501-800g) and Brooder (1301-1600g) were captured with the help of gill nets from the Trimu Head, at River Chenab which is about 95 km away from Faisalabad, Pakistan. There are four groups of fish and each sample group contains seven fish.

The farmed fish were fed a commercial diet (35% crude protein, 13% lipids, 2.8% carbohydrates and 1.3% minerals excluding some palatable substances), while the wild fish diet evidently consisted mainly of crustaceans, insects, phytoplankton and some insect larvae. In order to reduce the risk of any contamination or other biochemical changes in the body, freshly collected fish samples were used for the fatty acid analysis.

2.2. Preparation of Fish for Experiment

Fish were transported live to the Fisheries Research Laboratory, Department of Zoology, GC University Faisalabad, Pakistan. All the fish specimens were cleaned out in running de-chlorinated tap water for two days, thereby facilitating the removal of stomach contents. The fish were then dissected and tissues of interest, viz., gonads, meat and liver, were removed for analysis.

2.3. Extraction and Fatty Acid analysis

Total protein contents were determined using an automatic analyzer made by Tecator of Sweden, based on Kjeldahl's method using a digestion unit, a distillation unit and a titration unit. A definite amount of fish sample was transported into the crucible (weighed) and placed in an electric furnace at 550ºC to determine ash contents.

Table 1
Proximate composition of *Labeo rohita*.

Fish	Non-brooder (W)	Brooder (W)	Non-brooder (F)	Brooder (F)
Moisture	77.56 $^{\pm 0.07\ a}$	75.50 $^{\pm 0.07\ a}$	75.40 $^{\pm 0.10\ a}$	71.68 $^{\pm 0.07\ b}$
Protein	16.62 $^{\pm 0.02\ a}$	17.76 $^{\pm 0.01\ b}$	16.81 $^{\pm 0.03\ a}$	19.38 $^{\pm 0.02\ b}$
Lipids	01.94 $^{\pm 0.04\ a}$	01.30 $^{\pm 0.02\ b}$	02.32 $^{\pm 0.02\ a}$	04.14 $^{\pm 0.03\ c}$
Carbohydrates	03.29 $^{\pm 0.08\ a}$	04.63 $^{\pm 0.08\ b}$	03.46 $^{\pm 0.03\ ab}$	02.57 $^{\pm 0.04\ b}$
Ash	00.58 $^{\pm 0.02\ a}$	00.80 $^{\pm 0.03\ a}$	01.01 $^{\pm 0.01a}$	01.23 $^{\pm 0.02\ a}$

Means with different letters are significantly different at ($P<0.05$). Non-brooder (weight: 501-800g). Brooder (weight: 1301-1600g). W = Wild. F = Farmed.

Lipids were extracted according to Folch *et a*l., (1957), as modified by Bell *et al*., (1991). Fatty acids were analyzed by gas-liquid chromatography (GLC), in the flavor laboratory at the Nuclear Institute for Agriculture and Biology Faisalabad, Pakistan following the method of Kiessling *et al*., (2001). Fatty acid methyl esters (FAME) of each lipid sample were prepared according to the standard method by the Association of Official Analytical Chemists (AOAC, 1990: Hassan *et al*., 2010). FAME were separated, identified and quantified using a GLC Perkin-Elmer Model 3920 column (glass) filled with 20% DEGS on Chromosorb W equipped with an FID detection with temperature programming at 200ºC injector, 190ºC column and 250ºC detector: 20 Psi H_2, 50 Psi air with 0.2 µl injection. Individual methyl esters were identified by the comparison of chromatograms to the standards of known retention times.

2.4. Statistical analysis

A Different Procedure of Statistical Analysis System ANOVA by Minitab packages (S.A.S., 1995) was used to analyze the data.

3. RESULTS AND DISCUSSION

The experimental data recoded through the physical and chemical analyses showed significant differences in brooder and non-brooder wild and farmed fish in the cases of moisture, proteins, carbohydrates and ash contents of the selected tissues. There are no significant differences in the in the concentrations of protein and carbohydrates in the case of non-brooders of wild or farmed fish.

The observed changes in individual fatty acids of the total lipid fraction are shown in tables 2 to 4. The data shown for the individual fatty acids of total lipids is limited to fish gonads, flesh and the liver of wild and farmed *L. rohita* of the two weight categories of brooder and non-brooder fish. A difference in either body weight or total lipid contents results in fatty acids being strongly affected by increasing age, size and weight of the fish in farmed and wild habitats for different seasons.

Farmed fish contained more saturates in gonads approximately twice that of wild fish, C16:0 and C14:0 were the dominating fatty acids and showed a decreasing trend in higher weight brooder fish closely followed by C18:0 and C20:0 which showed increasing trends; while in the case of wild fish they showed decreasing trends. Brooder fish contained more saturates in the gonads both in wild and farmed fish. Among the unsaturates, C18:2n-6 and C20:5n-6 were the dominating unsaturated fatty acids in the gonads of non-brooders and brooders, C20:4n-6, C22:6n-6 were found in higher concentrations. C20:4n-6 was found in equal proportions both in brooder and non-brooder farmed fish. Brooder fish of lower weight categories contained more unsaturates as compared to those of higher weight category brooder fish both in farmed and wild habitats (Table 2).

In the case of the fatty acid profile of the meat, non-brooder fish contained more unsaturated fatty acids as compared to brooder fish and farmed fish contained higher amounts of saturated fatty acids as compared to wild fish. C18:1n-9 and C20:4n-6 were found in higher quantities in the case of wild fish and among saturates, C16:0 is the dominating one both in farmed and wild fish (Table 3).

Similar results were found for the saturated fatty acids in the liver of breeding and non-breeding fish but considerable variations existed among the unsaturated fatty acids. The variations for individual fatty acids are shown in table 4. The environmental and nutritional effects on the fat contents in fish bodies have been reported in a number of studies (Polvi and Ackman, 1992). However, due to the limited time span of most experiments and the small size of the fish, the results are often difficult to link with the more practical fish farm situations. During recent years, fish lipids have been focused on as being beneficial for human health (Anon, 1992). The meat is often the main part of the fish used for human consumption and a major human dietary source of n-3 fatty acids of nutritional and medical interest (Ackman, 1967; Burr *et al*., 1989). Excessive dietary energy is mainly stored in the form of triacylglycerols deposited in meat adipose tissue, the main depots of fish (Kiessling *et al*., 2001).

Brooder farmed fish showed a higher concentration of fatty acids as compared to the wild category. One of the possible reasons might be that the wild fish has to spend more energy and time in search of food so contained lower amounts of saturates stored in these tissues. So in the present study, low concentrations of various MUFAs and PUFAs are probably due to efforts exerted by the fish to forage and ingest food in river water. The observed changes in the levels of different fatty acids from the three investigated tissues included in the present study indicated that disparity with starvation, under feeding as well as gross over-feeding (particularly by farmed fish), induced a selective mobilization and deposition of fatty acids in farmed *L. rohita* in different weight groups. Sheridan (1994) suggested that red meat and liver act as short term and white muscle and mesenteric fat, as long term fat storage depots in Salmon. The fact that several fatty acids, that were observed to change with body weight in these weight categories of *L. rohita,* were found to differ in both wild and farmed fish. The most noteworthy finding was a higher level of lipid deposition in liver and gonads, which increased in direct proportion with increasing weight of the fish. In this study, the PUFAs of wild and farmed fish were directly related to age and body weight. However, the body weight seems to be the dominating factor (Tables 2-4).

The statistical analysis showed considerable differences among the fatty acid profiles of wild

Table 2
Fatty acid profile (%) of Gonads from Brooder and Non-brooder fish.

Fish	Non-brooder (W)	Brooder (W)	Non-brooder (F)	Brooder (F)
		Saturated fatty acids		
C8:0	00.10 ± 0.02 a	00.02 ± 0.01 b	00.49 ± 0.01 a	02.76 ± 0.13 a
C10:0	00.02 ± 0.04 a	01.93 ± 0.01 b	01.31 ± 0.04 a	03.00 ± 0.02 b
C12:0	08.70 ± 0.01 a	02.49 ± 0.00 a	01.97 ± 0.12 b	02.07 ± 0.03 b
C14:0	10.36 ± 0.02 ab	11.41 ± 0.04 b	04.13 ± 1.04 c	07.47 ± 0.06 b
C16:0	18.06 ± 1.09 b	12.14 ± 0.31 b	17.22 ± 0.94 b	21.73 ± 0.24 c
C18:0	06.32 ± 0.04 c	11.94 ± 0.03 a	10.44 ± 0.07 c	16.42 ± 0.09 c
C20:0	08.44 ± 0.08 a	18.00 ± 0.21 a	07.47 ± 0.04 a	11.17 ± 0.03 a
Σ SFAs	52.01 ± 0.18 a	45.03 ± 0.08 a	43.03 ± 0.32 a	64.62 ± 0.10 a
		Monounsaturated fatty acids		
C16:1(n-7)	00.03 ± 0.02 a	00.01 ± 0.01 b	00.01 ± 0.00 a	01.00 ± 0.01 b
C16:1(n-9)	00.95 ± 0.04 a	00.99 ± 0.01 b	00.90 ± 0.22 a	01.63 ± 0.02 a
C18:1(n-7)	00.67 ± 0.02 b	02.41 ± 0.02 ac	03.26 ± 0.01 b	02.10 ± 0.01 a
C18:1(n-9)	02.02 ± 0.01 a	01.01 ± 0.01 c	02.81 ± 0.02 ab	02.31 ± 0.01 a
C20:1(n-9)	00.90 ± 0.03 a	00.02 ± 0.02 b	00.49 ± 0.02 b	00.03 ± 0.02 c
C22:1(n-9)	04.79 ± 0.01 a	02.35 ± 0.10 a	02.82 ± 0.23 b	00.29 ± 0.01 a
Σ MUFAs	09.36 ± 0.02 a	06.97 ± 0.02 a	10.29 ± 0.08 b	07.36 ± 0.01 a
		Polyunsaturated fatty acids		
C18:2(n-6)	00.44 ± 0.21 a	02.97 ± 0.02 a	08.73 ± 0.17 a	03.86 ± 0.03 a
C18:3(n-3)	05.48 ± 0.07 a	04.38 ± 0.01 b	04.00 ± 0.03 b	02.41 ± 0.02 b
C18:4(n-3)	02.17 ± 0.00 b	06.59 ± 0.28 b	02.02 ± 0.03 c	02.09 ± 0.03 a
C20:2(n-6)	02.46 ± 0.12 a	03.45 ± 0.01 a	03.30 ± 0.44 c	03.45 ± 0.02 a
C20:4(n-6)	06.48 ± 0.40 b	04.02 ± 0.02 a	04.07 ± 0.03 c	04.01 ± 0.01 a
C20:5(n-6)	07.42 ± 0.06 b	05.49 ± 0.01 ab	06.76 ± 0.39 a	01.31 ± 0.03 a
C20:5(n-3)	00.43 ± 0.03 a	06.42 ± 0.02 b	00.66 ± 0.01 a	00.06 ± 0.03 b
C22:4(n-6)	02.72 ± 0.10 a	04.72 ± 0.02 b	02.00 ± 0.04 a	00.42 ± 0.03 b
C22:5(n-6)	01.42 ± 0.14 a	00.86 ± 0.03 c	02.63 ± 0.02 a	01.00 ± 0.31 a
C22:5(n-3)	01.81 ± 0.07 b	02.72 ± 0.01 b	02.00 ± 0.02 b	01.90 ± 0.04 b
C22:6(n-3)	05.72 ± 0.02 c	02.75 ± 0.02 b	05.46 ± 0.09 b	04.92 ± 0.03 a
Σ PUFAs	37.55 ± 0.11 a	44.37 ± 0.04 b	42.63 ± 0.15 b	25.43 ± 0.05 a

Values with different letters in the same row are significantly different at ($p<0.05$). Non-brooder (weight: 501-800g). Brooder (weight: 1301-1600g). W = Wild. F = Farmed

and farmed *labeo rohita*. These differences are related to individual fatty acids as the weight of the fish increases with age especially considerable variations among poly-unsaturates as shown in the tables. The present findings about the fatty acid profile of L. rohita are consistent with those of Wouter *et al*., (2001) who suggests that the regular intake of fish in the diet can play an important role in the maintenance of good health because of the high concentration of arachidonic acid (C20:4n-6) and eicosahepaenoic acid (C20:5n-3) that are important for reducing cardiovascular disease.

4. CONCLUSIONS

From the present study it is concluded that wild fish contained more unsaturated fatty acids as compared to farmed fish in the gonads, meat and liver. Fish of lower weight categories (Non-brooder) contained more unsaturated fatty acids as compared to higher weight categories (Brooder) fish. The present study suggests that small sized fish are more beneficial for consumption due to the quality of their unsaturated fatty acids so it is recommended that the brooders should be left for breeding purpose.

Table 3
Fatty acid profile (%) of meat from Brooder and Non-brooder fish.

Fish	Non-brooder (W)	Brooder (W)	Non-brooder (F)	Brooder (F)
		Saturated fatty acids		
C8:0	00.08 ± 0.40 a	00.03 ± 0.01 a	00.05 ± 0.00 a	01.21 ± 0.03 a
C10:0	00.55 ± 0.04 a	00.94 ± 0.02 a	01.78 ± 0.02 a	03.09 ± 0.07 a
C12:0	01.01 ± 0.10 b	03.46 ± 0.02 a	00.21 ± 0.01 a	01.75 ± 0.07 b
C14:0	00.76 ± 0.03 b	04.19 ± 0.21 b	07.43 ± 0.07 a	12.10 ± 0.03 b
C16:0	10.03 ± 0.02 a	16.03 ± 0.09 b	13.91 ± 0.04 b	18.95 ± 2.07 b
C18:0	09.98 ± 0.07 a	14.03 ± 0.03 b	14.70 ± 0.09 b	20.04 ± 0.13 b
C20:0	01.11 ± 0.13 b	00.85 ± 0.03 b	02.17 ± 0.04 b	00.92 ± 0.01 a
Σ SFAs	23.52 ± 0.11 b	39.53 ± 0.06 a	40.25 ± 0.03 a	58.06 ± 0.34 a
		Monounsaturated fatty acids		
C16:1(n-7)	00.09 ± 0.04 a	00.02 ± 0.02 a	00.02 ± 0.02 a	01.72 ± 0.02 a
C16:1(n-9)	03.31 ± 0.10 a	01.27 ± 0.01 a	02.79 ± 0.01 a	04.95 ± 0.04 a
C18:1(n-7)	04.51 ± 0.07 b	02.89 ± 0.01 c	03.00 ± 0.06 c	01.27 ± 0.13 c
C18:1(n-9)	12.41 ± 0.08 b	12.00 ± 0.01 b	12.73 ± 0.17 b	09.03 ± 0.08 a
C20:1(n-9)	00.69 ± 0.02 b	02.74 ± 0.03 a	00.99 ± 0.06 a	00.93 ± 0.02 a
C22:1(n-9)	00.03 ± 0.01 a	00.02 ± 0.00 c	–	00.02 ± 0.02 b
Σ MUFAs	21.04 ± 0.05 b	18.94 ± 0.01 b	19.53 ± 0.05 a	17.92 ± 0.05 b
		Polyunsaturated fatty acids		
C18:2(n-6)	05.12 ± 0.04 a	03.01 ± 0.07 ab	03.20 ± 0.09 c	01.41 ± 1.03 b
C18:3(n-3)	04.45 ± 0.01 c	02.91 ± 0.03 c	03.18 ± 0.02 a	02.00 ± 0.06 a
C18:4(n-3)	03.64 ± 0.08 a	01.42 ± 0.01 b	04.48 ± 0.07 a	02.88 ± 0.03 b
C20:2(n-6)	01.47 ± 0.03 b	00.49 ± 0.02 c	03.43 ± 0.01 b	00.33 ± 0.02 a
C20:4(n-6)	14.00 ± 0.07 b	10.47 ± 0.03 a	06.87 ± 0.04 b	04.91 ± 0.01 c
C20:5(n-6)	04.95 ± 0.04 c	03.22 ± 0.06 c	05.15 ± 0.09 a	03.42 ± 0.03 b
C20:5(n-3)	01.48 ± 0.49 b	04.01 ± 0.09 b	02.74 ± 0.03 a	01.01 ± 0.02 a
C22:4(n-6)	00.99 ± 0.01 a	00.46 ± 0.01 a	00.66 ± 0.01 a	00.23 ± 0.01 c
C22:5(n-6)	02.19 ± 0.01 a	02.04 ± 0.05 a	02.76 ± 0.03 c	00.49 ± 0.03 a
C22:5(n-3)	06.39 ± 0.13 c	03.37 ± 0.07 a	02.11 ± 0.06 b	01.24 ± 0.04 b
C22:6(n-3)	09.04 ± 0.10 b	05.88 ± 0.14 b	07.24 ± 0.07 b	03.26 ± 0.17 a
Σ PUFAs	53.72 ± 0.09 b	37.28 ± 0.05 a	35.46 ± 0.04 c	21.18 ± 0.13 a

Values with different letters in the same row are significantly different at ($p<0.05$). Non-brooder (weight: 501-800g). Brooder (weight: 1301-1600g). W = Wild. F = Farmed.

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Table 4
Fatty acid profile (%) of liver from Brooder and Non-brooder fish.

Fish	Non-brooder (W)	Brooder (W)	Non-brooder (F)	Brooder (F)
		Saturated fatty acids		
C8:0	00.02 ± 0.00 a	00.41 ± 0.02 b	00.02 ± 0.01 a	00.39 ± 0.02 a
C10:0	00.34 ± 0.02 c	00.02 ± 0.02 ab	00.91 ± 0.01 a	02.03 ± 0.04 a
C12:0	00.21 ± 0.01 b	00.29 ± 0.07 a	01.85 ± 0.01 a	01.99 ± 0.01 b
C14:0	13.92 ± 0.04 c	14.07 ± 0.19 a	12.02 ± 0.09 c	16.03 ± 0.04 b
C16:0	19.12 ± 0.22 c	25.95 ± 0.12 c	24.09 ± 0.08 b	28.01 ± 3.09 a
C18:0	13.01 ± 0.13 b	19.31 ± 0.07 c	13.39 ± 0.13 a	18.04 ± 0.08 a
C20:0	02.76 ± 0.04 b	05.31 ± 0.17 b	04.27 ± 0.10 b	04.23 ± 0.07 a
Σ SFAs	49.38 ± 0.06 b	65.09 ± 0.09 b	56.55 ± 0.06 b	70.72 ± 0.47 a
		Monounsaturated fatty acids		
C16:1(n-7)	04.59 ± 0.03 b	02.03 ± 0.03 ab	02.38 ± 0.07 a	00.83 ± 0.03 c
C16:1(n-9)	00.10 ± 0.02 b	00.31 ± 0.02 a	01.63 ± 0.07 b	–
C18:1(n-7)	03.92 ± 0.03 ab	01.12 ± 0.12 c	00.94 ± 0.03 b	00.48 ± 0.40 b
C18:1(n-9)	06.81 ± 0.12 a	04.80 ± 0.12 a	04.47 ± 0.13 b	00.73 ± 0.04 b
C20:1(n-9)	00.02 ± 0.02 a	00.94 ± 0.03 b	00.39 ± 0.12 a	00.09 ± 0.02 b
C22:1(n-9)	01.20 ± 0.05 c	00.54 ± 0.00 a	01.95 ± 0.01 a	00.72 ± 0.01 b
Σ MUFAs	16.64 ± 0.04 a	08.94 ± 0.05 a	11.76 ± 0.07 a	02.85 ± 0.08 a
		Polyunsaturated fatty acids		
C18:2(n-6)	00.00 ± 0.00	05.43 ± 0.09 a	00.42 ± 0.02 a	02.56 ± 0.14 ab
C18:3(n-3)	00.91 ± 0.33b a	00.33 ± 0.03 a	06.97 ± 0.08 b	03.02 ± 0.09 c
C18:4(n-3)	01.24 ± 0.03 a	02.74 ± 0.02 b	01.42 ± 0.01 b	01.00 ± 0.03 a
C20:2(n-6)	07.12 ± 1.24 b	03.83 ± 0.14 a	03.83 ± 0.01 c	05.07 ± 0.05 a
C20:4(n-6)	05.12 ± 0.03 c	06.24 ± 0.17 c	04.48 ± 0.01 a	03.84 ± 0.07 c
C20:5(n-6)	00.59 ± 0.03 a	00.31 ± 0.02 a	02.44 ± 0.02 a	00.32 ± 0.01 c
C20:5(n-3)	00.37 ± 0.06 a	00.04 ± 0.01 a	00.02 ± 0.01 ab	00.02 ± 0.01 c
C22:4(n-6)	06.32 ± 0.03 b	02.02 ± 0.02 b	02.88 ± 0.01 a	01.49 ± 0.02 b
C22:5(n-6)	00.03 ± 0.02 a	00.26 ± 0.01 a	00.99 ± 0.01 a	00.43 ± 0.03 a
C22:5(n-3)	00.97 ± 0.03 a	00.32 ± 0.05 b	04.39 ± 0.02 a	02.03 ± 0.04 a
C22:6(n-3)	06.09 ± 0.08 a	02.92 ± 0.07 a	02.91 ± 0.09 c	04.82 ± 0.02 a
Σ PUFAs	28.76 ± 0.17 a	24.44 ± 0.06 b	30.75 ± 0.02 a	24.60 ± 0.04 b

Values with different letters in the same row are significantly different at ($p<0.05$). Non-brooder (weight: 501-800g). Brooder (weight: 1301-1600g). W = Wild. F = Farmed.

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