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Original scientific paper

Evaluation of sensory characteristics of common carp reared in purified wastewater from a slaughterhouse

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ABSTRACT

The aim of the present research was to evaluate the sensory characteristics of common carp as well as their correlation with the season of sampling in the common carp reared in integrated production system. Fish were collected in spring and autumn from fish pond which received purified water from slaughterhouse. The sensory quality of common carp fillets shows very high scores for all examined parameters and overall impression.

1. Introduction

Consumption of fish meat is encouraged because of its high protein content, presence of essential amino acids, minerals, vitamin A, and other nutrients (*Hussain et al.*, 2011). Furthermore, fish meat is one of the most important sources of n-3 highly unsaturated fatty acids (HUFAs). These fatty acids can lower the blood cholesterol and triglyceride levels and can prevent cardiovascular and neurological diseases (*Morris et al.*, 2003), thus making fish meat valuable in the human diet.

Although aquaculture is increasing worldwide, it is encountering an unused potential in Serbia. In some regions of the country, there are vast unused areas which are not cultivated or suitable for other agricultural activities. However, these areas are in the immediate vicinity of slaughterhouses, and could be used for aquaculture. Furthermore, fish production in Serbia mostly consists of the traditional rearing system, which is a semi-intensive culture system, and the fish diet is based on a combination of natural food and supplementary feed (cereals, such as wheat, maize and barley). A similar situation is found in many countries worldwide. To improve and intensify carp production, in the last few years, cereals have been replaced by extruded feed (*Steffens and Wirth*, 2007; *Ljubojević et al.*, 2013). Rural areas present ideal hotspots for developing integrated production, since the land is far away from human settlements, purified wastewater can be used for filling ponds, thus significantly reducing the release of harmful agents into rivers and the environment, and applying good agricultural practices could lead to favourable natural food composition.

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Wastewater from slaughterhouses in developing countries is mostly discharged into rivers, lakes and seas without being adequately treated to removed impurities. Such wastewater contains plenty of organic matter which is ideal source of nutrients for fish, but also for development of different microorganisms. However, usage of slaughterhouse wastewater in aquaculture could be a health risk for humans and fish and other aquatic organisms due to possible introduction of pathogenic bacteria into the aquatic environment (*Sapkota et al*., 2008). Therefore, an integrated production system could present a significant risk for public health. It is already known that fish and other aquaculture products can be vehicles for various pathogens (*Ljubojević et al.*, 2016), and the health advantages arising from consuming products from wastewater-fed fish ponds are questionable. *Lan et al.* (2007) underlined that the safety of consuming fish from wastewater fed ponds is questionable. *Scallan et al.* (2011) stated that more foodborne outbreaks are caused by pathogens than by chemical or physical contaminants.

In the available literature, there are insufficient data on meat safety and quality regarding the common carp reared in purified wastewater-fed earthen ponds, which makes this investigation a novelty in the field of integrated fish production systems. Since there are also scarce data about the sensory quality of fish reared in integrated production systems with purified slaughterhouse wastewater in the literature, the aim of this study was to assess the meat quality of freshwater fishes cultivated in an integrated fish pond and compare them with other cultivation systems.

2. Materials and methods

2.1. Fish ponds and waters

An earthen pond with an area of 1 ha and average depth of 1.2 m was built in Pećinci village (N 44°54′19″, E 19°57′35″), Srem District, Serbia, in the vicinity of a slaughterhouse facility. Fish ponds were filled directly with purified water from the slaughterhouse and with added well water, and aeration of the pond was secured. A channel, 2 m wide, was dug around the pond for filtering the water from the pond and thus significantly reducing the required amount of water. The fish pond was aerated by continuous use of an aerator. The water flow was approximately 3.5 L s^{-1}, which secured the absence of harmful effects of carbon dioxide and ammonia on the fish.

The wastewater treatment system for slaughterhouse wastewater consisted of a pump station and tanks. The dimensions of the system were 25.50 × 16.15 m, and it contained: accumulation tank, fat separation system, denitrification treatment system, equalization tank and a biological oxidation tank for biological wastewater treatment.

2.2. Fish species and supplementary feed

Two year old fingerlings of common carp (*Cyprinus carpio*) obtained from a commercial fish farm were stocked at density 2500 individuals/ha. The fish pond was stocked in March 2017. The mean of initial live weight of fish was 200 g. Carp were grown under variable natural atmospheric conditions. Relatively low cost, locally available nutrients were used as additional feed and industrial feed for fish was supplied to the fish.

2.3. Sampling

Fresh reared common carp were collected from the fish pond that was fed with purified wastewater from slaughterhouse using the same protocols in spring (April 2018) and autumn (October 2018). Seven fish at each sampling time were sacrificed by a quick blow to the head, and the average weight was 820 g and 1950 g in April and October, respectively. Each fish was placed in a sterile plastic bag. All fish were kept at refrigerator temperature during transportation to the laboratory and were analysed and assessed for sensory characteristics and quality within four hours of harvesting.

2.4. Sensory analysis

Sensory assessment was conducted at the laboratory of Scientific Veterinary Institute Novi Sad in Novi Sad, Serbia, equipped in accordance with the ISO standard (*SRPS*, 2015). Five trained panellists with expertise in sensory evaluation of fish and fish products evaluated selected properties for fillets (colour, odour, taste, softness, chewiness and juiciness) of the common carp. Sensory analyses were evaluated using a point system of analytical descriptive tests with a scale from 1 to 5, for the colour (1=very bad; 2=bad, 3=good; 4=very good; 5=extremely good), for the odour and taste (1=extremely unpleasant; 2=unpleasant; 3=insufficiently pleasant; 4=pleasant, good; 5=extremely pleasant, excellent), for softness (1=moderately ten-

der; 2=tender; 3=moderately tender; 4=moderately soft; 5=soft), for chewiness (1=moderately tough; 2=slightly tough; 3=chewable; 4=moderately soft; 5=soft), for juiciness (1=dry; 2=moderately dry; 3=moderately juicy; 4=juicy; 5=extremely juicy) and for overall impression (1=sufficient; 2=suitable; 3=good; 4=very good; 5=excellent). Panellists were randomly supplied with thermally processed samples of fillets of common carp. Between each sample evaluation, panellists cleansed their palates with distilled water, bread or apple. Between each repetition period of sample evaluation, one hour was allowed for the panellists to rest their senses.

2.5. Statistical analysis

The Student's t-test was used to compare the geometric mean sensory results from the common carp that were harvested in spring and in autumn. The data were analysed in Excel 2013. The average of duplicate scores for all responses were averaged. All data are presented as means ± S. D. and the differences were regarded as significant when $p<0.05$. Significant effects of type of analysed sample were further evaluated using analysis of variance (ANOVA). A significance level of $P<0.05$ was used.

3. Results

Results for sensory characteristics (colour, odour, taste, softness, chewiness, juiciness and overall impression) of fillets of the common carp collected in spring and autumn are presented in Table 1. No significant differences ($P>0.05$) in meat quality characteristics were obtained, with exception of chewiness (fish were more chewy in autumn than in spring), which could be attributed to the fish size, as fish harvested in October were bigger in comparison with fish harvested in April. The fillets from both seasons had almost the same visual colour scores. The visual colour score of fillets (4.4) was very high. For the fish fillets' odour, significant differences ($P>0.05$) were not seen, but a numerically higher score of 4.0 was recorded in autumn, while the score in spring was 3.8, mainly due to an earthy/musty odour. However, wastewater off-flavours and odours were not reported by panellists. A similar tendency (numerically higher score in autumn than in spring) was observed for the taste of the fillets. As was the case with the fillets' odour, a higher score for meat softness was observed in autumn than in spring, so autumn fillets were moderately soft. A lower chewiness score was recorded in spring than in autumn, but the mean score was 4.0, i.e., fillets were moderately soft, which is very acceptable to consumers. The fillets received higher juiciness scores of 4.2 in autumn and lower scores of 4.0 in spring. For overall impression, average scores were 4.0 and 4.4 in spring and autumn, respectively.

4. Discussion

Sensory analysis is one of the oldest means of fish quality control that allows manufacturers to identify, understand and respond to consumer preferences more effectively, and consequently, helps manufacturers to be more competitive on the market (*Özogul et al.*, 2005). Off-flavours are one of the most economically significant problems encountered in freshwater fish production (*Vallod et al.*, 2007). In our study, the sensory quality of common carp fillets received very high mean scores for all

Table 1. Sensory quality (mean scores*) of fillets from common carp reared in purified slaughterhouse wastewater-fed fishpond in spring and in autumn

Sensory characteristics	Spring	Autumn	p-value
Color	4.4±0.8	4.4±0.48	1
Odour	3.8±0.74	4.0±0.63	0.6938
Taste	3.6±0.49	4.0±0.63	0.346594
Softness	3.8±0.4	4.0±0.63	0.607511
Chewiness	3.6±0.49	4.4±0.49	0.049736
Juiciness	4.0±0.63	4.2±0.75	0.6938
Overall impression	4.0±0.63	4.4±0.49	0.346594

* Seven fish fillets from each group were assessed by five trained panellists

examined parameters and overall impression, which leads to the conclusion that the rearing of these fish in purified slaughterhouse wastewater had no adverse effects on the sensory properties of the fillets. We believe that this rearing system should be compared with conventional systems of carp rearing in earthen ponds or with wild carp originated from rivers. Contrary to our results, *Mahmoud and Buettner* (2016) evaluated the sensory quality of fish fillets and showed the characteristic taste and off-odours of mud were transferred to the fish meat. The results obtained by *Vallod et al*. (2007) show that strongly off-flavour carp were found in ponds colonized by cyanobacteria, mainly *Anabaena* spp. in summer. The same authors reported that sensory evaluation confirmed the existence of off-flavours in the carp tested, and that the most commonly used descriptors associated with geosmin, a wastewater, earthy/musty odour and taste, were identified by the sensory panellists. According to *Houle et al.* (2011) geosmin causes off-flavour in fish, and *Yarnpakdee et al.* (2014) stated that the term off-flavour in fish meat refers to earthy/musty odour and taste.

Despite the fact that common carp rearing has a long tradition in European countries, the economic value of carp is still at relatively low level, mainly due to prejudices that common carp is a fatty fish with numerous bones and muddy taste. *Vallod et al.* (2007) reported that the intensity of off-flavour was the highest in July and August, and that it was lower at the end of the season, which is in accordance with our study. The lower level off-flavour in autumn is also significant from the economical point due to fact that the common carp are mainly harvested and sold during autumn and winter.

Although the option of expanding the existing area of fish ponds is not an acceptable global approach to increase food production, it can be applied in Serbia and likely in surrounding countries too, since there are vast amounts of unused land. It is necessary to introduce appropriate incentives in the form of the cession of the land in the vicinity of slaughterhouses which would be used to set up primarily small-scale fish ponds, providing incentive loans with reasonable interest rates and repayment periods that would allow this type of aquaculture to be established. Moreover, it is necessary to establish the market for products from integrated aquaculture, which would stimulate this type of production. With proper marketing and medical advice, people's awareness and nutritional habits could be changed, leading to an increase in the consumption of fish. In addition to ensuring a highly valuable and safe food for the local market and for export, this type of production could provide jobs for people and facilitate the development of rural areas.

5. Conclusion

Fish reared in this integrated production system produce fillets with satisfactory sensory properties. Comparison with common carp from conventional production systems requires further study. The presented results could be helpful to common carp processors for developing a quality-assurance program for common carp from integrated production systems.

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