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Utility value and meat quality of rainbow trouts (*Oncorhynchus mykiss* Walb.) from extensive and intensive farming

Piotr Skałecki, Agnieszka Staszowska, Agnieszka Kaliniak, Mariusz Florek

University of Life Sciences in Lublin
Department of Commodity Science and Processing of Raw Animal Materials
ul. Akademicka 13, 20-950 Lublin; e-mail: skalka_p@op.pl

The aim of this study was to compare the utility value and intrinsic properties of meat of rainbow trout from intensive and extensive farming. Material consisted of 40 rainbow trouts caught in the selected fish farm in the Lublin region. Fish were harvested from intensive farming (concrete ponds, n=20) and from extensive farming (natural ponds, n=20). Despite significant differences in the weight, length and height of body, fish from an extensive farming (mean weight 342.7 g) and an intensive farming (mean weight 516.2 g), had a similar content of the fillet (43.1% and 44.5%, respectively). Meat of fish from the intensive farming contained significantly more fat (about 2.26 p.p.) and calories (about 64.4 kJ·100 g^{-1}), and its colour was brighter (higher L*) and significantly less intense (lower redness, yellowness, lower saturation and hue) compared with the meat of fish from an extensive farming.

KEY WORDS: rainbow trout / farming system / utility value/ chemical composition / meat colour

Fish are these food products, which are considered to be most preferred and highly recommended by dietitians thanks to their contents of essential unsaturated fatty acids (including omega-3 and omega-6), quality protein and minerals [2, 25]. Next to marine fish, Poles increasingly often choose domestic freshwater species, replacing imported panga (pangasius) and tilapia. In 2012 fish consumption in Poland amounted to 11.8 kg live weight per capita. The most commonly eaten freshwater fish species include carp and rainbow trout, which shares in the total fish consumption amount to over 3.8% and 3.6%, respectively [14].

The rainbow trout is one of the most popular fish species farmed in Poland. The share of this species in the total volume of freshwater fish production amounts to over 28%. In 2012 production of this fish species was over 14.6 thousand ton [16]. Quality of fish meat, carcass yield and chemical composition are determined, among other things, by environmental conditions, physiological status, sex, age as well as fishing season [6, 20].

The aim of this study was to compare the utility value and physico-chemical parameters of meat from rainbow trout from the Lubelskie Province, farmed in the extensive and intensive systems.

Material and methods

The experimental material comprised a total of 40 females of rainbow trout (*Oncorhynchus mykiss* Walb.), aged over 1 year (1+), caught in the winter season (February/March) of 2013 at a selected fish farm in the Lublin region. The fish were kept in concrete tanks – the intensive farming system (n=20) and earthen ponds – the extensive farming system (n=20).

Trout in the intensive farming system were fed high energy (total energy 24.3 MJ, digestible energy 20.1 MJ) commercial feed (pellet size 4.5 mm) containing 43% protein, 29% fat, 15% carbohydrates, 7% ash and 1% fibre. Fish from the extensive farming system (kept in earthen ponds) were fed solely on natural food and they were not provided with supplementary feeds.

After being caught the fish were stunned mechanically and next killed by spiking. After being transported to the laboratory of the Department of Commodity Science and Processing of Raw Animal Materials, the University of Life Sciences in Lublin and subjected to biometric measurements to determine body weight (g), total length (cm) and body length (cm) using a ruler, while lateral length and head height, the greatest and smallest body height and body height were measured using a metric Vernier caliper (cm). Based on the total length and body weight of animals their values of Fulton's condition index were calculated [1].

After preliminary processing (scaling, gutting, beheading and fin removal) the weight (g) of individual body parts was recorded in order to determine their percentage shares in the body weight of the fish. Next physico-chemical quality of meat was evaluated. Physico-chemical analyses included measurements of pH using a CP-401 waterproof pH-meter immediately after slaughter and after 1, 24 and 48 h (pH 0, 1, 24 and 48, respectively). Meat colour in the dorsal part of the body was determined instrumentally after 30-minute oxygen exposure using a Minolta CR-310 chromameter in the CIE L*a*b* system [5], analysing lightness L*, the share of the red colour a*, the share of the yellow colour b*, saturation C* and hue h°.

The basic chemical composition was determined using conventional methods on samples of the large lateral muscle from its dorsal part. Water content was determined by gravimetry (103°C) according to PN-ISO 1442:2000; ash content by incineration in a muffle furnace (550°C) according to PN-ISO 936:2000; crude ash according to Kjeldahl using a Büchi B-324 apparatus following the PN-75/A-04018 standard; free fat according to Soxhlet (using n-hexane as a solvent) with a Büchi B-811 apparatus according to PN-ISO 1444:2000. The energy value of meat was determined based on contents of protein and fat, taking into consideration respective energy equivalents for fish.

Statistical analysis was performed using a one-way analysis of variance with the STATISTICA ver. 6.0 programme [21], providing in the tables mean values (x) and standard deviation (SD). Significance of differences ($P \leq 0.05$ and $P \leq 0.01$) was determined by Tukey's test.

Results and discussion

Rainbow trout kept in the intensive farming system were characterised by a significantly (P≤0.05) greater body weight, greater total length, body length and the greatest body height in comparison to fish coming from earthen ponds (Table 1).

The average body weight of trout coming from the intensive farming system ranged from 480 to 610 g, which is consistent with the values reported for that species by Łuczyńska et al. [10]. In turn, in the case of trout kept in the extensive farming system the body weight was much lower, which was most probably caused by the type and availability of food. No significant differences were found in terms of the other morphometric parameters such as the lateral length of the head, head height, the smallest body height and body width.

The total length of rainbow trout farmed in the intensive system recorded in this study was comparable to that reported by Tasaduq et al. [22] for female trout from fish farms, i.e. 37.08 cm, while it was slightly higher than the value recorded by Skałecki et al. [18] at 34.67 cm.

According to Kimmerer et al. [7], the dependence between total length and body weight of fish may vary considerably within a species, particularly when analysing data from different regions, nutrition systems or fishing seasons. The condition index for fish exhibiting good condition assumes the value above 1, while for those being in a deteriorated condition it is below 1 [23]. In the case of compared fish no significant differences were found in their condition, although fish from the intensive production system received higher values of this parameter, ranging from 0.96 to 1.44, reported by Tasaduq et al. [22] for farmed trout. The average condition index for trout coming from earthen ponds turned out to be lower (0.91) and did not fall within the above-mentioned range.

When analysing the percentage shares of individual body parts in the body weight of fish significantly higher (P≤0.05) shares of the head and skin were recorded in the case of trout kept in the extensive production system (by 1.25 and 3.1 percentage points, respectively), at the simultaneously significantly lower (P≤0.05) share of the gut (by 3.63 percentage points; Table 1), which may have been caused by the differing environmental conditions of the fish (living conditions and the food base).

The shares of the fillet, fins and the skeleton were comparable. In an earlier study by the authors [19] no effect of body weight in rainbow trout (merchantable grade) was observed on the share of meat. In contrast, a higher meat yield (49.16%) in rainbow trout with body weight exceeding 300 g was reported by Litwińczuk et al. [9].

Post-slaughter changes in meat pH depend on many factors, including e.g. fishing method and fish handling or the species [13]. When analysing measured pH of muscle tissue in trout, irrespective of the adopted farming method, a generally downward trend was observed for the values of this parameter in the investigated 48-h period, decreasing from the average level of 7.25 to 6.68 (Fig.). A significant (P≤0.01) difference was only shown for the measurement taken after 1 h after slaughter, i.e. higher pH (by 0.3 units) was found in trout caught from intensive farming systems in comparison to animals kept in extensive farming conditions. A similar difference (although non-significant) was also

Table 1
Morphometric measurements and the percentage of selected body parts of rainbow trouts depending on farming system

Specification	Farming system			
	extensive		intensive	
	x	SD	x	SD
Body weight (g)	342.73[a]	74.30	516.21[b]	100.71
Total length (cm)	33.38[a]	2.72	37.38[b]	1.89
Body length (cm)	27.88[a]	2.02	31.50[b]	2.04
Side length of the head (cm)	6.35	0.40	6.83	0.35
Height of the head (cm)	3.95	0.34	4.30	0.52
The largest height of body (cm)	6.88[a]	0.33	7.78[b]	0.54
The smallest height of body (cm)	2.83	0.17	3.03	0.22
Width of the body (cm)	3.30	0.28	3.78	0.38
Fulton coefficient	0.91	0.02	0.98	0.1
Fillet (%)	43.08	1.12	44.52	3.78
Head (%)	16.68[b]	0.78	15.43[a]	0.24
Guts (%)	9.21[a]	1.08	12.91[b]	2.53
Fins (%)	3,74	0.76	3.23	0.50
Bones (%)	10.92	1.54	12.15	1.81
Skin (%)	11.73[b]	1.71	8.63[a]	1.66

x – mean; SD – standard deviation
Means with different letters: a, b differ significantly at $P \leq 0.05$; A, B differ significantly at $P \leq 0.01$

recorded after 48 h. Bugeon et al. [4] in farmed trout at 48 h after slaughter reported lower pH values (approx. 6.4) in comparison to the results given in the presented study.

In the opinion of Marx et al. [12], the boundary value of pH_{24} for fresh fish meat is 6.5. Summing up, it may be stated that the tested meat of fish coming from both intensive and extensive farming systems, showed an appropriate course for the changes occurring post mortem.

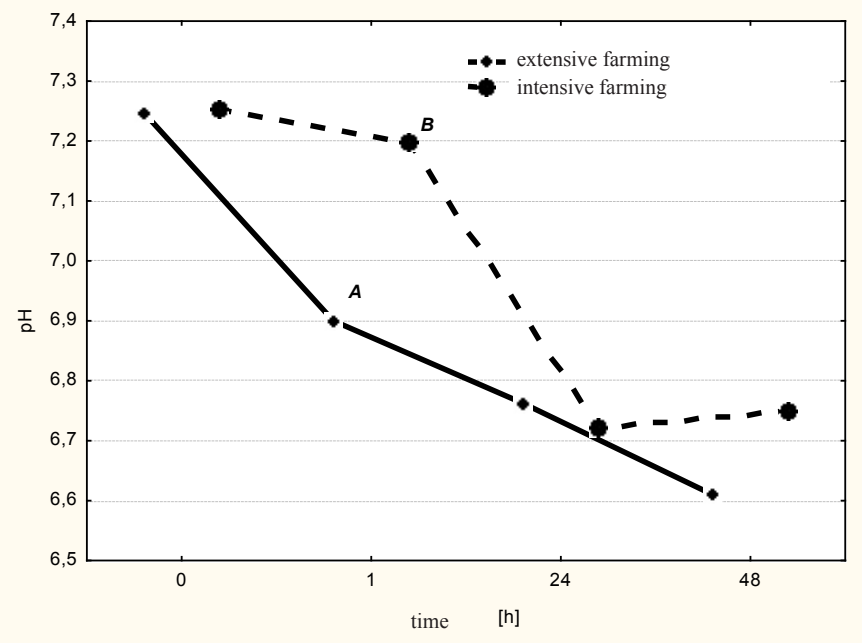

Fig. Meat pH value of rainbow trout depending on farming system and *post mortem* time (hours); A, B – P≤0.01

Significant differences in colour parameters were found for muscle tissue of rainbow trout depending on the management system (Table 2). Significantly higher values of all parameters (except for lightness L*) were observed in the case of muscles of trout coming from the extensive farming system in comparison to fish kept in the intensive system. Bugeon et al. [4] in the case of fillets from farmed trout showed a comparable share of the red colour (13.3≤a*≤13.8), lower lightness (43.5≤ L*≤46.1) and a higher share of the yellow colour (18.1≤ b*≤18.3) in comparison to the presented study.

A greater lightness (although non-significantly) was observed in the case of meat from trout from the intensive farming system, which may be connected with the significantly higher (P≤0.05) fat content (Table 3). The relationship of meat lightness L* with fat content was earlier confirmed also by other authors [4, 11].

When analysing the chemical composition of meat from the examined fish a significantly (P≤0.05) higher protein content and a simultaneous lower fat content were recorded in the muscle tissue of trout kept in the extensive farming conditions (Table 3).

Contents of ash and water did not differ significantly depending on the fish farming system, although a lower share of water was recorded in the meat of trout farmed in con-

Table 2
Flesh colour (CIE L*a*b*) of rainbow trout depending on farming system

Specification	Farming system			
	extensive		intensive	
	x	SD	x	SD
L*	51.13	3.02	52.16	1.35
a*	20.08^{b}	3.45	14.97^{a}	1.50
b*	10.34^{B}	2.77	1.35^{A}	1.18
C*	22.61^{B}	4.21	15.05^{A}	1.61
h°	26.90^{B}	3.73	4.80^{A}	3.80

x – mean; SD – standard deviation
Means with different letters: a, b differ significantly at P≤0.05; A, B differ significantly at P≤0.01

crete tanks, which indicates its negative dependence on fat content [17]. Fat concentration in muscle varies and depends not only on the species, but also on age, sex, environmental conditions and type of consumed food [15]. In turn, Tkaczewska and Migdał [24] reported fat content in meat of rainbow trout from various Polish fish farms to range from 3.63 to 7.40%, i.e. similarly to the results of this study.

Table 3
Chemical composition (%) and calorific value (kJ·100 g^{-1}) of meat of rainbow trout depending on farming system

Specification	Farming system			
	extensive		intensive	
	x	SD	x	SD
Water (%)	75.11	1.44	73.94	1.32
Ash (%)	1.21	0.11	1.29	0.14
Fat (%)	3.13^{a}	0.86	5.39^{b}	1.03
Protein (%)	20.34^{b}	0.65	19.23^{a}	0.15
Gross energy (kJ·100 g^{-1})	603.66	33.16	667.23	44.07
Net energy (kJ·100g^{-1})	442.86^{a}	31.07	510.29^{b}	41.00

x – mean; SD – standard deviation
Means with different letters a, b differ significantly at P≤0.05; A, B differ significantly at P≤0.01

The energy value of fish meat is determined by the contents of basic chemical components, particularly fat [3]. Analyses of energy value for meat of investigated trout significant differences were found ($P \leq 0.05$) for net energy, which was higher (by 67.43 kJ) in fish coming from the intensive farming system. According to Kołakowska and Kołakowski [8], energy value of an average fish serving (100 g) ranges from less than 400 to approx. 1225 kJ.

Summing up it may be stated that the farming system adopted for rainbow trout had a significant effect on fish size. Fish from the intensive farming system in comparison to those from the extensive farming system were heavier, longer and higher, although no significant difference in the share of the edible parts (fillet) was recorded. Meat of trout from the intensive farming system contained significantly more fat and energy; moreover, its colour was lighter and less saturated in comparison to meat of fish kept in the extensive system.

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