ABSTRACT

Key - words: sensory analysis, fish freshness, proximate composition, chemical indicators of spoilage, microbiological analysis

The sensory analysis is the primary method used for assessing freshness in the entire fishing industry (Hootman, 1992). Lyngby Laboratory (Institut für Dänischen Fischereiforschung) developed the application of the QIM quality assessment scheme (Jønsdottir, 1992) also for freshwater fish (Hyldig and Foschi, 2006). In support of its efforts comes the quality assessment scheme developed by the Max Rubner Institute Hamburg (Fish Department of Federal Research Institute for Nutrition and Food, Germany) for the freshwater fishes. In order to investigate the seasonal variations of sensory qualities, recorded in two types of maraena whitefish (*Coregonus maraena*) and a species of pike-perch (*Sander lucioperca*), were used samples from Szczecin Lagoon and adjacent river Peene and aquaculture systems respectively (in Schleswig-Holstein and Mecklenburg-Vorpommern FRG Districts). In addition and according to the same procedures of the sensory methods using a panel were reviewed also pike-perch samples of frozen fillets from import and exotic fish fillets: mahi-mahi (*Coryphaena hippurus)* and emperor sea bream (*Lethrinus* spp.), sold in supermarket chains and on the Hamburg's fish market.

In completion of the methods for sensory quality's evaluation were used physical (pH, textural analysis), biochemical and physicochemical methods, in order to establish the integrity of the investigated samples (several species of fish, bivalve molluscs and cephalopods). Were analyzed: the basic chemical composition, pH, TVB-N, volatile amines (MMA, DMA, TMA, OTMA) and the total phosphorus content for a total number of 446 samples. The researches and the results were shown in 187 photographs and figures and 55 tables respectively. The results were compared with actual, meaningful data available in the international literature.

All methods (with the exception of the usual gravimetric methods for measuring percentages of water and ashes), **photographs and figures contained in this thesis** (except some from QIM chapter) **are ORIGINAL**. **Many research methods are described for the first time in Romania**. **Were made important contributions to the original QIM scheme developed by the Max Rubner-Institut for freshwater fishes** (rainbow-trout, european whitefish and maraena whitefish), **this method being described for the first time in Romania.**

The work comprises 267 pages divided into two main parts: the first three chapters containing the bibliographical study (67 pages, 25%) and the following six chapters, the personal research (200 pages, 75%).

The bibliographical part

Chapter I contains data on the evolution of fish resources, modern trends of production and recovery of aquatic creatures, perspectives of global aquaculture, fishes' classification or basic biological aspects.

Chapter II describes the proximate composition of fish muscle (fat, protein, nitrogen extracts, vitamins, minerals) and their importance for nutrition and freshness evaluation.

Chapter III describes the quality factors and provides all the methods used for quality evaluation of fish. Among these methods is described in detail the freshness evaluation by sensory analysis and why it remains the method of choice available until today, despite technical advances. It is shown how to apply in practice the necessary facilities and the minimum requirements that must be met by the evaluators. Briefly are being described the quality index method (QIM) and all other objective methods of evaluation and classification

of fish, upon the degree of freshness; were summarized the chemical, physical, physicochemical and microbiological methods used for the same purpose.

The personal research part

Chapter IV describes the general objectives of the research contained here and the place of research.

Each chapter and sometimes subchapter (in Chap. VIII), in the following personal research part, is divided into four parts: the purpose and importance of research; material and method; results and discussion; partial conclusions.

Chapter V includes basic research on the proximate composition of marine and freshwater fish. Integrity parameters determination was performed on 175 samples of fish and 239 other fishery products. Was analyzed the degree of correlation between the parameters of integrity (water, protein, fat, phosphorus) and freshness indicators (pH, TVB-N). Was analyzed the integrity including the fatty acid profile for one species of maraena whitefish (*Coregonus maraena*), which is currently endangered and was raised in different conditions (wild individuals from Szczecin Lagoon, adjacent river Peene and aquaculture systems respectively). Additionally, were analyzed two types of feed used in german aquaculture for freshwater fishes and the nutrients' use efficiency (assessing the muscle retention of nitrogen and phosphorus) was studied.

Chapter VI contains data on the evaluation of fish freshness by biochemical, physical and physicochemical methods. Chemical indicators of alteration were analyzed (TVB-N), ammonia, volatile amines; textural analysis were performed using a Stable Micro Systems device. Were made correlations between pH and texture and TVB-N results are compared with the legislation in force. Are experimentally studied the recovery rates by capillary GC method for TMAO-N, DMA-N added and the consecutive TMA-N neoformation in european whitefish muscle. Was shown that capillary GC method can be successfully used to estimate TMAO-N recovery (> 100%) and DMA-N recovery (between 79 and 111%) in marine fish. In this chapter, the pH is analyzed in 167 samples of fish, cephalopods and bivalve molluscs; TVB-N is measured in 370 samples; texture and water binding capacity in 12 samples of fresh pike-perch.

Chapter VII contains data on microbiological quality of raw and frozen marine fish processed by threading. In the first case, was estimated the total number of germs/ cm^2 of skin, and in the second case the TVC/ g of muscle and the specific spoilage bacteria (SSO/ g). The microbiological results obtained are described for 10 samples of exotic valuable fishes (mahi-mahi, emperor sea bream). Correlations were made between the TVC/ g and the pH-values or between SSO/ g and the pH- values.

Chapter VIII includes research regarding the effectiveness of sensory methods in determining the freshness and quality of raw and cooked fish. Are given here the methodologies applied when performing the quality descriptive analysis (QDA) using a panel, the objective method for calculating the quality index (QIM), the instrumental method using an electronic nose, an original method for setting the thresholds of sensory perception, for unpleasant flavors in freshwater fish (geosmin and 2-methyl-isoborneol). Are shown here, the results of analyzes carried out in the Max Rubner-Institut, Hamburg together with experienced researchers in this field (Frau Monika Manthey-Karl, Herr Karl Horst, Frau Ines Lehmann Herr Carsten Meyer, Frau Ute Schröder etc.). Chapter VIII is illustrated by 49 figures (73% are original photographs) and 17 original tables.

Chapter IX includes general conclusions and recommendations from the research contained in this doctoral thesis. Is shown here, among other things, the existence of high positive correlations between TVB-N and protein percentage in mahi-mahi samples analyzed; reasonable positive correlation between pH and the percentage of water in monkfish (*Lophius* spp.) samples; reasonable positive correlation between pH and the amount of phosphate in

turbot (*Scophthalmus maximus*); very high positive correlation between pH and the percentage of water in pike-perch grown in RAS and fed with two types of pellets; perfect positive correlation between muscle retention of nitrogen and phosphorus in the pike-perch grown in RAS; positive reasonable correlation between the amount of phosphate and the percent of ice in glazed bivalve mollusks samples; reasonable positive correlation between SSO/ g and TVC/ g and a good or sufficient microbiological status of mahi-mahi samples; reasonable positive correlation between pH and log TVC/ g and a good microbiological status of emperor sea bream samples.

TVB-N values in the fish analyzed here were low (between 7.1 and 23.2), showing a good or sufficient freshness degree. The increased values of TVB-N/ 100 g samples were recorded in raw octopus samples (301.5) and *Loligo* spp. (275.2), these values being correlated with increased pH-values.

The water binding capacity was very high (75%) in fresh aqua-cultured pike-perch samples analyzed, which facilitated the sensory pleasant impressions during QDA. It was established here that the investigated exotic fishes and the two types of whitefish presented excellent hedonic and nutritional qualities and a reduced microbial load. QIM, usually applied only to marine fishes, was adapted here by original contributions also to freshwater fishes (rainbow-trout, whitefish).

Unpleasant artificial flavors, (geosmin and 2-methyl-isoborneol) injected in pike-perch muscle, in form of standardized solutions could not be detected by QDA, after boiling the samples their remanence being null. The detection of unpleasant flavors using the electronic nose is difficult or impossible, very different concentrations being practically very close to each other on the graph obtained, which proves yet a small degree of practical applicability of the method, the necessity and the peerless utility of sensory analysis using human senses.

The thesis ends with references' and appendices' part, followed by the CV in romanian, english and german languages.