A practical quality index method (QIM) developed for aquacultured rainbow trout (*Oncorhynchus mykiss*)

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**ABSTRACT**

Quality index method (QIM) was developed for whole (W) and gutted (G) rainbow trout during ice storage. Draft schemes were modified and final schemes consisted of 30 and 15 demerit points, and 12 and 14 days of shelf life was found for whole and gutted rainbow trout, respectively. Linear regression was calculated with storage time and correlation of QI scores was found to be 0.98 and 0.99 for W and G samples, respectively. Moreover, the developed QIM for W and G rainbow trout with this study is a non-destructive and rapid method for the sensory evaluation of rainbow trout.

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*Oncorhynchus mykiss*; quality index method; shelf life; aquacultured rainbow trout; sensory analysis

**Introduction**

Sensory methods are the methods that depend on trained assessors. Thus, the use of quality control to assess the freshness of fish and other seafood requires objective sensory methods to determine the remaining shelf life. Sensory evaluation is now considered as the main and most important method for evaluating the freshness of aquatic products. Sensory evaluation is defined as a scientific discipline, which is used for measuring, analyzing, and interpreting the characteristics of sensed food by senses such as see, smell, taste, and touch. In sensory analysis, the appearance, smell, aroma, and texture of the whole fish are evaluated with human senses. Subjective and objective methods are applied to sensory evaluation. Subjective methods are based on the preference and acceptability of a product of the panelist and may be inconsistent across the assessors. To determine freshness changes in fish, it is necessary to use a quick and inexpensive method that is not destructive to the fish in all sensory analyzes. In addition, quality index method (QIM) is a method that takes into account the specific state of each species or product applied to determine the freshness and quality of fish, with a set of identified qualitative sensory that analyzes and allows estimating the remaining shelf life of the fish. QIM is simply a process of determining the quality of a fish as a systematic and objective guide. QIM is a commonly used method that developed in Europe, mostly in the form of QIM schemes, with origin from Tasmania. The method is based on the characteristic changes that occur in raw fish. The European Fisheries Research Institute has developed a new instrument with sensory identification to identify fish quality in close cooperation with the fisheries and aquaculture industry. Objective is carried out in a systematic and secure manner in the form of a method of quality determination and is referred to as QIM. The QIM is based on the significant, well-defined characteristic changes of the appearance characteristics (eyes, skin, gills, and smell) for raw fish and includes a dermatologic index score of 0 (freshest state) to 3 (most deteriorated) for each character in the score system. Low scores indicate the best quality. The sum of the scores of all the characteristics gives the sensory score and is called the quality index. Relatively large number of fish quality characteristics are evaluated by sight, smell, and touch in turn. The QIM developed for various species aims to increase the quality index over time in a linear manner. The direct relationship between QIM and storage time facilitates the easy calculation of the remaining shelf life of fresh fish when the fish is stored at 0°C. QIM is an accurate and objective method for determining fish...
freshness. It provides highly reliable information on fish quality and facilitates and improves management of fish processing and marketing. It is recommended as a practical and objective tool for the evaluation of fresh fish in production management, as in other parts of the QIM chain, based on a measurement method established. [7]

Sensory analysis is the most appropriate approach to measure changes in the quality characteristics of fish, mainly reflecting both otolytic and microbial impairments. This method is generally applied in the product development and the market research studies. [2] There are several studies in the literature regarding the development of QIM for some fish species, namely, salmon (Salmo salar), [6,13] gutted carp, [14] whole aquacultured sea bream (Sparus aurata), [5,15,16] bogue (Boops boops), [17] anchovy (Engraulis anchoita), [18] anchovy (Engraulis encrasicolus), [19] sardines (Sardina pilchardus), [20] whole and gutted red tilapia (Oreochromis spp), [21] whole tilapia (Oreochromis shiranus), [22] gutted Acoupa weakfish (Cynoscion acoupa), [23] fresh blackspot seabream (Pagellus bogaraveo), [24] flounder (Pomphorhynchus patagonicus), [25] whole mullet (Mugil platanius), [26] and rohu (Labeo rohita). [27] However, there is no detailed study to determine the sensory quality changes in rainbow trout. In this context, the aim of the study is to develop a practical QIM for whole and gutted aquacultured rainbow trout.

Materials and methods

Materials, harvesting, and transport of fish

Portion size cultured rainbow trout were obtained from fish farm (Aksu-Isparta) with the average weight of 224.19 ± 4.56 g that were fasted for 36 h. After harvesting, fishes were immersed in slurry ice. After killing the fish by thermal shock, samples were placed in polystyrene box with drainage covered by flake ice and transported to the laboratory with in 2h and divide into t o groups such as whole (W) and gutted (G). A total of 1090 fishes were used for the study and were stored in polystyrene box with ice at 2°C until spoilage. The ice of the fish was changed daily.

Quality index method

The panel was consisted of 10 assessors that were trained in accordance with. [28] In each session of training, 15 fishes were evaluated in accordance with their sensory changes. For the development of QIM for W and G rainbow trout, the QIM schemes were used that developed for rainbow trout [29] (Table 1) and Atlantic salmon [13] (Table 2).

The sensory evaluation of W and G rainbow trout were performed under controlled laboratory conditions. Each of the samples was coded as a three-digit number or letter and placed randomly on the evaluation desks. Each assessor has his own bench for the evaluation of descriptors for rainbow trout. In order to reduce the number of descriptors geometric mean classification was used (Eq. 1).

| Table 1. The QIM scheme developed for rainbow trout (Oncorhynchus mykiss) by [29] | Quality parameters | Points |
|---------------------------------|-------------------|-------|
| Skin                            | Color/appearance  | 0–2   |
|                                 | Mucus             | 0–1   |
|                                 | Odor              | 0–2   |
|                                 | Texture           | 0–2   |
| Eyes                            | Pupils            | 0–2   |
|                                 | Form              | 0–2   |
| Gills                           | Color/appearance  | 0–2   |
|                                 | Mucus             | 0–2   |
|                                 | Odor              | 0–3   |
| Abdomen                         | Blood in abdomen  | 0–1   |
|                                 | Odor              | 0–2   |
| Quality Index Total             |                   | 0–21  |
where $F$ is the number of times the descriptor is mentioned over the total number of the mention and $I$ is the sum of intensities given by the whole panel for a descriptor. Schemes that were used for the development of QIM for rainbow trout were modified in accordance with the results obtained from Eq. (1).

**Statistical analysis**

The mean results obtained from QI scores for each assessor were subjected to one-way ANOVA to determine the bias of the assessors. A statistical package program (SPSS 20.0 IBM) was used to conduct the statistical analysis.\[30\]

**Results and discussion**

Regarding to the development of QIM for whole and gutted rainbow trout Tables 1 and 2 was used and final schemes were composed (Tables 3 and 4). For the W samples, QIM scheme was consisted of 16 parameters and 30 demerit points while scheme for G samples was consisted of 7 parameters.
and 15 demerit points. Samples were examined in accordance with the changes in skin, mucus, elasticity, belly, flesh odor, whole fish odor, eyes, gills, peritoneum, inner organs, fins, and rigor mortis for W samples and skin, mucus, elasticity, odor of abdominal cavity, and fins for G samples. All of the determined parameters were considered to be useful; however, least contributed parameters were evicted for the final scheme.

For rainbow trout kept in ice under chilled conditions, the values of QIM obtained from the developed schemes of W and G samples were revised. In this context, the correlation between the demerit points and the storage time in the draft QIM (results not shown) schemes developed using Tables 1 and 2 for use in shelf-life estimation studies were determined (Figs. 1 and 2).

Sensory quality changes in rainbow trout kept under cold conditions were assessed according to Table 3 during storage time. In this context, it is clear that the correlation between storage time and

### Table 3. Final developed QIM scheme for whole (ungutted) rainbow trout samples.

| Parameter          | Changes          | Description                      | Points |
|--------------------|------------------|----------------------------------|--------|
| Skin               | Brightness       | Bright                           | 0      |
|                    |                  | Faded                            | 1      |
|                    |                  | Mate                             | 2      |
| Mucus              | Clarity          | Clear                            | 0      |
|                    |                  | White/high viscosity             | 1      |
|                    |                  | Gray/blackish/low viscosity      | 2      |
| Elasticity         | Fingerprints     | Elastic                          | 0      |
|                    |                  | Fingerprints < 3 s               | 1      |
|                    |                  | Fingerprints ≥3 s                | 2      |
| Belly              | Softness         | Rough                            | 0      |
|                    |                  | Started to be soft               | 1      |
|                    |                  | Soft                             | 2      |
|                    | Color            | White                            | 0      |
|                    |                  | Locally yellow/brown             | 1      |
| Odor of whole fish | Fresh/rotten     | Fresh/characteristic             | 0      |
|                    |                  | Neutral                          | 1      |
|                    |                  | Soil/metallic/rotten             | 2      |
| Eyes               | Clarity          | Clear                            | 0      |
|                    |                  | Locally opaque                   | 1      |
|                    |                  | Mate                             | 2      |
|                    | Shape            | Convex                           | 0      |
|                    |                  | Flat                             | 1      |
|                    |                  | Concave                          | 2      |
| Gills              | Color            | Red/pinkish                      | 0      |
|                    |                  | Mate/locally red                 | 1      |
|                    |                  | Dark red/yellowish               | 2      |
|                    | Odor             | Characteristic/soil              | 0      |
|                    |                  | Neutral/metallic                 | 1      |
|                    |                  | Rotten/metallic/sour             | 2      |
| Mucus              | Clear/liquid     | Clear/liquid                     | 0      |
|                    |                  | Red/pinkish                      | 1      |
| Peritoneum         | Status           | Attached/firm                    | 0      |
|                    |                  | Locally separated                | 1      |
|                    |                  | Separated                        | 2      |
| Inner organs       | Status           | Whole                            | 0      |
|                    |                  | Locally fractured                | 1      |
|                    |                  | Liquid accumulation/fractured    | 2      |
|                    | Odor             | Characteristic/soil              | 0      |
|                    |                  | Metallic                         | 1      |
|                    |                  | Rotten/sour/metallic             | 2      |
| Fins               | Status           | Firm rays                        | 0      |
|                    |                  | Locally fractured                | 1      |
|                    |                  | Fractured                        | 2      |
| Rigor mortis       |                  | In rigor                         | 0      |
|                    |                  | Postrigor                        | 1      |
| Quality Index      |                  | Total                            | 30     |
QIM values is calculated as \( r = 0.9746 \), but the QIM value observed at 0 and 24 h is lower than expected (Fig. 1). However, at 100 and 200 h, the observed values are more than the expected values, which is an indication that the developed model is not correct. Sensory quality changes occurring under cold conditions in gutted rainbow trout are shown in Fig. 2.

The correlation between storage time and QIM of G (\( r = 0.99 \)) was found to be higher than those of W samples which found to be \( r = 0.97 \). In accordance with the results from the final schemes, some parameters are excluded from the draft scheme to obtain the final scheme of QIM such as the term of very bright from the change of skin of the fish was changed to bright for the final scheme. For the elasticity parameter, instead of \( = 3 \) s and \( > 3 \) s, these two changes are combined to be \( \geq 3 \) s. The meat color parameter was removed because it also contained gills and mucus smells, and the abdominal color parameter was added because of the color changes in the abdominal area during storage. The parameter of meat color has been removed since there is no change in this parameter during the storage of the samples. Regarding to the final QIM scheme the correlation is obviously increased (Figs. 3 and 4).

| Parameter         | Changes    | Description                        | Points |
|-------------------|------------|------------------------------------|--------|
| Skin              | Brightness | Bright                             | 0      |
|                   | Faded      | 1                                  |        |
|                   | Mate       | 2                                  |        |
| Mucus             | Clarity    | Clear                              | 0      |
|                   |            | White/high viscosity               | 1      |
|                   |            | Grey/blackish/low viscosity        | 2      |
| Elasticity        | Fingerprints| Elastic                           | 0      |
|                   |            | Fingerprints < 3 s                 | 1      |
|                   |            | Fingerprints \( \geq 3 \) s        | 2      |
| Odor of whole fish| Fresh/rotten| Fresh/characteristic               | 0      |
|                   |            | Neutral                            | 1      |
|                   |            | Soil/metallic/rotten               | 2      |
| Eyes              | Clarity    | Clear                              | 0      |
|                   |            | Locally opaque                     | 1      |
|                   |            | Mate                               | 2      |
|                   | Shape      | Convex                             | 0      |
|                   |            | Flat                               | 1      |
|                   |            | Concave                            | 2      |
| Odor of peritoneum| Fresh/rotten| Characteristic/soil/fruity/neutral| 0      |
| Fins              | Status     | Firm rays                          | 0      |
|                   |            | Locally fractured                  | 1      |
|                   |            | Fractured                          | 2      |
| Quality Index     | Total      |                                    | 15     |

The correlation between storage time and QIM is given by \( y = 0.1076x + 1.3533 \), \( R^2 = 0.97 \).

**Figure 1.** QIM scores obtained from the draft scheme for whole rainbow trout.
For the G samples, the parameter of the color of skin, abdominal cavity, and meat and meat odor, which has no change during the storage period were removed from the scheme of the QIM. For elasticity parameter the values were changed from = 3 s to ≥ 3 s. The changes in fins are redefined from two demerit points to three change levels. The relationship between the storage time and the QIM values is shown in Fig. 4. It is seen that the correlation is high (r = 0.99) even though the final
QIM diagram developed for the G samples (Table 4) contains fewer parameters than the draft scheme (Fig. 4). The parameters used in this framework have contributed enough to the system.

In this study, W and G rainbow trout were stored on ice until the end of shelf life and QIM was developed for both mentioned groups. All parameters specified for QIM developed for W and G rainbow trout during storage increased over time and reached the indicated 30 and 15 demerit point quality index score for W and G rainbow trout, respectively. When it is thought that the shelf life is limited in perishable foods such as fish is the shelf life determined by QIM for W samples on ice as 12 and 14 days for the G samples. The correlation between QIM and storage time for W and G samples was found to be \( r = 0.98 \) and \( r = 0.99 \) (Figs. 3 and 4, Tables 3 and 4) that is observed to be quite high. The shelf life (12 days (W) and 14 days (G)) determined in this study for rainbow trout stored in ice showed similarities and differences in some freshwater and marine species. Rodríguez et al.\(^{31}\) found a shelf life of 5 and 6 days, for W and G samples, which is lower than those of rainbow trout from this study, and they determined the mentioned shelf life when a slight bitter aroma occurred. Rezaei et al.\(^{32}\) noted that the shelf life of wild rainbow trout on ice is 9–11 days.

Massa et al.\(^{18}\) indicated the shelf life of anchovy (\(E.\ anchoita\)) as 7 days while Pons-Sanchez-Cascado et al.\(^{19}\) reported 5 days shelf life for anchovy (\(E.\ encrasischolus\)). Another study\(^{21}\) reported the shelf life of whole and gutted red tilapia (\(Oreochromis\ spp\)) as 6–9 and 8–11 days, respectively. For gutted Acoupa weakfish (\(C.\ acoupa\)) the shelf life was determined as 8–9 days.\(^{23}\) Triqui and Bouchriti\(^{20}\) found the shelf life of sardines (\(S.\ pilchardus\)) as 5 days. Massa et al.\(^{25}\) reported the shelf life of flounder (\(P.\ patagonicus\)) as 7 days on ice.

Similar shelf life for rainbow trout was reported in other studies. Wunnenberg and Oehlenscläger\(^{33}\) reported the shelf life of rainbow trout that are stored on ice on autumn for 14 days and on winter, spring, and summer for 16 days. Ninan et al.\(^{34}\) found the shelf life of whole rainbow trout in accordance with the sensory results for 12–14 days while Özoğul et al.\(^{35}\) found similar shelf life, namely, 14 days for whole wild and aquacultered rainbow trout. In addition, Chytiri et al.\(^{36}\) reported 15–16 days in whole rainbow trout on ice and 10–12 days shelf life for fillet. In the study in Poland, as a whole and gutted rainbow trout samples had a shelf life of 11 days in the whole fish and 14 days for the gutted samples.\(^{37}\)

The fresh whole \(P.\ bogaraveo\) fishes have a shelf life of 12–13 days\(^{38}\) and 15 days of shelf life was reported for fresh whole tilapia (\(O.\ shiranus\)).\(^{22}\) The shelf life of the whole mullet (\(M.\ platanus\)) on ice and in the refrigerator was determined to be 14 and 7 days, respectively.\(^{26}\) In addition, it has been reported\(^{17}\) 20 demerit points in bogue (\(B.\ boops\)) beneath the fish farm and caught from the natural environment and reported shelf life as 17 and 12 days, respectively. Higher than the shelf life of rainbow trout of this study\(^{39}\) was found 17 days of shelf life for \(S.\ alpinus\) in ice, 20 days for Atlantic salmon (\(S.\ salar\)) in ice\(^6\) and 17 days for aquacultured coho salmon (\(O.\ kisutch\)) in ice\(^{40}\) and supported this findings with oxidized odor.

Agüeria et al.\(^{14}\) determined the shelf life of gutted carp as 18 days and the shelf life of rohu (\(Labeo rohita\)) was reported in accordance with the organoleptic analysis as 17 days in ice.\(^{27}\) Shelf life of whole aquacultered sea bream was reported as 14–18 days.\(^{5,15,16,41}\) In this study, 30 demerit points were determined for W and 15 demerit points were determined for G samples while lower demerit points were reported in other studies. Agüeria et al.\(^{14}\) reported 19 demerit points for gutted carp, 15 for whole sea bream (\(S.\ aurata\)),\(^5\) 15 for whole wild and aquacultered sea bream,\(^{41}\) and 16 demerit points for fresh aquacultered seabream in ice.\(^{16}\) A total of 16 demerit points were determined in fresh whole harvested tilapia (\(O.\ shiranus\)),\(^{22}\) 20 for bogue (\(B.\ boops\)) that were caught from the beneath of the fish farm from the natural environment,\(^{17}\) 23 for anchovy,\(^{19}\) and 23 for gutted Acoupa weak fish (\(C.\ acoupa\)) that were stored in ice.\(^{23}\)

Similarly, 29 and 21 demerit points were observed in whole and gutted red tilapia (\(Oreochromis\ spp\)),\(^{21}\) respectively, 28 for anchovy (\(E.\ anchoita\)) in ice,\(^{18}\) 20 for sardines (\(S.\ pilchardus\)) in ice,\(^{20}\) and 30 for fresh whole \(P.\ bogaraveo\).\(^{24}\) Compared to our study in whole and gutted rainbow trout, reported higher demerit points were reported for rainbow trout,\(^{32}\) in flounder (\(P.\ patagonicus\)),\(^{25}\) and Andrade et al.\(^{26}\) 33 demerit points for mullet (\(M.\ platanus\)). In some studies, it is notable that
the correlation between storage time and QIM scores is lower than the values found in rainbow trout. The correlation between the storage time and the QIM scores of the individuals stored in ice for the *S. alpinus* from the Salmonidae family \( r = 0.97 \) and the correlation for the Atlantic salmon were reported to be \( r = 0.97 \).\(^{[13]}\) It has been reported that in the flounder (*P. patagonicus*) in the ice QIM increases linearly with the storage time and the correlation is found to be \( r = 0.97 \).\(^{[25]}\) Correlation in the gutted rainbow trout stored on ice was \( R^2 = 0.947 \)\(^{[37]}\); in the ice-cold gutted Acoupa weakfish (*C. acoupa*) the correlation is found to be \( R^2 = 0.9614 \) and correlation was reported as \( R^2 = 0.7596 \) in Atlantic herring (*Clupea harengus*) stored in ice.\(^{[42]}\) Agüeria et al.\(^{[14]}\) reported a relatively low value (\( r = 0.76 \)) for gutted carp. For whole tilapia (*O. shiranus*) stored in ice the correlation was determined as \( R^2 = 0.89 \).\(^{[22]}\) However, in some studies, values were similar to the results of this study. Correlation for whole fish was found to be \( R^2 = 0.992 \) with storage time in the rainbow trout stored in ice.\(^{[37]}\) Massa et al.\(^{[18]}\) found \( R^2 = 0.98 \) for the anchovy fish in the ice and \( R^2 = 0.987 \) for the anchovy (*E. encrasicholus*) in ice.\(^{[19]}\) The correlation between storage time and QIM scores in sea bream (*S. aurata*) stored as whole and obtained from wild and aquaculture environment and stored in ice was \( r = 0.989 \) in wild fish and \( r = 0.968 \) in cultured fish, while QI scores increased during storage and lower QI scores were determined in farm fish.\(^{[41]}\) In a study conducted with codfish (*Gadus morhua*) fillet, the correlation between storage time and QIM scores was found to be \( R^2 = 0.98 \).\(^{[43]}\) Andrade et al.\(^{[26]}\) determined the QI correlations as \( R^2 = 0.982 \) and \( R^2 = 0.966 \), respectively, when storing the whole mullet (*M. platanus*) in ice and in the refrigerator. In this context, the developed QIMs should be depended on the species and processing type and samples should be evaluated independently.

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