THE QUALITY OF RAINBOW TROUT (*ONCORHYNCHUS MYKISS*) CULTURED IN VARIOUS POLISH REGIONS*

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Abstract
There is a lack of regulations regarding labeling of the place of cultivation of freshwater fish, even though some research indicates that environmental factors can influence the quality of rainbow trout meat. The purpose of this study was to assess the necessity of such regulations and to determine the meat quality of rainbow trout cultivated in different regions of Poland. The analysis of color measurement, fatty acid profile, sensory evaluation and microbiological analysis of trout muscle were performed to assess the influence of cultivation region on the quality of trout meat. The place of cultivation did not influence the redness (a*) and yellowness (b*) of fillet, but had impact on lightness (L*). The microbiological analysis showed no pathogenic microorganisms on the fish surface. The fatty acids composition differed highly significantly (P<0.01) depending on the place of cultivation. Since there are significant differences in quality and nutritional value between studied samples, the necessity of labeling the place of cultivation of rainbow trout for the final consumer should be implemented.

Key words: rainbow trout, quality, microbiological analysis, fatty acid profile, color

According to Commission Implementing Regulation no. 404/2011 products from freshwater fisheries and aquaculture do not have to be traceable at all stages of production. processing and distribution.

Oncorhynchus mykiss (Walbaum, 1792), commonly known as rainbow trout, inhabits cold headwaters, creeks, rivers and lakes. It is widely used in aquaculture in many countries because of its rapid growth and high market value due to its flesh quality (Sarma et al., 2013). Rainbow trout, one of the most important aquacultured freshwater fish species, is commonly consumed in most European countries including Poland (Ehsani et al., 2013).

In the last few decades, the production of rainbow trout in Poland has increased dynamically from 500 tons in the 1970s to 17 000 tons in recent years (Ciereszko and Ocalewicz, 2007; Pieńkowska and Hryszko, 2013). During the last thirty years Po-

land has shifted from primitive pond cultures to modern trout production technology, with one of the highest productions in Europe (Bontemps, 2009). Moreover, rainbow trouts are among the most popular freshwater fish consumed in Poland, accounting for 3.6% of total fish consumption (Pieńkowska and Hryszko, 2013).

The consumer's acceptance of fish and fishery products depends on several attributes of food quality. The most important indicators of flesh quality with respect to consumer's acceptance are microbial load and safety, sensory parameters, mainly flavour. texture and color and nutritional factors such as the amount of omega-3 fatty acids and overall fat content (Alam et al., 2012).

From the variety of factors which can influence the quality of cultivated fish, environmental conditions and microclimate factors, such as water temperature or the amount of sunny days and days with snow cover, are one of the most important (Shearer, 1994).

The purpose of this work was to establish if the differences in climate conditions of different Polish regions affect the quality of cultivated rainbow trout meat. This would allow determining the need of establishing new legal regulations which would make it necessary to label the place of cultivation of freshwater fish available on the market for the final consumer.

Material and methods

Material

Ten rainbow trouts (*Oncorhynchus mykiss*) from each of 4 different cultures (40 trouts in total) were purchased weekly, directly from the producer. The methods used during cultivation and the location of cultures are shown in Figure 1 and Table 1. Fatty acid composition of fish feed is shown in Table 2. Fish weight variations are shown in Table 3.
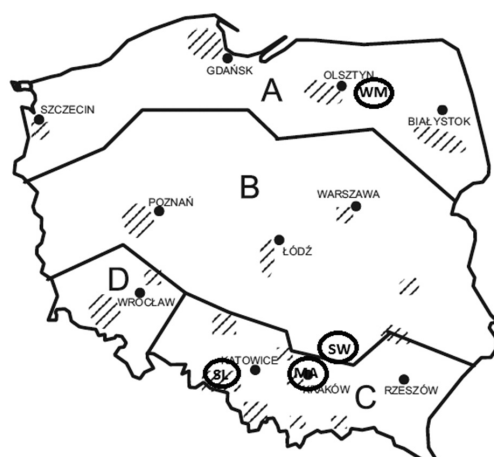

Figure 1. Climate regions of Poland with sample collection locations (Climate regions in Poland A – Temperate-warm and dry; B – warm, temperate-humid and dry; C – warm and humid; D – warm, humid and radon prone Sudety area (Kozak et al., 2011))

Table 1. Description of cultivation place and method in the studied cultures

Culture	Geographic location	Cultivation method	Composition of the diets	Microclimate conditions
WM	warmińsko-mazurskie	high intensity concrete tank recirculated water system	extruded feed produced by "X" feed composition: protein 45–55% fat 20–27% carbohydrates 15–18% ash 7%	average yearly temperature: +7.5°C, snow cover: 70–100 days/year
SW	świętokrzyskie	high intensity concrete tank flow through water system	extruded feed produced by "Y" feed composition: protein 41–47% fat 22–31% carbohydrates 15–16% ash 5.6–6.2%	average yearly temperature: +7.5°C, snow cover: 80–100 days/year
MA	małopolskie	high intensity concrete tank through water system	extruded feed produced by "X" feed composition: protein 45–55% fat 20–27% carbohydrates 15–18% ash 7%	average yearly temperature: +8°C, snow cover: 68 days/year
SL	śląskie	high intensity concrete tank flow through water system	extruded feed produced by "X" feed composition: protein 45–55% fat 20–27% carbohydrates 15–18% ash 7%	average yearly temperature: +8.5°C, snow cover: 60–75 days/year

Table 2. Fatty acid composition of feed (% of fatty acids)

Fatty acid	Feed produced by "X"	Feed produced by "Y"
C14:0	4.89	5.08
C14:1	0.39	0.27
C16:0	18.63	18.74
C16:1	5.11	5.13
C17:0	1.03	1.07
C18:0	3.36	3.56
C18:1	20.59	21.12
C18:2 *n-6*	11.27	10.74
C18:3 *n-3*	2.75	2.95
C18:4 *n-3*	2.02	1.98
C20:1	5.64	5.94
C20:2	0.68	0.50
C20:3	0.32	0.12
C20:4 *n-6*	0.51	0.78
C20:5 *n-3*	8.82	8.84
C22:1	4.26	5.20
C22:5 *n-6*	0.84	0.91
C22:6 *n-3*	7.84	7.00
Other	1.05	0.07

Table 3. Fish weight variation depending on the place of cultivation (g)

Culture	Average weight	SD	Max	Min
WM	506	47	533	428
SW	643	122	784	379
MA	495	117	719	222
SL	336	37	414	302

SD, max, min – standard deviation, maximum, minimum.

Directly after purchase fish were slaughtered by the blow in the head and transported in ice to laboratories belonging to the Faculty of Food Technology of the University of Agriculture in Cracow, Poland. Afterwards fish were gutted, filleted and stored at 4ºC in the refrigerator. The analyses were performed during 24 hours after catch.

Color measurement

Fish fillets were wrapped in aluminum foil and baked at 180ºC until the temperature in thermal center reached 77ºC. The color measurement was performed using Minolta CR-200b reflection chromameter (Osaka, Japan) on the surface of the fillet in three areas: front (near the head), middle and rear (near caudal fin). The results for each fish sample were calculated as a mean from all three measurements. Before each measurement the chromameter was calibrated on the standard white plate. All results were expressed using CIE L*a*b* system according to Clydesdale (1976).

Fatty acid composition

Analysis was performed on epaxial part of the skinned fillet. The muscle was separated from the bones and ground on the grinder.

Samples were extracted with chloroform-methanol (2:1, v/v) according to the method of Folch (Folch et al., 1957). Then 1 g of meat samples was mixed with 15 mL chloroform–methanol mixture and homogenized for 10 min at 5000 rpm, and after 5 min pause – 5 min at 1000 rpm using homogenizer MPW-120 (Mechanika Precyzyjna, Warsaw, Poland). The mixture was then filtered through filter paper to the regular cylinder and completed with extraction mixture up to 15 mL. Next, 3 mL of 0.74% KCl solution was added to 15 mL of filtrate. The alcohol–water phase was removed, and the chloroform phase was washed 3 times using 2 mL solution of chloroform:methanol:0.74% KCl (3:48:47, v/v/v). Subsequently the chloroform phase was recovered, dehydrated with anhydrous sodium sulphate (Na_2SO_4) and dried using nitrogen at 45ºC. To the sample (about 10 mg) were added 0.5 ml 0.5 N KOH in methanol and heated at 85ºC. Next 1 ml, 12 % BF_3 in methanol were added to the sample and again heated at 85ºC. After cooling in room temperature 1 ml hexane and 5 ml saturated solution of NaCl were added. Fatty acid methyl esters in 1 µl samples at the split ratio of 10:1 were separated by gas chromatography on a TRACE GC ULTRA gas chromatograph, equipped with 30 m capillary column SUPELCOWAX 10 of 0.25 mm inner diameter and coating thickness of 0.25 µm (30 m × 0.25 mm × 0.25 um). Operating conditions were as follows: helium was used as a carrier gas, flow 1 ml/min, split flow 10 ml/min, injection port temperature 220ºC, detector temperature 250ºC, initial column temperature 160ºC.

The quality of acquired fatty acids composition was established using peroxidizability index (PI) (Arakawa and Sagai, 1986), atherogenicity index (AI) and thrombogenictiy index (TI) (Ulbricht and Southgate, 1991).

Microbiological analysis

The microbiological analysis was performed on mucus from the surface of studied fish. Swabs from 6.25 m^2 surface of fish skin were transported in tubes containing AMIES medium with carbon (BioCorp, Warsaw, Poland). Tubes were closed in icebox filled with ice bags and transported to microbiological laboratories located in the Faculty of Food Technology of the University of Agriculture in Cracow. Each swab was mixed with 100 ml of Peptone water solution and then shaken for 3 min. Further decimal dilutions were made up to 10^{-6} and then 0.1 ml of each dilution was pipetted onto the surface of agar plates in triplicate.

All microbiological analyses were performed in compliance with European standards. The preliminary suspension and dilutions were performed according to EN ISO 6887-3:2003. The total viable count (TVC) was performed using the Plate Count Agar (BioCorp PS37, Warsaw, Poland) according to EN ISO 4833-2:2013. Plates were incubated at 30ºC for 72 hours.

Pseudomonas sp. count was determined using Cetrimide agar (BioCorp PS49) according to EN ISO 13720:2010 and oxidase detection test for confirmation (OxiTest, BioCorp 10003324) *Escherichia coli* count was determined using TBX agar (BioCorp PS135) according to EN ISO 16654:2001. The coagulase-positive staphylococci were determined in compliance with EN ISO 6888-1:1999/A1:2003 using Baird-Parker agar (BioCorp PS33) with addition of chicken egg yolk emulsion and sodium tellurite (BioCorp SL 0036). All plates were incubated at 37ºC for 24 hours.

Sensory analysis

Forty respondents aged 20–30 years old took part in the sensory analysis. 66% of respondents liked fish and 45% consumed it several times a month. 57% of respondents take into consideration the place of cultivation when purchasing fish products.

Sensory analysis was performed on fish steaks frozen immediately after catch and pretreatment, all coming from the same batch of fish. Twenty-four hours before the analysis steaks were thawed at 4ºC, wrapped in aluminum foil and baked at 180ºC without any spices, until the temperature in the thermal center reached 77ºC. Afterwards the steaks were cooled down to the temperature below 55ºC and distributed for sensory analysis. Respondents marked the color, odour, taste, juiciness and overall acceptability parameters on a hedonic differential scale of "relative-to-ideal" type, on the scale from 1 to 10 where 5 meant "ideal". In the case of overall acceptability parameter, respondents used a 10 point scale where 1 meant "dislike very much" and 10 meant "like very much".

Statistical analysis

Statistical analysis was performed using Statistica software (StatSoft, Tulsa, USA). Shapiro-Wilk test and Brown-Forsythe test were used to determine the normality of results and the equality of variances. The significance of differences was established using one way ANOVA with Tukey post hoc test. Differences between results with non-normal distribution were determined using Kruskal-Wallis nonparametric test with Dunn multiple comparison test. For sensory analysis the significance of difference was determined using nonparametric Friedman's test. Differences were significant for $P<0.05$ and highly significant for $P<0.01$.

Results

Color

Color parameters of rainbow trout meat from different Polish cultures are shown in Table 4.

Table 4. Color parameters of trout meat from different Polish cultures

Culture	L*		a*		b*	
	$\overline{x}$	SD	$\overline{x}$	SD	$\overline{x}$	SD
WM	67.23 b	2.84	0.93 A	0.96	18.79 A	2.87
SW	72.00 a	0.71	1.49 A	0.73	23.56 A	4.70
MA	70.26 a	1.94	1.83 A	0.56	20.84 A	2.57
SL	69.83 ab	1.84	1.74 A	0.73	19.59 A	2.73

Results presented as means with standard deviation (SD).
Results with different letters differ significantly (A, B – P<0.05) or highly significantly (a, b – P<0.01).

Highly significant differences were observed in lightness (L*) of rainbow trout muscle between studied cultures. The highest levels of L* were observed in muscle of trouts from SW and MA cultures, while significantly lower levels of lightness

were found in the muscle of trouts from WM culture. Results obtained in this study show no significant differences in a* and b* of rainbow trout muscle.

Fatty acid composition
The analysis showed highly significant influence of place and method of cultivation on fatty acid composition of trout meat (Table 5).

Table 5. Fatty acid composition of trout meat from different Polish cultures and quality indicators of fat (% of fatty acids)

Fatty acid	WM	SW	MA	SL
C10:0	0.01 b	0.006 a	0.005 a	0.006 a
C12:0	0.05 a	0.05 a	0.07 b	0.05 a
C14:0	4.08 b	3.51 a	5.64 c	3.50 a
C15:0	0.36 b	0.25 a	0.27 a	0.25 a
C16:0	16.30 b	12.92 a	16.37 b	13.00 a
C17:0	0.21 a	0.17 a	1.28 b	0.18 a
C18:0	2.68 a	2.61 a	2.97 b	2.63 a
C20:0	0.23a	0.28 a	1.27 b	0.29 a
C14:1	0.05 b	0.02 a	0.07 c	0.02 a
C16:1*n-9*	0.40 b	0.33 a	0.48 c	0.33 a
C16:1*n-7*	6.71 b	4.74 a	7.89 c	4.75 a
C17:1	0.26 b	0.53 a	1.36 c	0.52 a
C18:1*n-9*	23.31 c	27.60 a	17.06 b	27.35 a
C18:1*n-7*	3.31 a	3.33 a	3.28 a	3.38 a
C 20:1*n-9*	3.53 c	0.18 a	1.54 b	0.18 a
C22:1	0.42 b	0.26 a	0.71 c	0.27 a
C18:2*n-6*	7.59 c	11.31a	5.13 b	11.31a
C18:3*n-6*	0.15 b	0.24 a	0.21 c	0.24 a
C18:3*n-3*	2.21 b	9.78 a	2.74 c	9.65 a
C18:4*n-3*	1.40 a	1.60 bc	1.78 c	1.58 ab
C20:2*n-6*	0.45 c	1.79 a	0.26 b	1.71 a
C20:3*n-6*	0.20 a	0.48 b	0.22 a	0.49 b
C20:4*n-6*	0.53 c	0.77 a	0.48 b	0.80 a
C20:5*n-3*	5.10 b	5.67 a	10.09 c	5.68 a
C22:4*n-6*	0.10 c	0.06 a	0.00 b	0.06 a
C22:5*n-3*	1.85 c	1.49 a	3.60 c	1.49 a
C22:6*n-3*	14.34 c	8.22 a	11.01 b	8.34 a
SFA	23.94 b	19.82 a	27.90 c	19.92 a
MUFA	37.58 c	36.76 a	31.71 b	36.56 a
PUFA	34.40 b	41.72 a	36.27 c	41.67 a
PUFA*n-3*	24.92 b	26.78 a	29.23 c	26.76 a
PUFA*n-6*	8.60 c	12.88 a	6.05 b	12.92 a
n-6/n-3	0.34 b	0.48 a	0.20 c	0.48 a
UFA/SFA	3.01 c	3.96 a	2.44 b	3.93 a
PUFA/SFA	1.44 b	2.11 a	1.30 b	2.10 a
PUFA/MUFA	0.92 b	1.14 a	1.14 a	1.14 a
PI	178.85 b	153.66 a	191.92 c	154.37 a
AI	0.46 b	0.35 a	0.58 c	0.36 a
TI	0.23 a	0.18 b	0.22 a	0.18 b
Fat content (%)	4.93 ab	7.40 c	5.51 a	3.63 b

a, b, c – means marked with different letters differ highly significantly (P<0.01).

Oleic acid (C18:1*n-9*) was the predominant fatty acid in the muscle of rainbow trouts. Among saturated fatty acids (SFA), the most abundant fatty acids were palmitic acid (C16:0), myristic acid (C14:0) and stearic acid (C18:0). Among monounsaturated fatty acids (MUFA), oleic acid (C18:1*n-9*), palmitoleic acids (C16:1*n-7*) and vaccenic acid (C18:1*n-7*) were the predominant fatty acids. Linoleic acid (C18:2*n-6*) and docosahexaenoic acid (DHA) (C22:6*n-3*) were the dominant polyunsaturated fatty acids (PUFA). Similar results were reported by Ehsani and Jasour et al. (2013) and Zakipour Rahimabadi et al. (2012). Despite the fact that the fish were fed in a similar way. and the FA profile of their feed was closely related (Table 2), the fatty acid composition of their muscle differed.

According to Wood et al. (2004), the recommended PUFA/SFA ratio in human diet should exceed 0.40. Although the most favorable fatty acids ratio was found in trouts from SW culture, fish lipids from all studied cultures show high ratios of unsaturated fatty acids (UFA)/SFA and PUFA/SFA.

n-3 fatty acids are one of the most important ingredients of fish meat. The content of eicosapentaenoic acid (EPA), docosapentaenoic acid (DPA) and DHA in the muscle of rainbow trouts from different cultures differed highly significantly. The highest levels of EPA and DPA were observed in the muscle of trouts from MA culture, while the richest in DHA were muscles of trouts from WM culture. Meat of trouts from Świętokrzyskie and Śląskie regions showed the lowest levels of DPA and DHA.

The AI of trout lipids varied from 0.35 in SW culture to 0.58 in MA culture. The highest TI was observed in trouts from WM culture.

Microbiological analysis

The results of microbiological analysis on the body surface of rainbow trout are shown in Table 6.

Table 6. Microbiological contamination of trout body surface

Culture	Number of aerobic bacteria log10 cfu/cm^2		Coagulase-negative staphylococci		*Pseudomonas* sp. log10 cfu/cm^2		*Escherichia coli* log10 cfu/cm^2	
	$\overline{x}$	SD	$\overline{x}$	SD	$\overline{x}$	SD	$\overline{x}$	SD
WM	7.44 d	0.14	6.15 c	0.29	Number of bacteria lower than 10 cfu/cm^2 on skin surface of fish		Number of bacteria lower than 10 cfu/cm^2 on skin surface of fish	
SW	5.43 b	0.27	4.80 b	0.31				
MA	4.22 a	0.39	3.56 a	0.36				
SL	6.41 c	0.15	3.82 a	0.09	4.88	0.18		

$\overline{x}$ – average; SD – standard deviation.
a, b, c, d – means marked with different letters differ highly significantly (P<0.01).

The TVC on the skin surface of rainbow trouts differed highly significantly and varied from 4.20 log cfu/cm^2 in MA culture to 7.40 log cfu/cm^2 in WM culture. No coagulase-positive staphylococci were observed on the body surface of studied rainbow trouts. In fish from WM, SW, and MA culture, rods of *Pseudomonas* sp. were found below the level of 10 log cfu/cm^2. Those bacteria were found only on the

surface of fish from the water ponds in SL culture. The *E. coli* count in all analyzed samples was below 10 log cfu/cm^2.

Sensory analysis

The sensory analysis of rainbow trout meat did not show any significant differences in odor, taste, juiciness and overall acceptability between fish from different studied cultures (Table 7).

Table 7. Results of sensory analysis of trout meat obtained from different Polish cultures (number of points)

Culture	Color		Odor		Taste		Juiciness		Overall acceptability	
	X_{avg}	SD	X_{avg}	SD	X_{avg}	SD	X_{avg}	SD	X_{avg}	SD
WM	4.70 a	0.80	4.73 a	1.27	5.77 a	1.76	6.35 a	1.89	4.06 a	2.12
SW	4.60 a	1.60	4.81 a	1.64	5.27 a	1.89	5.95 a	1.81	4.95 a	2.20
MA	5.56 b	1.30	4.69 a	1.75	5.93a	2.2	5.56 a	1.80	4.18 a	2.14
SL	5.58 b	1.20	4.30 a	1.67	4.94 a	2.40	3.78 a	153	4.12 a	1.86

a, b – means marked with different letters differ highly significantly (P<0.01).

Highly significant differences were observed in color parameter of trout meat. The highest marks for color were given by the respondents to trouts from SL culture (5.59 points), which indicates that the sample was too bright. while the lowest value was given to fish from SW culture (4.60 points), which indicates that the sample was too dark.

Discussion

The place and method of cultivation affects the quality of fish meat. Bauer and Schlott (2009) concluded that the geographical location of carp (*Cyprinus carpio*) culture influences the fish composition and quality of their meat. Similar results were acquired by Varga et al. (2013) who studied carp from different cultures located in different regions of Hungary.

Color

The color parameters of predatory fish can differ depending on the place of dwelling. González et al. (2006) and Jankowska et al. (2006) observed that redness (a*) and yellowness (b*) of perch muscle differs when fish lives in natural environment or when it is fed with commercial feeds. Similar results were obtained by Bjørnevik et al. (2003) for cod. Fish living in natural habitats show higher activity in order to acquire food, which can affect the amount and diameter of muscle fibers, which in turn can influence the color parameters of fish muscle. Results obtained in this study show no significant differences in a* and b* of rainbow trout muscle, This could be the result of so called "technology unification" of trout cultivation, which means that the methods used during cultivation of rainbow trout are similar in all studied

cultures. Farmers use almost identical technological solutions and similar industrial feeds.

The color of fish meat is significant for farmers since it is one of the most important factors that influence consumer's fish choice (Kreft and Zabrocki, 2010).

Fatty acid composition

The place of cultivation of rainbow trouts significantly affects the saturation of their lipids. Erdem et al. (2009) studied seabass (*Dicentrarchus labrax* L.) cultivated in different regions of Turkey and found statistical differences in the content of SFA, MUFA and PUFA depending on region of cultivation. This is also supported by Çelik et al. (2005) who stated that microclimate conditions in which the fish are cultivated affect significantly their fatty acid composition.

The fatty acid profiles are affected by extrinsic and intrinsic factors such as genetics, development phase, environmental condition and dietary lipids (Ehsani et al., 2013; Varga et al., 2013). Even though rainbow trouts from all studied cultures were fed in a similar fashion, there were significant differences in *n-3* fatty acids. This leads to the conclusion that the place of cultivation and genetic heritage affect the amount of *n-3* fatty acids in the meat of those fish.

Some indicators such as AI and TI indicate the universal dietetic quality of lipids and evaluate their predisposition to develop the coronary heart disease. The nutritional quality of lipids and the AI or TI values are inversely related (Ehsani et al., 2013). The acquired values of AI and TI are lower than values reported in the meat of other livestock such as pigeons, poultry or rabbits (Dal Bosco et al., 2004; Dal Bosco et al., 2005).

Due to higher content of PUFA, especially DHA and EPA, fish oils are susceptible to autoxidation and thus formation of various toxic compounds (González et al., 1992; Rupasinghe and Afsana, 2010). The highest PI was observed in trouts from MA culture (191.92) while the lowest susceptibility to oxidation changes was found in trouts from SW and SL cultures (153.66 and 154.37, respectively).

Microbiological analysis

According to Wogu and Maduakor (2010) the bacterial count on body surface of fish is higher than in the muscle or lungs. They reported the TVC on skin surface of different fish species from aquaculture to be from 7.04 to 7.33 log cfu/cm^2. On the other hand Adams and Moss (2008) reported that bacterial count on fish body surface varies between 2.00 and 7.00 log cfu/cm^2.

Baird-Parker agar allows the growth of both coagulase-positive and negative staphylococci. No coagulase-positive staphylococci were observed on the body surface of studied rainbow trouts. In contrast, the coagulase-negative staphylococci count differed highly significantly between studied groups. The isolated staphylococci probably belong to allochthonous microflora which is washed out from contaminated soil or air into the water ponds.

Ayulo et al. (1994) performed research on 175 samples of fresh smooth weakfish (*Cynoscion leiarchus*) and reported that 20% of them were contaminated with *Staphylococcus aureus*. Only 9 of them, however, were the strains which exhibit

pathogenicity. *Staphylococcus aureus* is commonly used as indicator of hygienic conditions present during fish processing. Such organisms should not be present on a fresh-caught fish (Novotny et al., 2004).

According to Chytiri et al. (2004) the *Pseudomonas* sp. count in the meat of rainbow trouts during first day after catch can vary from 1.00 to 3.50 log cfu/cm². Bacterial spoilage in refrigerated fish and fish products under aerobic storage conditions is caused by gram-negative psychotropic organisms such as *Pseudomonas*. Although *Pseudomonas* sp. occurs naturally in fresh water reservoirs (Kazuń et al., 2011), faulty rearing, harvesting, and processing practices can result in additional cross-contamination of fish with foodborne pathogenic bacteria (Chytiri et al., 2004). Due to higher content of *Pseudomonas* sp., the fish from SL culture can have shorter shelf life than trouts from other cultures.

E. coli occurrence in fish is considered a sanitary hazard and may represent a risk to the consumers if related to pathogenic strains, especially diarrheagenic *E. coli*. However, the presence of non-pathogenic *E. coli* in fish and shellfish should also alert the public health institutions, since this bacterium is recognized as an indicator of fecal contamination, possibly indicating the presence of other enteric pathogens (Costa, 2013). Results acquired from microbiological analysis show good sanitary conditions of water in all studied cultures in which the trouts were cultivated.

Sensory analysis

The respondents recognized the trouts from WM culture as the closest to the "ideal" point. Surprisingly, samples marked by respondents as too dark (trouts from SW culture) had the highest lightness (L*) according to instrumental color analysis, while the "ideal" samples from WM culture had the lowest values of L*. These variations in instrumental and sensory color measurement can indicate that the human sight, as a measuring apparatus, is inaccurate and the results acquired by sensory analysis are subjective.

The results obtained suggest that the place and method of cultivation do not influence the sensory quality of cultivated rainbow trout. This seems to be supported by the findings reported by Zakrzewski et al. (2011) and Ginés et al. (2004) who reached similar conclusions studying rainbow trout and Arctic charr (*Salvelinus alpinus*).

Conclusions

The geographic region in which rainbow trout was cultivated had significant influence on the color and fatty acid composition of their muscle and on the amount of aerobic bacteria present on their body surface. Since fatty acid composition is one of the most important health aspects of fish consumption, the labeling of the place and method of cultivation on the fish products available for the final consumer should be implemented.

Moreover, the results acquired from microbiological analysis performed on the body surface of rainbow trout cultivated in different regions of Poland showed that the microbiological quality of water in Polish cultures is satisfactory since none of the analyzed pathogenic bacteria were found on all studied samples.

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