applied sciences

MDPI

*Editorial*

# Aquatic Products' Quality, Processing and Preserving: Recent Developments, Trends and Advances

**Chuang Pan [1,2,3,†], Haiyun Wu [4,†] and Yongqiang Zhao [1,2,3,*]**

[1] Key Laboratory of Aquatic Product Processing, Ministry of Agriculture and Rural, South China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Guangzhou 510300, China
[2] Co-Innovation Center of Jiangsu Marine Bio-Industry Technology, Jiangsu Ocean University, Lianyungang 222005, China
[3] Collaborative Innovation Center of Seafood Deep Processing, Dalian Polytechnic University, Dalian 116034, China
[4] Graduate School of Marine Science and Technology, Tokyo University of Marine Science and Technology, Tokyo 1088477, Japan
* Correspondence: zhaoyq@scsfri.ac.cn
† These authors contributed equally to this work.

check for updates

**Citation:** Pan, C.; Wu, H.; Zhao, Y. Aquatic Products' Quality, Processing and Preserving: Recent Developments, Trends and Advances. *Appl. Sci.* **2022**, *12*, 12924. https://doi.org/10.3390/app122412924

Received: 7 December 2022
Accepted: 10 December 2022
Published: 16 December 2022



According to the FAO, the production of global fisheries and aquaculture has reached 214 million tonnes, and the amount for human consumption reached 20.2 kg per capita in 2020. Aquatic products are playing an increasingly important role in providing food sources and nutrition, including in ensuring global food security in the future [1]. It is well known that the processing and storage methods used affect the quality and safety of aquatic products, which are important issues for scientists, consumers and the industry as a whole. Research and development of new processing and preservation technologies, investigations of quality change phenomena and their mechanisms, the application of new quality evaluation methods as well as the establishment of risk assessment and control technologies for aquatic products are the main research aspects in this field working to ensure the supply of high-quality and safe aquatic products.

Unlike mammals, aquatic products are derived from cold-blooded animals. Their protein structures are relatively soft so that they can perform physiological functions in different environments [2,3]. This makes the storage of aquatic products are more difficult than livestock and poultry meat because they need to be carried out under lower temperature conditions to obtain a longer shelf life [4–7]. Undesirable changes such as protein denaturation, lipid oxidation, the growth of ice crystals and loss of texture properties can still occur in aquatic products during low-temperature storage [2,3,8,9]. These phenomena negatively affect the products' quality and consumer acceptability. Moreover, in industrial production, contamination by micro-organisms also plays an important role in food quality and shelf life [10–12]. With the extension of storage time, nutrients of food are used as substrates for some psychrophile growth and reproduction, and the resulting metabolites seriously threaten food safety [2,5,13].

There are some disadvantages of protein-based conventional food analysis: (1) when using highly processed and low-protein aquatic products, the analysis may yield false/negative results [2,9]; (2) the content of the same protein can show different expression levels in different tissues in aquatic animals, which affects determination using traditional methods [8,11]; and (3) there are many other substances in aquatic animals other than protein, such as lipids, polysaccharides, phenols, etc.., and the changes in quality are also correlated with these substances, which cannot be determined by traditional protein-based methods [10,11]. Furthermore, metabolomics is another systematic analysis method which illustrate the species, quantity and change regulation of metabolites in a given biological system. There have been

related studies on aquatic products that mainly focused on environmental challenges [13] and potential quality biomarkers [14,15].

Aquatic product producers are increasingly demanding effective quality control procedures to meet and regulate consumer demands, improving processing feasibility and quality [16]. In addition, chemical and microbiological changes during processing and storage can affect food quality and shelf life [17,18]. Therefore, understanding the impact of each preservation technique and handling method on the production system is essential in food processing to maintain food quality and ensure its safety [19,20]. However, traditional analytical safety and quality monitoring methods take time and require well-trained operators, so there is a need to develop fast, sensitive and reliable methods to rapidly monitor aquatic products' safety and quality.

Biosensors can be a suitable alternative to traditional methods. Biosensor devices are the most appropriate diagnostic methods for food analysis and environmental and clinical inspections. This is because they are specific, fast, easy to manufacture and economically applicable [21,22]. The specificity of these devices is achieved by bioconjugation reactions involving antigens or antibodies, enzymes, cofactors/substrates, ligands/receptors, nucleic acid hybridization and chemical reactions in combination with many sensors. Biosensors are combinatorial receptor transducer systems that provide discriminatory semi-quantitative or quantitative analytical descriptions via biometric recognition units [23]. Miniature biosensors can be incorporated into packaging materials and combined with wireless tracking technologies to generate tracking information about the production system and the supply chain [24]. In addition, biosensors are manufactured for various types of analytes related to food safety. To improve food quality, these biosensors detect contaminants such as metal ions, gases, vapours, biomolecules, organic molecules and foodborne micro-organisms. Most conventional methods take about a week to produce results when identifying foodborne pathogens, while biosensors can yield results in just a few hours [25]. In recent years, there have also been some reports of biosensors in the detection of stress response and disease resistance in aquatic animals such as fish [26,27]. Through these biosensors, producers can better control the source and the process of aquatic products to improve product quality and safety.

In conclusion, the establishment of novel aquatic product quality evaluation methods with the advantages of being fast, accurate and non-destructive will be a prerequisite for ensuring the quality and safety of aquatic products. The in-depth investigation of molecular mechanisms of aquatic product quality changes based on foodomics can provide a theoretical basis for the development of novel methods and technologies for aquatic products processing and preserving. In addition, the identification and assessment of new food safety risk factors will be an important aspect to ensure the safety of aquatic products. In the future, research on the quality, processing and storage of aquatic products will also focus on these aspects.

**Author Contributions:** Writing—original draft preparation, C.P. and H.W.; writing—review and editing, C.P., H.W. and Y.Z.; Conceptualization, Y.Z.; funding acquisition, Y.Z. All authors have read and agreed to the published version of the manuscript.

**Funding:** This work was supported by the Central Public-interest Scientific Institution Basal Research Fund, CAFS (2020TD73).

**Conflicts of Interest:** The authors declare no conflict of interest.

## References

1. FAO. The State of World Fisheries and Aquaculture 2022. In *Towards Blue Transformation*; FAO: Rome, Italy, 2022. [CrossRef]
2. Rituparna, B.; Naveena, B.M. Superchilling of muscle foods: Potential alternative for chilling and freezing. *Criti. Rev. Food Sci.* **2019**, *59*, 1256–1263. [CrossRef]
3. Naimeh, K.; Mohsen, E.; Zahra, E.D. Application of active edible coating made from basil seed gum and thymol for quality maintenance of shrimp during cold storage. *J. Sci. Food Agric.* **2017**, *97*, 1837–1845. [CrossRef]

4. Diao, Y.D.; Cheng, X.Y.; Wang, L.X.; Xia, W.S. Effects of immersion freezing methods on water holding capacity, ice crystals and water migration in grass carp during frozen storage. *Int. J. Refrig.* **2021**, *131*, 581–591. [CrossRef]
5. Odeyemi, O.A.; Burke, C.M.; Bolch, C.C.J.; Stanley, R. Seafood spoilage microbiota and associated volatile organic compounds at different storage temperatures and packaging conditions. *Int. J. Food Microbiol.* **2018**, *280*, 87–99. [CrossRef]
6. Walayat, N.; Tang, W.; Wang, X.; Yi, M.; Guo, L.; Ding, Y.; Liu, J. Effective role of konjac oligosaccharide against oxidative changes in silver carp proteins during fluctuated frozen storage. *Food Hydrocolloid* **2022**, *131*, 107761. [CrossRef]
7. Wang, Q.Y.; Lei, J.; Ma, J.J.; Yuan, G.F.; Sun, H.Y. Effect of chitosan-carvacrol coating on the quality of Pacific white shrimp during iced storage as affected by caprylic acid. *Int. J. Biol. Macromol.* **2018**, *106*, 123–129. [CrossRef]
8. Salihah, N.T.; Hossain, M.M.; Lubis, H.; Ahmed, M.U. Trends and advances in food analysis by real-time polymerase chain reaction. *J. Food Sci. Technol.* **2016**, *53*, 2196–2209. [CrossRef]
9. Ahmed, M.U.; Saaem, I.; Wu, P.C.; Brown, A.S. Personalized diagnostics and biosensors: A review of the biology and technology needed for personalized medicine. *Crit. Rev. Biotechnol.* **2014**, *34*, 180–196. [CrossRef]
10. Lim, S.A.; Yoshikawa, H.; Tamiya, E.; Yasin, H.M.; Ahmed, M.U. A highly sensitive gold nanoparticle bioprobe based electrochemical immunosensor using screen printed graphene biochip. *RSC Adv.* **2014**, *4*, 58460–58466. [CrossRef]
11. López-Calleja, I.M.; de la Cruz, S.; Pegels, N.; González, I.; Martín, R.; García, T. Sensitive and specific detection of almond (*Prunus dulcis*) in commercial food products by real-time PCR. *LWT Food Sci. Technol.* **2014**, *56*, 31–39. [CrossRef]
12. Pan, C.; Sun, K.T.; Yang, X.Q.; Wang, D.; Hu, X.; Chen, S.J. Insights on *Litopenaeus vannamei* quality deterioration during partial freezing storage from combining traditional quality studies and label-free based proteomic analysis. *J. Food Comps. Anal.* **2022**, *112*, 104655. [CrossRef]
13. Xu, W.; Ma, Q.; Sun, J.; Li, Y.; Wang, J.; Tang, Y.; Liu, Y.; Mu, J.; Wang, W. Changes in quality characteristics of shrimp (*Penaeus chinensis*) during refrigerated storage and their correlation with protein degradation. *J. Food Comps. Anal.* **2022**, *114*, 104773. [CrossRef]
14. Li, R.; Sun, Z.L.; Zhao, Y.Q.; Li, L.H.; Yang, X.Q.; Cen, J.W.; Chen, S.J.; Li, C.S.; Wang, Y.Q. Application of UHPLC-Q-TOF-MS/MS metabolomics approach to investigate the taste and nutrition changes in tilapia fillets treated with different thermal processing methods. *Food Chem.* **2021**, *356*, 129737. [CrossRef] [PubMed]
15. Wang, Y.Q.; Li, C.S.; Li, L.H.; Yang, X.Q.; Chen, S.J.; Wu, Y.Y.; Zhao, Y.Q.; Wang, J.X.; Wei, Y.; Yang, D.Q. Application of UHPLC-Q/TOF-MS-based metabolomics in the evaluation of metabolites and taste quality of Chinese fish sauce (Yu-lu) during fermentation. *Food Chem.* **2019**, *296*, 132–141. [CrossRef] [PubMed]
16. Caba, K.; Guerrero, P.; Trung, T.S.; Cruz-Romero, M.; Kerry, J.P.; Fluhr, J.; Maurer, M.; Kruijssen, F.; Albalat, A.; Bunting, S.; et al. From seafood waste to active seafood packaging: An emerging opportunity of the circular economy. *J. Clean. Prod.* **2019**, *20*, 86–98. [CrossRef]
17. Zhao, Y.; Yang, X.; Li, L.; Hao, S.; Wei, Y.; Cen, J.; Lin, H. Chemical, Microbiological, Color and Textural Changes in Nile Tilapia (*Oreochromis niloticus*) Fillets Sterilized by Ozonated Water Pretreatment During Frozen Storage. *J. Food Process. Preserv.* **2017**, *41*, e12746. [CrossRef]
18. Ghosh, T.; Bhagya Raj, G.V.S.; Kumar Dash, K. A comprehensive review on nanotechnology based sensors for monitoring quality and shelf life of food products. *Meas. Food* **2022**, *7*, 100049. [CrossRef]
19. Xiang, Y.; Sun, C.; Zhao, Y.; Li, L.; Yang, X.; Wu, Y.; Chen, S.; Wei, Y.; Li, C.; Wang, Y. Label-free proteomic analysis reveals freshness-related proteins in sea bass (*Lateolabrax japonicus*) fillets stored on ice. *LWT Food Sci. Technol.* **2022**, *155*, 112885. [CrossRef]
20. Niina, H.; Petra, S.P.; Andrea, B.; Cecilia, F.; Rakesh, N.; Giorgia, S.; Krisztian, K. Bio-Based Smart Materials for Food Packaging and Sensors—A Review. *Front. Mater.* **2020**, *7*, 82. [CrossRef]
21. Mishra, G.K.; Barfidokht, A.; Tehrani, F.; Mishra, R.K. Food Safety Analysis Using Electrochemical Biosensors. *Foods* **2018**, *7*, 141. [CrossRef]
22. Wu, H.; Shinoda, R.; Murata, M.; Matsumoto, H.; Ohnuki, H.; Endo, H. Real-time fish stress visualization came true: A novel multi-stage color-switching wireless biosensor system. *Biosens. Bioelectron.* **2019**, *130*, 360–366. [CrossRef] [PubMed]
23. Zhang, X.; Wu, D.; Zhou, X.; Yu, Y.; Liu, J.; Hu, N.; Wu, Y. Recent progress in the construction of nanozyme-based biosensors and their applications to food safety assay. *TrAC Trends Anal. Chem.* **2019**, *121*, 115668. [CrossRef]
24. Neethirajan, S.; Ragavan, V.; Weng, X.; Chand, R. Biosensors for Sustainable Food Engineering: Challenges and Perspectives. *Biosensors* **2018**, *8*, 23. [CrossRef] [PubMed]
25. Zhang, R.; Belwal, T.; Li, L.; Lin, X.; Xu, Y.; Luo, Z. Nanomaterial-based biosensors for sensing key foodborne pathogens: Advances from recent decades. *Compr. Rev. Food Sci. Food Saf.* **2020**, *19*, 1465–1487. [CrossRef] [PubMed]
26. Wu, H.; Ogata, M.; Ohnuki, H.; Endo, H. Development of biosensor for measuring oxidative stress of fish. *Fish. Sci.* **2021**, *87*, 151–159. [CrossRef]
27. Endo, H.; Wu, H. Biosensors for the assessment of fish health: A review. *Fish Sci.* **2019**, *85*, 641–654. [CrossRef]