eISBN: 978-1-68108-267-7
ISBN: 978-1-68108-268-4

PRACTICAL NOTIONS ON FISH HEALTH AND PRODUCTION

Editors:
Maria Manuela Castilho Monteiro de Oliveira
Joana Isabel Espírito Santo Robalo
Fernando Manuel D'Almeida Bernardo

Bentham e Books

Practical Notions on Fish Health and Production

Edited By:

Maria Manuela Castilho Monteiro de Oliveira
Laboratory of Microbiology and Immunology, Avenida da Universidade Técnica
Lisbon, Portugal

Joana Isabel Espírito Santo Robalo
Eco-Ethology Research Unit, ISPA-IU R. Jardim do Tabaco, 34, 1149-041
Lisbon, Portugal
&

Fernando Manuel D'Almeida Bernardo
Faculdade de Medicina Veterinária, Universidade de Lisboa
Avenida da Universidade Técnica
1300-477, Lisboa, Portugal

Practical Notions on Fish Health and Production

Editors: Joana Isabel Espírito Santo Robalo, Ana Cristina Gaspar Nunes Lobo Vilela & Maria Manuela Castilho Monteiro de Oliveira

ISBN (eBook):978-1-68108-267-7

ISBN (Print): 978-1-68108-268-4

First published in 2016.

Bentham Science Publishers Ltd.
Executive Suite Y - 2
PO Box 7917, Saif Zone
Sharjah, U.A.E.
Email: subscriptions@benthamscience.org

CONTENTS

FOREWORD

Fish health, both of farmed and wild productions, is requesting continuous upgrading not only to avoid significant losses but also to facilitate seafood security and safety. The work in this field is complex, as many different factors need to be considered in relation. Preventive fish health work has to be based on knowledge, not limited to the fish, but relating to all aspects of the conditions under which the fish exist, is traded and processed. Although important literature has been accumulated on this area, there is undoubtedly a need to have contemporary and practical knowledge in this respect summarized in one volume.

This difficult work was undertaken by well-known professors from the Faculty of Veterinary Medicine of the University of Lisbon, authorities on the covered subjects. In this practical, but very comprehensive book, the authors envelop three sections encompassing the general biology, sensible concepts on fish health and useful notions on fish production. The first section includes a brief review on particular features of fish anatomy and physiology as well as the embryonic and larval development. The second section comprises of three chapters devoted to aquaculture and diagnosis practices, infectious and parasitic diseases of fish, and anesthesia and surgery in fish. The last section contains relevant information on the fishery production, catch, trade and processing and the official veterinary inspection practices.

The combined issues offered in this book, well written and well arranged, confirming thus the authors´ rich experience, make this publication an excellent modern key work. Certainly it will have a great impact on the enhancement of fish health and production, allowing also a better understanding of fish health implications on the aquatic systems and furthermore contributing for seafood processing, security, quality and safety. This volume will be undoubtedly appreciated as an important source of information for scientists, university students, authorities, fish farmers, fishermen and fish processors.

The book as a whole is of a high standard, and I am convinced that the readers will find it very valuable for their professional and research activities and a significant contribution for understanding the fascinating complexity of the fauna of our planet. Both the authors and the editor are to be congratulated on this publication.

Maria Leonor Nunes
Principal Scientist
Coordinator of Aquaculture and Seafood Valorization
Portuguese Institute of Sea and Atmosphere
Lisbon, Portugal

PREFACE

Industrial fishing activity is limiting natural fish populations and aquaculture seems to be the only sustainable alternative.

Fish stock management in the wild implies the monitoring of several ecological parameters concerning the evolution of fish population, namely mortality, growth, availability of feed, predatory acts and climate changes. One of the most predictable consequences of global warming is ocean water acidification due to the increasing CO_2 concentration in the atmosphere. This achievement may have a significant impact on trophic chains affecting namely synthesis of exoskeleton of marine zooplankton based on $CaCO_3$.

Aquaculture productivity is conditioned by several factors, including feed and health management, species behavior, reproduction requirements and water characteristics in captivity. Inadequate management procedures may have significant impact on fish health and welfare and subsequently lead to severe economic losses for producers and regular market supply.

In fact, these activities are inter-dependent, since for instance the feed management in aquaculture is dependent on fish capture from the wild. All is connected and related, requiring contributes of different levels of interdisciplinary knowledge for an adequate management including contributions of politicians, judicial authorities, biologists, veterinarians, public health entities, producers and consumers.

In terms of aquatic productivity, interaction between veterinarians and biologists is crucial. Practitioners and researchers of both areas must cooperate, share knowledge, and develop complementary research activities.

This text book aims to contribute to an integrated approach concerning practical notions of ichthyology, fish health and production systems. It is an attempt to contribute to fish related research in biology and veterinary sciences.

The book is organized in three sections. The first includes two reviews on general aspects of fish biology and development and the second included three chapters on fish health related subjects. The remaining three chapters are included in the last section, devoted to fish production aiming food chain supply.

We would like to thank all authors who have contributed to this book and all people who somehow helped us to bring it to daylight, including our family, friends, colleagues and students.

Unfortunately, during the drafting process of this book, two of our major contributors passed away, rendering additional challenges to text edition. However, a comprehensive attitude from our publishers allowed us to overcome the moments of discouragement. For that we would like to express our deepest gratitude.

Professor Cristina Vilela (1958-2013) was a Full Professor with Tenure and the Vice-Dean of the Faculty of Veterinary Medicine of the University of Lisbon. Her main research areas were Clinical Microbiology and Mucosal Immunology, but as a devoted scientist she was also interested on several subjects related to Veterinary Sciences, namely on fish infectious diseases. Her dedication to science and teaching was exceptional, and she will be deeply missed.

Professor VítorAlmada (1950-2013) was a Full Professor with Tenure at ISPA-IU in Lisbon. He started his research activity studying the behavior of littoral fishes, but soon started to spread his research to the ecology, genetics and biogeography of both freshwater and marine fishes. He was a devoted researcher and teacher and also an enthusiastic naturalist. Always happy to build bridges between sciences and research topics, he is, and certainly will be, a reference to present and future fish researchers. His work will last in the form of published papers and in the research of his students. We will always miss him.

Both were wonderful scientists with long and productive carriers. But most of all they were dear friends so this book is dedicated to their loving memory.

Manuela Oliveira
Laboratory of Microbiology and Immunology
Avenida da Universidade Técnica
Lisbon, Portugal

Joana I. Robalo
Eco-Ethology Research Unit
ISPA-IU R. Jardim do Tabaco
34, 1149-041, Lisbon
Portugal
&
Fernando Bernardo
Faculdade de Medicina Veterinária
Universidade de Lisboa, Avenida da Universidade Técnica
1300-477, Lisboa
Portugal

List of Contributors

Ana Faria	Eco-Ethology Research Unit, ISPA − Instituto Universitário, R. Jardim do Tabaco 34, 1149-041, Lisboa, Portugal
António Pedro Correia Margarido	Direção Geral de Alimentação e Veterinária, Largo da Academia Nacional de Belas Artes 2, 1249, Lisboa, Portugal
Cláudia Faria	Instituto de Educação da Universidade de Lisboa, Alameda da Universidade, 1649-013, Lisboa, Portugal
Fernando Bernardo	Faculdade de Medicina Veterinária, Universidade de Lisboa, Avenida da Universidade Técnica, 1300-477, Lisboa, Portugal
João Afonso	Centro de Investigação Interdisciplinar em Sanidade Animal, Faculdade de Medicina Veterinária, Universidade de Lisboa, Avenida da Universidade Técnica, 1300-477, Lisboa, Portugal
Manuel Abreu Dias	Alicontrol, Tecnologia e Controlo de Alimentos, Lda., Rua Fernando Vaz, lote 26-B, 1750 108, Lisbon, Portugal
Maria Gabriela Lopes Veloso	Faculdade de Medicina Veterinária/Universidade de Lisboa, Avenida da Universidade Técnica, 1300-477, Lisboa, Portugal
Maria João Fraqueza	CIISA/Faculdade de Medicina Veterinária, Universidade de Lisboa, Avenida da Universidade Técnica, 1300-477, Lisboa, Portugal
Miguel José Sardinha de Oliveira Cardo	Direção Geral de Alimentação e Veterinária, Largo da Academia Nacional de Belas Artes 2, 1249, Lisboa, Portugal Faculdade de Medicina Veterinária/Universidade de Lisboa, Avenida da Universidade Técnica, 1300-477, Lisboa, Portugal
Nuno Pereira	Oceanário de Lisboa, Esplanada D. Carlos I, 1990-005, Lisboa, Portugal Faculty of Veterinary Medicine, Universidade Lusófona de Humanidades e Tecnologias, Lisboa, Portugal ISPA, Instituto Universitário, Ciências Socias, Psicológicas e da Vida, Lisboa, Portugal IGC, Instituto Gulbenkian de Ciência, Oeiras, Portugal
Paula Cruz e Silva	Direção de Serviço De Alimentação e Veterinária, Avenida do Mar e das Comunidades Madeirenses, n° 23, 2° andar9000-054 Funchal, Portugal
Rita Borges	Centre of Marine Sciences, CCMAR, University of Algarve, Campus de Gambelas, 8005-139, Faro, Portugal Eco-Ethology Research Unit, ISPA − Instituto Universitário, R. Jardim do Tabaco 34, 1149-041, Lisboa, Portugal

CHAPTER 1

Particular Features of Fish Anatomy and Physiology – A Brief Review

João Afonso[*]

Centro de Investigação Interdisciplinar em Sanidade Animal, Faculdade de Medicina Veterinária, Universidade de Lisboa, Avenida da Universidade Técnica, 1300-477 Lisboa, Portugal

Abstract: Besides basic anatomical and physiological features common to all fishes, due to the aquatic environment they share, there are some very significant differences. Such differences range from major ones common to all species within each main group, namely cyclostomes, chondrichthyans and osteichthyans, to more limited ones between different species within each group. Even the latter can be very significant, conditioning, for instance, the feeding behavior/strategy of a given species or its reproductive ability. Some of the main anatomical and physiological features of the different fishes are briefly reviewed, since a good knowledge of such features is crucial to understand the behavior of each species in the wild and/or to assure the most correct management of its populations either in captivity or in the wild.

Keywords: Anatomy, Chondrichthyans, Cyclostomes, Osteichthyans, Physiology.

INTRODUCTION

Fishes are aquatic, vertebrate animals, with fins as appendages and gills that allow them to breathe by absorbing water oxygen [1]. They are also ectothermic (or "cold-blooded") animals [1 - 3] (although some fishes, such as tunas, can keep their body temperature some degrees above the temperature of the surrounding water, the former still varies as the latter varies) [4].

While all fishes are very well adapted to the aquatic environment where they live,

[*] **Address correspondence to João Afonso:** Faculdade de Medicina Veterinária, Universidade de Lisboa, 1300-44 Lisboa, Portugal; E-mail: jafonso@fmv.ulisboa.pt

Manuela Oliveira, Fernando Bernardo, Joana I. Robalo (Eds.)

there are some very significant differences that justify the division of modern fishes into cyclostomes (hagfishes and lampreys), chondrichthyans (or cartilage fishes) and osteichthyans (or bony fishes). Even within any of these groups there is considerable variability between different species, concerning both external and internal features.

EXTERNAL FEATURES

Body Shape

While the general body structure of a fish is designed for ease of movement in water, fish show a large variety of shapes and sizes, depending on their way of life and on their specific habitat [3, 5]:

- Fish living near the surface usually have a long and fusiform shape, adequate to swim quickly for considerable periods of the time or to allow big bursts of speed.
- Mid-water fish are usually laterally compressed, for easy movement through aquatic vegetation and crevices of rocks and reef where they hide from predators or forage (*e.g.*, angelfish).
- Benthic or bottom-dwelling fish are usually flattened from top to bottom, to conform to the bottom where they live (*e.g.*, rays).

Fins

Fish have fins which they use to maintain position, help balance, move, steer and stop.

Some fins are paired, corresponding, in some manner, to the pectoral and pelvic limbs of mammals – these are the pectoral and pelvic fins, supported by the pectoral and pelvic girdles and placed on both sides of the body. Other fins, such as dorsal, caudal (or tail) and anal (or ventral) fins, are unpaired, being placed in a median position.

In most fishes, pectoral fins are placed just behind the operculum and are used essentially to help a fish to turn, climb or dive, or stop, but may have other functions, such as a propelling one, either helping in swimming (*e.g.*, rays) or, for instance in the case of some bottom-dwelling species (*e.g.*, frogfishes), helping the fish to move around over the surface where it lives [2, 3, 6 - 8]. These fins may also present touch receptors or spines [5, 9]. In rays, the pectoral fins are expanded and connected to the sides of the head, being responsible for the flattened body of these fishes [10, 11].

In osteichthyans the pectoral girdle consists of two sets of endochondral (coracoid, scapula and four radials) and dermal bones (post-temporal, supracleitrum, cleithrum and postcleithrum) articulated with the neurocranium [3, 8, 10 - 12].

In chondrichthyans the pectoral girdle consists of a U-shaped coracoscapular cartilage – the paired coracoid parts are fused ventrally while the scapular parts form the extremities which are projected dorsally on each side [8, 10]. In sharks this cartilage is not connected to the axial skeleton [5], but in rays the scapular parts are connected to the vertebrae [8].

Pelvic fins are placed in the ventral region of the body, in any position cranial to the anal fin (eventually even ahead of the pectoral fins, as in the cods), and add stability in swimming [2, 3]. In some fishes, they are also used to reduce their speed. Some fishes present modified pelvic fins, such as thread-like appendices with a tactile function (*e.g.*, gouramis) or a disc-like sucker structure (*e.g.*, gobies), for instance. Male chondrichthyans have modified pelvic fins, called claspers, which are used as intromittent organs for internal fertilization [13, 14].

The pelvic girdle is much less developed than the pectoral girdle, namely in osteichthyans, and not connected to the vertebral column [11].

In osteichthyans the pelvic girdle consists of two endochondral bones called basipterygia [12], which may be separated or fused, while in chondrichthyans the pelvic girdle is just a cartilaginous bar, the ischiopubic bar, placed transversely on the caudoventral part of the trunk [4, 11].

Cyclostomes have no pectoral or pelvic girdles, nor paired fins [3, 7, 12, 15]. In fact, hagfishes do not have any true fins, but just a rudimentary caudal fin consisting of a skin fold that runs around the caudal end of the body and extends

CHAPTER 2

Embryonic and Larval Development

Rita Borges[1,2,*], **Ana Faria**[2] and **Cláudia Faria**[3]

[1] *CCMAR, CIMAR-Laboratório Associado, University of Algarve, Campus de Gambelas, 8005-139 Faro, Portugal*

[2] *MARE-Marine and Environmental Sciences Centre, ISPA-Instituto Universitário, Rua Jardim do Tabaco, 34, 1149-041 Lisboa, Portugal*

[3] *Instituto de Educação da Universidade de Lisboa Alameda da Universidade, 1649-013, Lisboa, Portugal*

Abstract: Fishes have a great diversity of reproductive strategies and associated traits, as well as complex life-cycles with multiple stages. This chapter briefly introduces different, commonly found, reproductive strategies and focus mainly on the early stages of fish life cycles, in particular eggs and larvae. Most fishes are iteroparous, spawning several times during their life, but some species, semelparous, adopt an extreme strategy, spawning only once in their life cycle.

There is a great diversity of fish egg types and adaptations, and they can be classified as either pelagic or demersal, depending on where they occur in the environment. The embryonic development depends on the species, and also on abiotic factors such as temperature, oxygen and salinity. The ontogenetic development that starts during the embryonic stage continues during the larval life. During this phase, fundamental structural and functional changes will occur in a short period, increasing the larval abilities to interact with the environment. Depending on the species reproductive strategy and life history, newly hatched larvae can vary from very small and poorly developed, to larvae that hatch larger with developed sensorial and functional capabilities; some larvae can even resemble the adults at hatching.

Keywords: Early ontogeny, Embryonic development, Fish eggs, Fish larvae, Larval development.

* **Address correspondence to Rita Borges:** MARE-Marine and Environmental Sciences Centre, ISPA-Instituto Universitário, Rua Jardim do Tabaco, 34, 1149-041 Lisboa, Portugal; E-mail: rborges@ispa.pt

Manuela Oliveira, Fernando Bernardo, Joana I. Robalo (Eds.)

INTRODUCTION

Reproduction can vary according to the breeding system, gender role, spawning habitat, spawning season, fecundity, among other features [1]. Most fishes are iteroparous, spawning several times during their life [2]. For these species, there are seasonal cycles of reproduction that are usually controlled by endogenous rhythms and synchronized in response to physical variables such as temperature and photoperiod [3]. The spawning strategy in each seasonal cycle can also vary: some species spawn only once in each breeding season (total spawners), while others release eggs in several batches over the spawning season (batch spawners). Some species adopt however an extreme strategy spawning only once in their life cycle (semelparous breeders) and investing all energy in a single, massive reproductive episode, followed by death [2].

Developing embryos can depend on maternal or yolk provisioning [2]. Viviparous species, also known as live-bearers, have internal fertilization and embryos develop within the female, giving birth to free-living larvae or juveniles. The vast majority of fish species are, nonetheless, oviparous [2], producing eggs that are spawned and made fertile afterwards. In this case, an egg membrane is present and the embryo is entirely nourished by the yolk.

Terminology

After spawning and fertilization, distinct developmental stages characterized by dominant physiological processes will succeed during fish life cycles. Several terminologies for intervals of fish development have been proposed, and there is not a single, widely accepted classification system given the variety of ways in which fishes develop. The terminology used in the present chapter for the early stages of fish life-cycles is based on the widely used system of [4] (Fig. **1**) as follows:

- "Egg stage": from fertilization to hatching;
- "Larval stage": from hatching to attainment of complete fin rays development and beginning of squamation (arrangement of scales on the skin). An important event during this stage is the flexion of the tip of the notochord that accompanies the hypochordal development of the caudal fin;

• "Juvenile stage": besides fully developed fin rays, there is a loss of larval characters and the completion of squamation. The individual already resembles the adult. The juvenile stage lasts until fish enters adult population or attain sexual maturity.

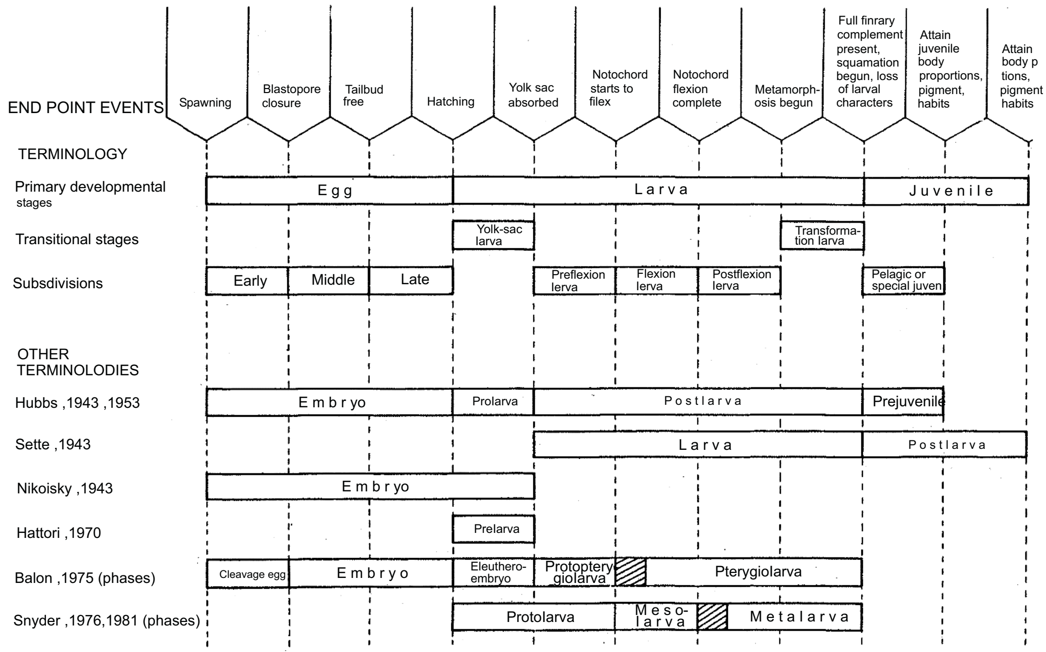

Fig. (1). Terminology of early life history stages [Adapted from [4], permission granted by ASIH].

Transitional stages can sometimes be recognized, such as a "yolk sac larval stage" (development stage beginning with hatching and ending with exhaustion of yolk reserves and characterized by the presence of a yolk sac); and a "transformation stage" (usually coincident with the beginning of metamorphosis, which is only considered complete when the fish assumes the juvenile features).

FROM FERTILIZATION TO HATCHING: THE EGG

There is a great variety of fish egg types and adaptations, with a large diversity in morphological and physiological traits. Fish eggs can be classified as pelagic or demersal, depending on where they occur in the environment. Pelagic spawning is the most common spawning mode in the marine environment, regardless of adult

CHAPTER 3

Introduction to Aquaculture

Paula Cruz e Silva*

Direção de Serviço De Alimentação e Veterinária, Avenida do Mar e das Comunidades Madeirenses, n° 23, 2° andar, 9000-054 Funchal, Portugal

Abstract: Farmed fish have been produced for more than four thousand years, but the most significant developments only arise in the last 50 years. Nowadays, fish and crustacean obtained in aquaculture systems represent almost 45% of all the fish products placed in the global market, about 160 million tons. Aquaculture involves human intervention in the life cycle of the cultivated organisms, and requires special techniques applied to housing, reproduction, feeding, fattening, healthcare and package to market distribution. The fish farms location depends on the species, space availability, climatic characteristics and environmental impacts. Most common regimes of exploitation are intensive, especially when they are intended for productions to be placed on the global market. Different production systems have distinct requirements in terms of ecological, reproductive and sanitary management, and their control is mandatory for the economic success of the aquaculture system. Health management is a key issue for the success of animal exploitation system.

Keywords: Aquaculture in ponds and raceways, Diseases diagnosis, Fish growing and fattening, Fish necropsy, Hatchery systems, Open-water aquaculture, Treatment and prophylaxis.

PRACTICAL NOTIONS FOR AQUACULTURE ESTABLISHMENT

One of the primordial factors to establish sustainable fish farm activities is the selection of place for its implantation. Aquaculture structures may be located in land, by the seashore, inshore and offshore (marine aquaculture). Most of the times, the most adequate locals for implantation of fish of farms of fresh, salt or

* **Address correspondence to Paula Cruz e Silva:** Direção de Serviço De Alimentação e Veterinária, Avenida do Mar e das Comunidades Madeirenses, n° 23, 2° andar, 9000-054 Funchal, Portugal; E-mail: paula.silva@netmadeira.com

Manuela Oliveira, Fernando Bernardo, Joana I. Robalo (Eds.)

brackish water, compete with agricultural practices or are located in geographic areas belonging to natural reserves. Due to this fact, a clear balance between environmental protection and economic development must be found [1].

Fish cultures implantation local is still dependent on the species to be harvested. Indigenous species should be preferentially chosen, since the physical and chemical composition of the water is more adequate for the development of the species. Market research and consumer preferences must also be taken into consideration in order to evaluate if the species are accepted by the consumer, in order to assure sustainability [2,3].

Another factor that can influence the choice of the implantation site is the material nature of the layout structures (ponds, cement and fibreglass tanks, metal cages, silos, frame nets) and also the regime of exploitation (intensive, semi-intensive, extensive).

In addition, other factors must be considered, including the proximity to the markets for products distribution (freshness), transportation facilities and the region climate, including water and air temperature, wind's regime and rainfall.

Regarding the water characteristics, which are major determinants on the success of a fish farm, several factors must be considered, including physical and chemical characteristics such as temperature, pH, suspended solids, solved gases and mineral content. Among these, it is important to refer the temperature, which affects fish life and growth. An optimum temperature can be established for the development of each fish species, and outside the eugenics temperature range, a decrease on the conversion rate and growth may be observed. Temperature variations also represent a stress factor and can also be responsible for disease development and for the success of spawning and egg hatching at the maternities.

AQUACULTURE IN PONDS AND RACEWAYS

In ponds, the constitution and characteristics of the land must also be taken into consideration, as well as the facilities for water runoff and ponds renewal. For an optimal water renewal, which improves fish handling, the pond must have a minimum inclination of 2% and water channels at the bottom.

In pond aquaculture systems, the soil characteristics are especially relevant, due to the necessity of dike construction to guarantee the detainment of the water column. Soil texture and porosity are the most important physical properties.

Intensive culture systems can also be applied, using raceways and circular tanks. Raceways are long tanks, with a water column of approximately one metre and preferably with a water inlet and outlet at each extreme. In circular tanks, there is usually a central water outlet and a peripheral water inlet. Therefore, the water flows with a vortex effect that promotes walls hygiene.

In raceways the fish stock density may be higher due to the constant water renewal, while the ponds just have one or two water renewals per day. They are grouped in series, by size, corresponding also to different age groups. In this production system, disease prevention is more difficult, as water moves between tanks. In fact, the water that comes out from the one tank must not be used in others to avoid pathogen dissemination.

OPEN-WATER AQUACULTURE

Open-water aquaculture can be performed in the ocean or in fresh water bodies, and may be applied to molluscs and fish. Rearing fish in off-shore cages is a quite promising practice in several European countries, including Portugal and Norway, but is a frequent traditional practice in some Asian countries and in America, the viability of the producing units in offshore systems is dependent on the quality of the marine environment and must take in consideration environmental impacts, namely aquatic animals' migration [4]. This production should not cause conflict with the ecosystem and other economic activities. Due to these facts, it is fundamental to determine which coastal areas are appropriate. When choosing the location of sea water cages there are logistic, oceanographic and environmental factors that must be considered (Table **1**).

Regarding the ecosystem characteristics, several parameters must be considered (Table **2**).

In addition to these factors, there are also official regulatory restrictions and concurrent recreational activities that may take place in the same spatial locations

CHAPTER 4

Microbial and Parasitic Diseases of Fish

Fernando Bernardo[1,*]

[1] *Faculdade de Medicina Veterinária, Universidade de Lisboa, Avenida da Universidade Técnica, 1300-477 Lisboa, Portugal*

Abstract: Diseases of fish, caused by biological agents (bacteria, fungi, virus or parasites), are better known in farmed or ornamental fish, since the access to the affected fish coming from the natural environment is less probable. In fact, the fish that are infected by a specific pathogenic agent, natural inhabitants of the marine, estuarine or freshwater ecosystems, are rapidly eliminated from its biotopes by other predatory animals, due to its higher vulnerability and susceptibility to the social interactions.

Diffusion of pathogenic bacteria, fungi, virus or parasites in the aquatic environments is more efficient than in the terrestrial ones. Diagnosis and therapeutics of fish disease have specific difficulties and the application of preventive measures is a very complex issue. Some of those diseases have the same epidemiological problems of the infectious diseases of the terrestrial animals: High spread of diffusion, very significant economic losses, restrictions to fish travel or commerce and some (few) have zoonotic impacts.

Keywords: Diagnosis of fish disease, Disease of fish, Health status of fish farms, Icthyopathology, International sanitary certification.

INTRODUCTION

Bruno Hofer (1861-1916) was the first author to describe diseases of fish on a scientific perspective and the creator of a new discipline - Icthyopathology. Since those early times, in the begining of the 20th Century, many evolutions were achieved concerning the study of microbial and parasitic fish diseases. Transmission of pathogenic bacteria, fungi or virus in the aquatic environments

* **Address correspondence to Fernando Bernardo:** Faculdade de Medicina Veterinária, Universidade de Lisboa, Avenida da Universidade Técnica, 1300-477 Lisboa, Portugal; Email: fbernardo@fmv.ulisboa.pt

Manuela Oliveira, Fernando Bernardo, Joana I. Robalo (Eds.)

is certainly more efficient than in the terrestrial one. Water, where fishes leave, is simultaneously its table, food store, bedroom, nursery, bathroom, sanitation plant and grave for most of them. Exception is those that are fished for consumption, whose latest graves are the human dishes. Infectious diseases of fishes arise when susceptible species are exposed to microbial pathogens under adverse ecological conditions. Compared with the terrestrial animals, the volume of research workload carried out to assess aquatic animal health is markedly inferior, including the effect of water sanitation status on infectious fish diseases outbreaks. Although, there is much literature showing the occurrence of infectious diseases in stressed fishes due to inappropriate temperatures (stenohaline fishes), water eutrophication, polluted discharges, metabolic products of sub aquatic living organisms and many chemical or physical residues and contaminants thrown into water, its health impacts in fish are not appropriately assessed. In disgenesic conditions, and in natural ones, fishes are vulnerable to a wide range of parasites and microbial agents which potentially impact with its health status, welfare and lifetime expectations. Some of those infectious diseases have an epizootic evolution, with high rates of mobility and morbidity [1]. In the natural environment, the morbidity and mortality rates triggered by fish diseases, may impact the life of other creatures dependent of them to survive in the given ecosystem (aquatic birds, mammals and invertebrate) and may also affect the subsistence of the local human communities (piscatorial). For those fishes produced in aquaculture systems, the consequences of infectious and parasitic diseases also have very relevant economic and social impacts [2]. The potential wide spread of those diseases to other regions where the specific involved pathogens are not present, they enhance a very serious threat to the indemnity status of a previous free geographic zone. This is why a very particular attention must be given to the rules of fish commerce (local, regional and international). Of special concern are the pathogens carried accidentally by ornamental fish, traded all over the world, especially if local official veterinary services have not sufficient capacity building to diagnose and to control fish diseases in the international markets. Global commerce is a major source of concern for the spread of the infectious and parasitic disease agents. Due to this potential threat, many international agreements have been stated, aiming to avoid such problem. The international organization for animal health, OIE, published and review, regularly, the "Aquatic animal health code", an essential document for the risk management of fish health, at local, national and international levels. Systematic veterinary controls at borders are a crucial tool to avoid spreading of those agents. At local level, farmed fishes for food or ornamental proposes, must be scrupulously scrutinised, monitored, surveyed, with the propose to early detect the presence of any the infectious agents, especially those that may have major sanitary and economic impacts. Veterinary authorities also need to have in place official efficient plans for control, eradication or surveillance. Registration of all the nosologic events is absolutely necessary. Without that, sanitary certification for international trade is not possible. Most relevant infectious and parasitic diseases of fishes are reported in the "Aquatic animal health code" published by OIE, but, in general, the recognition of a specific infectious disease in fish is not an easy task. Major difficulties come from the lack of clinical signs, unless high mortality, stop growing, feed refuse, abnormal movements or colour modifications. Many fish diseases have the same symptoms or clinical signs.

BACTERIAL DISEASES OF FISH

There are many bacterial species living in the aquatic ecosystems (freshwater, estuary and marine) that are able to infect multiple fish species. Most are opportunistic agents attacking whenever the natural defenses of fish organism breakdown. Most frequent bacteria that may be incriminated in fish diseases are: *Aeromonas hydrophila* and *A. salmonicida* sbp. *salmonicida; Edwardsiella tarda* and *E. ictaluri; Vibrio* spp.; *Yersinia ruckeri; Renibacterium salmoninarum; Flavobacterium psychrophilum, F. columnaris* and *F. johnsonae; Piscirickettsia salmonis; Mycobacterium marinum* and *M. fortuitum; Nocardia asteroides* and *N. kampachi; Carnobacterium piscícola;* and *Pseudomonas anguilliseptica.* Some of these bacteria express their virulence inducing morbid situations, expressing or not clinical signals having some specificity, although this is not mandatory [3]. Those bacteria species enhance morbidity in different fish species, yielding a series of specific nosologies.

BACTERIAL HEMORRHAGIC SEPTICAEMIA

Aetiology: *Aeromonas hydrophila* is the opportunistic pathogen responsible for

CHAPTER 5

Introduction to Anaesthesia and Surgery in Fish

Nuno Pereira[1,2,3,4,*]

[1] *Oceanário de Lisboa, Esplanada D. Carlos I, 1990-005, Lisboa, Portugal*

[2] *Faculty of Veterinary Medicine. Universidade Lusófona de Humanidades e Tecnologias, Lisboa, Portugal*

[3] *ISPA, Instituto Universitário. Ciências Socias, Psicológicas e da Vida, Lisboa, Portugal*

[4] *IGC, Instituto Gulbenkian de Ciência, Oeiras, Portugal*

Abstract: Handling and manipulation of fish, requires, almost without exception, sedation or anaesthesia due to integument fragility and health as well as welfare considerations.

Integument adaptations to fish immersed life such as thin epidermis covered with a protective layer of mucous, intradermic scales and slender hypodermis must be protected during physical manipulations. Also, as sentient animals, fish must be spared the eventual pain and stress caused by husbandry, research and veterinary procedures.

Fish anaesthesia and surgery have become common procedures in ornamental fish industry, public aquaria and research, and in the case of anaesthesia and aquaculture.

Surgery is one of the reasons to anesthetize fish as these animals can undergo a variety of surgical procedures, from simple cutaneous interventions to more sophisticated intracoelomic and even cardiac or hepatic surgeries.

Keywords: Analgesia, Anaesthesia, Anaesthesia monitoring, Fish, Fish surgery techniques, Sedation.

ANAESTHESIA

Despite persistent controversy, there is a robust data supporting the concept of

* **Address correspondence to Nuno Pereira:** Oceanário de Lisboa, Esplanada D. Carlos I, 1990-005, Lisboa, Portugal; E-mail: npereira@oceanario.pt.

Manuela Oliveira, Fernando Bernardo, Joana I. Robalo (Eds.)

fish being capable of nociception or even pain perception. Observation of nociceptors in teleost fish, behavior and physiological responses to pain that are controlled by analgesics, are strong arguments to consider the alleviation of pain and distress in fish undergoing surgery or other potentially painful procedures [1, 2].

Nevertheless, partial or total absence of peripheral afferent neurons with unmyelinated axons (C-fibers: responsible for the “delayed dull pain associated with noxious stimuli”) in elasmobranchs can cast some doubts on their nociception or pain perception capacities. On the other hand, the presence of opiate receptors in elasmobranchs can point to the existence of some pain perceptions [3 - 5].

For those with a more skeptical approach to this discussion, prudency recommends that a precautionary principle should be followed. Therefore, when in doubt, it is preferable to consider that fish pain perception is a possibility and to implement measures to prevent and alleviate pain [4, 6, 7].

Furthermore, avoidance of unnecessary stress mitigates homeostasis disturbances and prevents serious health and economic consequences caused by secondary and tertiary stress responses [8].

Sedation and anaesthesia (Table **1**) are necessary to alleviate stress and eventual pain in husbandry, clinical and surgical procedures in aquaculture, ornamental fish industry, public aquaria and research. Procedures like weighing, sorting, vaccination, transport, clinical examination, surgery and euthanasia should be performed under different depths or stages of anaesthesia [1, 4, 9, 10].

Table 1. Definitions of sedation, narcosis, hypnosis, general and surgical anaesthesia [Adapted from 4, 11 and 12].

Sedation	Preliminary state of anaesthesia characterized by depression of the central nervous system with drowsiness, generally unaware of its surroundings, dulled sensory perception and possibly with some analgesia but responsive to painful stimulation. No gross loss of sensory perception and equilibrium.
Narcosis	Drug-induced state of deep sleep from which a patient cannot be easily aroused. Analgesia may be present or not.

(Table 1) contd.....

General anaesthesia	Reversible and controlled depression of the central nervous system with loss of sensory perception, hypnosis (sleep-like state), analgesia, suppression of reflex activity and relaxation of voluntary muscle. In this state, the animal is not arousable by noxious stimulation.
Surgical anaesthesia	General anaesthesia in a state/plane that provides unconsciousness, muscular relaxation, and analgesia enabling painless surgery.

In fish, as in mammals, birds and reptiles, various stages of anaesthesia (Table **2**) can be identified indicating the depth of anaesthesia, that is influenced by the anaesthetic drug chosen, dose and length of exposure. Other factors may also contribute to the depth of anaesthesia, induction and recovery time, namely fish species and size, besides also water parameters including temperature, pH, salinity and hardness [4, 6, 9, 13]. Depending on the species and induction time, these stages can be more or less obvious, being more evident in slower inductions [13].

Table 2. Stages of anaesthesia [Adapted from 1, 4, 6, 13 - 16].

Stage	Plane	Description	Signs	Comments
0		Normal	Voluntary swimming Normal reaction to visual and tactile stimuli, equilibrium, muscle tone and respiratory rate	
1	1	Light Sedation	Voluntary swimming Small loss of reaction to visual and tactile stimuli Normal equilibrium, muscle tone and respiratory rate	In transports can reduce stress and physical trauma
	2	Deep sedation	Absence of voluntary swimming Normal equilibrium Muscle tone and respiratory rate with small decrease No reaction to visual and tactile stimuli Only aware of gross stimulation Still responds to postural changes	Good plane for close visual observation and for minimal manipulation

CHAPTER 6

Fish Production, Catch, Trade and Processing on Board

António Pedro Correia Margarido[1], Maria Gabriela Lopes Veloso[2,*] and **Miguel José Sardinha de Oliveira Cardo[1,2]**

[1] *Direção Geral de Alimentação e Veterinária, Largo da Academia Nacional de Belas Artes 2, 1249 Lisboa, Portugal*

[2] *Faculdade de Medicina Veterinária / Universidade de Lisboa, Avenida da Universidade Técnica, 1300-477 Lisboa, Portugal*

Abstract: World fish production is growing due to an economic growth of developing countries, where the population has greater access to expensive animal protein. The livelihoods and income provided to those involved in the fisheries production and subsidiary activities is bigger than that provided by the agriculture. The substantial demand for fish and fish-based products and overcapacity of fishing fleets are, in turn, responsible for the overexploitation of marine resources and for the negative impact on the economy and wealth of the communities living on fisheries. A proper management of marine resources is important in order to avoid multilevel problems, such as ecological, economic, food security and people's wealth. *The international trade in fish and fishery products* must comply the WTO agreements and with the guidance documents developed by the Codex *Alimentarius* Commission. Maintaining the cold chain is one of the largest contributors to the improvement of the international fish trade. Some fishing vessels are adapted to a single method of catch or fishing gear, in spite of many of them being versatile and equipped for polyvalent captures. Regarding the hygiene requirements and the operations carried out on board to the fishery products, the fishing vessels are classified as primary production vessels, freezer vessels and factory vessels. These categories are independent of the size of the vessel or fishing gear and methods used. The most important is to carry out all the operations on board hygienically to maintain the sanitary quality of the product, avoid contaminations and minimize spoilage by temperature abuse.

* **Address correspondence to Maria Gabriela Veloso:** Faculdade de Medicina Veterinária, Universidade de Lisboa, Avenida da Universidade Técnica, 1300-477 Lisboa, Portugal; E-mail: gveloso@fmv.ulisboa.pt

Manuela Oliveira, Fernando Bernardo, Joana I. Robalo (Eds.)

Keywords: Certification, Fishing areas, Fleet, Hygiene, Inspection, Trade, World production.

WORLD PRODUCTION

During the last century, there has been a growing demand on food needs caused by a growing population which is expected to reach 8 billion by 2025. Additionally, some developing countries are currently experiencing a strong economic growth, with a growing middle class with a greater access to expensive animal protein. In this context, fish has contributed for 16.6 percent of the consumption of animal protein at the level of the world population in 2009.

In 2008, a population of over 6 billion people were fed by food of animal origin. By 2020, it is expected that this demand undergoes an increase of about 50% [1].

Over the past 50 years the world's supply of fish and fish-based food has grown dramatically in the period 1961-2009 in which the average growth rate was 3.2% per year, outpacing the increase in world population that was 1.7% per year. According to the data provided by FAO on fisheries and aquaculture at a global level [2], fish catch and aquaculture were responsible for the global supply of the world with about 154 million tonnes, of which 131 million tonnes were utilized as food.

The supply of fish *per capita* at world level increased by an average of 9.9 kg in the 1960s to 18.9kg in 2009 and preliminary studies estimate a further increase in fish consumption to 18.6 kg [2]. The figures for fish consumption *per capita* by region are 9.1 kg for Africa, 20.7 kg for Asia, 24.6 kg for Oceania, 24.1 kg for North America, 22.0 kg for Europe, 22.0 kg for Latin America and 9.9 kg for the Caribbean [2].

Between developed and developing countries there are obvious differences on the contribution of fish as a source of animal protein for human consumption.

A substantial part of the fish that is consumed in developed countries is imported, due to a constant demand and a decline in domestic fishing (in the last decade the reduction was 10%). In developed countries, the reliance on imports is projected to grow in the forthcoming years.

In several regions of the world, it became very soon apparent that the natural resources in the fisheries were finite. Although the world captures have maintained a fixed pattern since 1990, which is about 85-90 million tonnes, some changes are noted in trends of captures by country, fishing area and fished species.

Besides this fixed pattern of captures, the world demand on fish has increased and it is clear that the gap is being fulfilled by aquaculture production (Table **1**).

Table 1. World fisheries and aquaculture production and utilization (million tonnes/year) (FAO, 2012).

PRODUCTION	2006	2007	2008	2009	2010	2011
Capture						
Inland	9.8	10.0	10.2	10.4	11.2	11.5
Marine	80.2	80.4	79.5	79.2	77.4	78.9
Total capture	90.0	90.3	89.7	89.6	88.6	90.4
Aquaculture						
Inland	31.3	33.4	36.0	38.1	41.7	44.3
Marine	16.0	16.6	16.9	17.6	18.1	19.3
Total aquaculture	47.3	49.9	52.9	55.7	59.9	63.6
TOTAL WORLD FISHERIES	137.3	140.2	142.6	145.3	148.5	154.0

China is one of the countries where fish production suffered a major increase, mainly from aquaculture, given that their contribution to the global fish production increased from 7% in 1961 to 35% in 2010.

The 2012 FAO figures for aquaculture show that the inland world production suffered an increase of 2.1 to 3.6 Million tonnes each year from 2006 to current days, while the marine aquaculture only had an increase of 0.3 to 1.2 Million tonnes each year, in the same period. The Asian countries are largely responsible for the catch growth in inland waters. In 2010, production figures attributed to Asia a share of global production approaching 89%. In recent years the expansion of aquaculture in North America ceased, but in South America, there has been some growth. At Europe, several important producers have recently ceased expanding. Over the past decade the contribution of Africa to the world production increased from 1.2% to 2.2%. Oceania accounts for minor share of the

CHAPTER 7

Official Veterinary Inspection of Fish

Fernando Bernardo*

CIISA/Faculdade de Medicina Veterinária, Universidade de Lisboa, Avenida da Universidade Técnica, 1300-477 Lisboa, Portugal

Abstract: Fish and shellfish products have been used as food supply since immemorial times. Earliest evidences show that for more than one million years ago, manual capture of gastropods and bivalves bordering the sea shore waterfront have been crucial for survival, development and increasing of human communities. Fish products are a unique source of rich nutrients, being easy to digested, representing a very relevant source of indispensable amino acids, fatty acids, minerals and vitamins for many millions of people worldwide. However, only products obtained from healthy fish and maintained in hygienic environments are suitable for consumption and can present those nutritional advantages. If such products are not handled and or correctly processed, consumer health may be put at risk.

Keywords: Fish products health, Nutrition, Official control, Sea food safety.

INTRODUCTION

Inspection of Fish has been performed for many centuries. Since medieval times in Europe, there were individuals from burgs that were responsible for checking if fish sold in popular markets or streets was fitted for human consumption or were “injured by the sunshine warming”. The safety concept applied to fish products came from the Ancient Egypt, where priests declared that some particular fish were unfitted for human consumption, considering that fish without scales were “unclean”. In Ancient times, technologies to preserve fish were developed to assure populations fish supply. Phoenicians, along their trips through the

* **Address correspondence to Fernando Bernardo:** CIISA/Faculdade de Medicina Veterinária, Universidade de Lisboa, Avenida da Universidade Técnica, 1300-477 Lisboa, Portugal; E-mail: fbernardo@fmv.ulisboa.pt

Manuela Oliveira, Fernando Bernardo, Joana I. Robalo (Eds.)

Mediterranean Sea, sold many fish products, including “Oenogarum”, “Allec”, “Garum”, “Muria”, “Lymphatum” and “Liquamen”, previously processed by “salsamentum”. Romans expanded Phoenicians heritage. They would frequently ate fish and transmitted their habits to Western cultures. For many centuries, Europeans ate fish products dried and salted, as the fundamental base of their daily diet. Only after the Industrial Revolution, with the triumph of the Physiocratic doctrine, the red meat substitute fish in the consumption behaviour of occidental populations. In recent decades, the nutritional value of fish based diet has been acknowledged once again. However, modern consumers are more sensitive regarding the diet role in their survival and personal development. Today’s consumers are extremely aware of all diet factors that may affect their health, and fish and fishery products are included in such scrutiny [1]. The first principle to consider is the one that states that “it is not possible to obtain fish products fitted for human consumption when the originating fish have some kind of illness”. To assure fish health is crucial that all fish should be subjected to inspection by a veterinarian before being placed into market. Globalization of fish trading is a risk factor for microbial and parasitic diseases worldwide dissemination. Therefore, veterinary certification of the fish and fishery products health status is a key issue for public health safeguard. This inspection is especially important when fish is eaten raw, dry, partially salted or smoked. There are many hazards that can be present in fish meat, including: biological hazards (pathogenic bacteria, virus, parasites); chemical hazards (environmental contaminants, biotoxins, biogenic amines, drug residues from aquaculture, additives in processed fish), and physical hazards (spines, hooks, foreign bodies such as sand, mud or soil)

ASSESSING BIOLOGICAL HAZARDS

In some food products, potentially pathogenic bacteria, viruses and parasites may be present. These hazards may be associated with fish and fishery products and its consumption [2].

BACTERIAL HAZARDS

Pathogenic bacteria may cause illness in animals, including fish, humans and plants. They can be found in all environments including the aquatic one, and so, can be present on fish before and after capture [3]. Pathogenic bacteria carried by humans and terrestrial animals can also contaminate the aquatic environment *via* sanitary waters and contaminate fish and shellfish due to deficient hygiene practices before and after capture. Some of the potential pathogenic bacteria found in fish may cause food poisoning, either through toxins release or as a result of bacterial colonization or invasion. Exposure to these food poisoning agents can cause illness, being vomiting and diarrhoea the most common signals. Clinical expression depends on several epidemiological determinants, such as microorganism virulence, infective doses, and the consumers' health status, including the immunity competence, individual predispositions, age and previous contacts with the agent. To trigger infection, the presence and multiplication of pathogenic bacteria in fish is determinant, being necessary to ingest live pathogenic bacteria which have to multiply inside the host. Under these circumstances, fever will also appear. In food poisoning, bacteria do not necessarily need to be ingested alive, being sufficient the presence of previous excreted toxins in food before ingestion. In fish, specific pathogenic bacteria from water can contaminate fish and shellfish, being a potential food safety hazard: *Clostridium botulinum, Listeria monocytogenes, Plesiomonas shigelloides, Aeromonas hydrophila* and *Vibrio* ssp. *Clostridium botulinum,* specifically types B, E and F, can be regularly found in sludges. This specie is anaerobic and psychrotrophic (> +3.3 ºC), particularly the E type, which can be found in cold waters. It can produce toxins that are stable to salt or acidic treatments [4]. Toxins are responsible for a major disease, known as botulism, in humans, ruminants, wild ducks and carnivores. Botulism mortality rate is very high and hospitalization cares are crucial for recovering. Poor handling and deficient hygiene practices are risk factors for bacterial contamination and growth [5]; toxin release is increased by thermal shock that occurs during sterilization of canned and vacuum packed fish [6]. Different fishery products have been incriminated in botulism outbreaks. Clinical signals vary with toxin doses and individual vulnerability, from a mild illness with head hake and nausea 30 minutes after ingestion, to a severe comatose disease, often fatal. Typical poisoning clinical signs include visual impairment, mouth and throat sensibility loss, muscular incoordination and breathing difficulties. *Clostridium botulinum* proteolytic types

CHAPTER 8

Processed Fishery Products

Maria João Fraqueza[1,*] and **Manuel Abreu Dias**[2]

[1] *CIISA/Faculdade de Medicina Veterinária, Universidade de Lisboa, Avenida da Universidade Técnica, 1300-477 Lisboa, Portugal*

[2] *Alicontrol, Tecnologia e Controlo de Alimentos, Lda., Rua Fernando Vaz, lote 26-B, 1750 108 Lisbon, Portugal*

Abstract: Many fish preservation technologies are based on multiple hurdles used to inhibit or reduce biochemical changes and microbial contamination that leads to spoilage. This chapter aims to describe some of the most traditional technologies currently applied to fishery products based on the control of water activity, pH, oxide-reduction potential, temperature, relative humidity and gaseous composition of the atmosphere. Emergent technologies, such as Ohmic heating and microwaving; amongst others, can be seen with particular interest for future application at industrial scale. In fact, the combination of traditional and emergent technologies (thermal or non-thermal processes) in processed fishery products, might be the trend to achieve and supply safer and high quality products.

Keywords: Chemical treatments, Emergent technologies, Non-thermal treatments, Processed fishery products, Thermal treatments.

INTRODUCTION

A major purpose of the processed fish production is to preserve fish, minimising losses in the distribution chain, over time and space. Another important goal for that industry is to add value to raw fish materials, which might be related to the application of emergent technologies, in order to develop new fishery products. Nowadays, there is an increased demand of ready-to-eat food products, or those

* **Address correspondence to Maria João Fraqueza:** Faculdade de Medicina Veterinária, Universidade de Lisboa, 1300-477 Lisboa, Portugal; E-mail: mjoaofraqueza@fmv.ulisboa.pt

Manuela Oliveira, Fernando Bernardo, Joana I. Robalo (Eds.)

requiring little or no preparation before serving. So, the further industrial processing of fish is not only common, but also desirable, to sustain the demand for a wide variety of value-added products. Fishery products processing industry receives raw fish materials (sardines, tuna, cod, mackerel, anchovy, crustaceans, molluscs) directly from fishery and preserves them using traditional preservation technologies. Presently, these technologies are more mechanized and automated in some processing steps. Processed fishery products include preparations, canned, chilled, frozen, smoked and dried fish, crustaceans and molluscs. The technologies for fish preservation aim the inhibition or reduction of the metabolic and biochemical changes that lead to spoilage. These preservation technologies are based on the control of specific parameters such as water activity, pH, oxide-reduction potential, temperature, relative humidity and gaseous composition of the atmosphere surrounding food under packaging. In general, technological treatments are physical (thermal treatments: cooling, freezing, pasteurization, sterilization, Ohmic heating, microwaving, and non-thermal treatments: irradiation, high hydrostatic pressure, ultrafiltration, pulsating electric fields, ultrasound and even dehydration) or chemical (addition of sugar, salt, acids, additives), the last with repercussion on the chemical composition of foods. Some of these technologies are currently applied to fishery products processes (pasteurization, sterilization, dehydration, addition of sugar, salt, acids, additives), others have been tested but without large industrial application (irradiation) while emergent technologies, such as Ohmic heating, microwaving, high hydrostatic pressure, pulsating electric fields, may be seen with particular interest by industry. Many fish preservation technologies are based on Leistner's [1] multiple hurdle theory, such as pasteurization-refrigeration, cook-chill, modified atmosphere packaging - refrigeration, salting-drying, salting-smoking, drying-smoking and salting-marinating .

All these technological processes may be applied to raw fish material aiming to have the best quality; however, it is mandatory to assure food safety. With that purpose, not only unitary preservation technologies should be applied but also safety measures founded on proactive methodologies such as Hazard Analysis Critical Control Point (HACCP) method. Finally, proper waste structures should be included in fish processing operations.

PRELIMINARY PROCESSING FISH OPERATIONS

The type of raw fish material affects its processing, being relevant to distinguish demersal fish (codfish, flatfish), pelagic fish, crustaceans (shrimp, prawn, lobster) and molluscs. Preliminary processing should assure the best market quality and safety of fish products, a suitable presentation of semi- processed final product, labor saving on raw materials processing, and waste reduction. Considering different fish, crustaceans and molluscs raw materials, with different specificities that enter a processing unit and all the obtained final products, proactive methodologies need to be implemented for hazards prevention and for decreasing human health and environmental risks.

Concepts related to HACCP methodologies and "cleaner production" must not be forgotten. The application of a proactive methodology, such as HACCP, involves a precise methodology of preventive measures to be managed throughout the fish products processing steps, according to an established plan which is a document for identifying, evaluating and controlling food safety hazards [2]. "Cleaner production" is a concept that seeks efficiency improvement and reduction of risks to humans and environment by the applying precautionary ecological approaches to practices, produces and services. It intends the preservation of fresh resources and energy, removal of toxic constituents, and decrease in quantity and toxicity of litters and discharges [3]. Typically, a fish processing industry spends considerable amounts of energy and water, and releases substantial amounts of biological effluents and solid wastes. Also, because of all the hand labor and manual operations, the fish industry is dependent on the operator performance, which in turn influences plant performance, mainly in small-scale units and low automated automat operations. The main steps of fish preliminary processing can be illustrated in a diagram as shown in Fig. (**1**). Fish is a perishable raw material, and immediately after death must be beheaded, gutted, washed and chilled to prevent enzymatic degradation and spoilage by microorganisms. Main fish preliminary processing operations are common to different methods of preservation beginning by sorting, grading, washing, flaking, head and tail removal, gutting, de-skinning, filleting, and trimming.

SUBJECT INDEX

Manuela Oliveira, Fernando Bernardo, Joana I. Robalo (Eds.)