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QUALITY ASSURANCE IN THE FISH INDUSTRY

Proceedings of an International Conference, Copenhagen, Denmark, 26-30 August 1991

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Foreword

The international symposium on "Quality Assurance in the Fish Industry" which was held at the Technical University, Lyngby, Denmark, august 26-30, 1991, was the result of a successful cooperation between the Technological Laboratory, Ministry of Fishery (FF) and the Food and Agriculture Organisation (FAO) of the United Nations, Rome. With this event, FF wished to celebrate its 60 years' anniversary, while FAO wished to acknowledge the importance of the subject and a long standing cooperation with FF by placing an Expert Consultation on the same subject at FF at the same time.

This arrangement turned out to be a very happy symbiosis improving the value and benefit for all participants. The editors therefore wish to express their sincere thanks to FAO for making this arrangement possible and for easy and excellent cooperation during the preparatory phase. In this respect we especially want to commend Mr. Hector Lupin, Project Manager and Mr. Ib Kollevik, FAO.

The symposium brought more than 200 scientists and industry representatives together from a total of 41 different countries from all over the world. This gave an unique opportunity for discussing all aspects of quality, how it can be measured and how it can be controlled during production and processing.

The editors wish to thank all people involved in making the present publication possible. The scientific committee are thanked for their help in planning the symposium and for reviewing the papers. All members of this committee are busy people, but the editors appreciate their willingness to assist us and their prompt reaction when action was needed.

A great number of people, staff and students of FF assisted in preparing and running the symposium. This assistance is gratefully acknowledged with special thanks due to Maria Henk, secretary, who worked for long hours taking care of practical matters as well as collecting, reviewing and retyping a number of the submitted manuscripts.

Finally the editors wish to express their sincere thanks to Dr. Lone Gram, scientific secretary. She made an outstanding contribution in keeping the wheels turning and holding everything together at all times: before - during - and after the symposium.

The editors feel that the present Proceedings provide the reader with a comprehensive and unique record of developments and thinking in the field of quality assurance and related scientific disciplines. Thus it should be a valuable document for all those working in the fish industry as well as in the research institutes.

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H.H. Huss et al., (eds.) Quality Assurance in the Fish Industry

Quality aspects of wild and reared fish

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Abstract

Fish muscle attributes such as appearance, colour, texture, taste and odour are highly species specific. The different species may be grouped into certain categories according to major characteristics, of which lipid content is one of the most important factors. Within each species biological variations are shown according to season, sexual maturity, fishing waters, etc. These variations are influencing the basic biochemical metabolisms. The protein metabolic changes have been studied extensively in species such as salmon (*Oncorhynchus* sp.) and cod (*Gadidae*) during and after the period of spawning. Depletion of protein and lipids from the muscle are frequently seen to affect the quality of the fish. The biochemical mechanisms have been investigated, including studies of proteinases active in the muscle. In addition to biological factors originating from the in vivo situation of the fish, quality variation is likely to occur during the catching of the fish and as a consequence of on board handling. The same applies to aquacultured fish, for which starvation before slaughtering and procedures for killing and gutting the fish deserves great attention.

INTRODUCTION

The biological factors affecting quality of the fish comprises basically 1) the inherent genetic features, i.e. species specific properties, and 2) the variability within a species caused by age, season, sexual maturity, access to feed, feed composition and the physical conditions experienced by the individual. The environments or habitat of the fish varies according to physical factors such as salinity, temperature, pressure and oxygen concentration.

The different species have adapted to a certain set of conditions. The variation within these conditions may change the metabolism of the fish in such a way that it affects the quality of the fish post mortem.

The quality parameters or features relevant to consider include taste, texture and appearance. The appearance is determined by the muscle structure, colour, transparency, etc. All these parameters will be affected by the biochemical metabolism in the fish

muscle, of which the protein and lipid conversions are considered the most important.

Inherent factors like amount of dark muscle used for continuous swimming activity, osmoregulatory properties, fat deposition etc., reflect the life pattern of the species considered. Further, when the fish is experiencing long migration, spawning and starvation, changes are seen in the muscle quality, measured as changes in post mortem pH, texture and water holding properties.

In aquacultured fish a marked change in properties is seen when feed composition and feeding regimes are varied. In contrast to wild fish, this opens for a possibility of determining the quality features of the harvested fish.

The literature concerning the biological factors affecting the fish in vivo is extensive. However, the present paper will be limited to studies of the impact on quality parameters for fish as food.

A qualitative description of the species specific properties may be done within the limits observed due to seasonal and other variations. Determinations in more quantitative terms are always difficult for fishes, as there is a large variation between individuals, particularly among wild fishes caught in the open sea. In aquaculture there is a possibility of reducing this variation by careful selection of a certain family of individuals raised under controlled conditions. However, great care should be taken when comparing the results from such experiments with measurements made on wild fish.

In addition to the individual variation in fishes, another difficulty arises when parts of the muscle are to be sampled for structural studies or for chemical analyses. This is due to the muscle anatomy with varying muscle cell dimensions along the body length. There is also reason to believe that the metabolic features in the different parts of the muscle may be different.

When reporting results of fish muscle investigations, it is therefore of particular importance to accurately describe the history before sampling, and the sampling procedure itself.

The literature on the biological factors responsible for the properties of fishes have been reviewed by Malcolm Love in "The Chemical Biology of Fishes" in 1970 [ref. 1] and in 1980 [ref. 2]. The present paper is just scratching the surface of the subject in comparison to these reviews.

SPECIES SPECIFIC PROPERTIES

A basic knowledge of the fish as a raw material is essential when processing procedures are to be selected and when the fish is to be cooked or in other ways prepared before consumption. The features making the fish suitable for various procedures are often found to be species specific. Some features may be shared by several species.

Thus, the different fish species may be grouped into a number of categories, each with its characteristic features. However, literature describing the inherent biological features for a given species in the context of application as food is limited. Usually these biological aspects are overlooked or taken for granted. Further, seasonal variation, effects of spawning and starvation, etc. are often described in general terms regardless of species.

In the following, the inherent biological properties of some commonly known species will be discussed.

The white fishes, of which cod (*Gadus morhua*) and other gadoids are the most well known, are characterized by their white flesh, a muscle that flakes when cooked, and a firm, elastic tissue [ref. 3]. The relative optical density of the raw muscle has been measured by Love [ref. 1], and the normal condition is described as bluish translucent. The optical density is apparently dependent upon the actual water content of the muscle, and may thus change into a less translucent, more white opacity if protein is depleted and water content increased.

The texture, which in raw muscle normally is firm and elastic, may upon storage in ice change into a soft and less elastic state. The texture after cooking will change correspondingly. Another typical feature of fresh, high quality white fish fillet, is its ability to separate into flakes after cooking. The flaking is usually reduced as the fish is stored for several days. This is probably due to softening of the muscle fibers, rather than changes in the collagen in the myocommata.

Large fish is considered to be slightly tougher than small fish [ref. 4]. This is seen in most species, and is possibly caused by a more coarse muscle structure in the large fish. In addition an effect of a slight ageing of the collagen may occur.

The taste of fresh cod and other white fishes is frequently termed neutral to slightly seaweedy. After short storage time, this fresh, sometimes called species specific taste, disappears. The nucleotides metabolize enzymatically to inosine and eventually hypoxanthine, and it has been suggested that these or intermediate metabolites may contribute to flavour development when the fish is stored [ref. 5].

Inosine monophosphate (IMP) is formed during the first 2-3 days storage. The compound itself being neutral to slightly "meaty" may intensify the taste of other compounds present [ref. 6]. Hypoxanthine has been described to be bitter [ref. 7].

Other aroma compounds have been characterised for the white fishes and a large number of other species [refs. 8 and 9].

Cod muscle has good functional properties. This is a feature that is necessary when a minced preparation of the muscle is used for making a gelled or emulsified product. Traditional products of this type are fish balls or fish cakes, and the surimi-type products, for which a washed mince is used. It is very important that the colour of the surimi, usually made from Alaska pollack (*Theragra chalcogramma*), is white.

Other fishes in the cod-family have slightly different properties, but the major characteristics are the same. In some species, like the saithe (*Gadus virens*), the colour of the tissue is darker, resulting in a grey appearance when cooked. Proper bleeding is very important, as a quality reduction due to a dark grey fillet colour otherwise will be the result.

Among other species that could be compared to cod may be mentioned the European hake (*Merluccius merluccius*) [ref. 10] and the blue whiting (*Micromesistius poutassou*) [refs. 11 and 12], for which the chemical composition, technological properties and seasonal variation have been described.

One of the most studied small, pelagic fishes with high fat content is the herring (*Clupea harengus*) [ref. 13]. The raw fillet is grey with a soft, but still elastic texture when of good quality. Storage makes the tissue less elastic.

When the herring is consumed fresh, it is typically fried before serving. The muscle

becomes more white when cooked, but more characteristic, a strong smell and a fairly strong taste is noticed.

The functional properties of herring are not as good as those of the white fishes, and in addition the dark coloured muscle and fat that easily becomes rancid makes this fish less suitable for mincing.

Unlike the lean fishes that store the triglyceride energy reserves in the liver, the herring stores triglycerides underneath the skin, in fat cells in the muscle, and as fat deposits in the belly cavity. The latter accumulates in the later stages of heavy feeding periods, and the fat appears solid toward the end of the feeding period.

The variation in total fat content may be considerable, from less than 1% immediately after spawning, to more than 20% before the spawning time approaches [ref. 13]. Together with the size of the fish and sexual maturity stage, the state of the fat deposits of the fish determines the suitability for processing into various products. The herring thus represents a fish species, whose biological variation has the utmost consequence for the application as food.

Another fatty fish is the mackerel (*Scomber scombrus*), which also has fat deposited under the skin and in fat cells distributed in the muscle. In addition, the mackerel has its characteristic high content of dark muscle.

The texture of mackerel is very soft, with a delicate, characteristic taste both in the fresh state and even when processed into canned products.

The tuna fishes (*Thunnus* sp.) are related to mackerel, but usually much larger when fully grown, and with a more red-coloured tissue. As the size of the fish is increased, the tissue becomes more coarse and may appear tough and dry after cooking. The delicate colour, taste and texture of the muscle makes it well suited for consumption in the raw state.

Large muscle cells making the tissue coarse but still delicate is also seen in large halibut (*Hippoglossus hippoglossus*) which could be characterized as a moderately fatty fish [ref. 14]. The fillet is white and has a neutral taste when cooked, but the texture may sometimes resemble the texture of animal meat like pork.

The salmon and trout (*Salmo* or *Oncorhynchus* sp.) may have a muscle with a fairly high fat content, and is additionally characterised by a red or red to orange colour [ref. 15]. This colour comes from carotenoids present in the feed, and creates a large natural variation in the wild fish, ranging from almost white in Baltic salmon to a deeply red colour in Pacific salmon.

After several years of marketing aquacultured salmon, a red colour is clearly preferred, being one of the most important quality features of this species [ref. 16]. Addition of carotenoids or naturally coloured crustaceans to the feed to obtain the desired colour is therefore very important for the salmon farmers.

These examples of typical groups of fish species clearly show the large biological variation leading to a considerable variation in fillet composition and properties among the species. The different features determine the use of the various species for processing.

In most cases the knowledge of processing properties is based on experience. Thus, the lean species with white tissue is suitable for fresh consumption or preservation by salting or drying, while the fatty species are more suitable for processing like smoking, marinating or canning. However, production of some traditional products requires not only