Pakistan J. Zool., pp 1-4, 2024. **DOI**: https://dx.doi.org/10.17582/journal.pjz/20240601234442

Short Communication

Preservation of Hairtail (*Trichiurus lepturus*) Using Water Soluble Chitosan Based Coatings Combined with Tea Polyphenols

Yunqian He[1,2], Yu Liu[1,2], Xiang Li[1,2]* and Shengjun Wu[1,2]*

[1]*Jiangsu Key Laboratory of Marine Bioresources and Environment/Jiangsu Key Laboratory of Marine Biotechnology, Jiangsu Ocean University, Haizhou, China*
[2]*Co-Innovation Center of Jiangsu Marine Bio-industry Technology, Haizhou, China*

Article Information
Received 01 June 2024
Revised 05 July 2024
Accepted 17 July 2024
Available online 25 November 2024 (early access)

Authors' Contribution
YH: Data curation, formal analysis, methodology; YL, YH, XL: Investigation; NYL, YH: Writing original draft; YL, XL, SW: Validation; XL: Supervision; XL, SW: Reviewing and editing; SW: Conceptualization, funding, project administration, resources.

Key words
Chitosan, Tea polyphenols, Hairtail, Preservation, Sensory quality

ABSTRACT

Chitosan has a coating-forming ability and antibacterial activity, whilst tea polyphenols (TPs) have antibacterial and potent antioxidant activities. The present study aims to explore the effects of water-soluble chitosan (WSC)-based coatings alone (10 g/L of WSC; treatment-1) or combined with TPs (1 g/L of TPs + 10 g/L of WSC; treatment-2) on the preservation of hairtail (*Trichiurus lepturus*) at 4 °C for 12 days. All treatments significantly inhibited bacterial growth, total volatile basic nitrogen content, pH value increases, total colour difference value increases and sensory deterioration of hairtail during refrigeration. Moreover, treatment-2 exhibited higher efficiency than treatment-1. Therefore, WSC-based coatings incorporated with TPs could be a potential method to inhibit the quality deterioration of hairtail.

Hairtail (*Trichiurus lepturus*) belongs to the bonefish order and hairtail family in the subphylum Chordata. This species is primarily distributed in the Western Pacific and Indian Ocean, as well as in East China Sea, China's Yellow Sea, South China Sea and Bohai Sea. Hairtail is also known as China's four major marine products along with large yellow croaker, small yellow croaker and squid (Memon *et al*., 2016; Panhwar *et al*., 2018; Sun *et al*., 2020). It dies immediately after being caught. Hairtail is highly perishable because of its high water and high nutrient contents (Semedo *et al*., 2018). At present, frozen storage is primarily used to preserve hairtail, but during frozen storage, the protein of hairtail will be denatured, which reduces the taste of hairtail. Refrigeration is beneficial to the taste of hairtail, but the shelf life is quite short (Luan *et al*., 2017). Thus, practical methods must be developed to extend the shelf-life of hairtail during refrigeration.

Chitosan is a biopolymer composed of most glucosamine and a small amount of acetylglucosamine (Alzahani and El-Magd, 2024; Abdelhady *et al*., 2023; Jabbin *et al*., 2023; Ruiz-Rico *et al*., 2023; Xin *et al*., 2023). It has antibacterial activity (Niu *et al*., 2009), immunomodulatory activity (Moran *et al*., 2018) and coating forming ability (Yang *et al*., 2022). Tea polyphenols (TPs), a class of polyphenols extracted from tea, have antibacterial and antioxidant activities (Yan *et al*., 2020; Yang *et al*., 2020). In the present work, whether chitosan-based coatings incorporated with TPs may have antioxidant and antibacterial activities and prolong the shelf-life of fresh hairtail is hypothesised.

Therefore, this study aims to explore the effects of chitosan-based coatings incombination with TPs on fresh hairtail during refrigeration, in which microbial growth, TVB-N level, pH value and sensory of hairtail were evaluated.

Materials and methods

Fresh hairtails with an average body weight of 600±23 g were obtained from an aquatic marketplace in Lianyungang, China. Water soluble chitosan (WSC) with a 57.2% degree of deacetylation and 38 × 10^3 Da of molecular weight was purchased from Shanghai Yuanye Biotech. Co., Ltd., China. TPs with a purity ≥ 990 g/kg were purchased from Xinxin Biotechnology Co., Ltd., Jining, China.

* Corresponding author: lx2567546020lx@163.com, wushengjun008@163.com
0030-9923/2024/0001-0001 $ 9.00/0

The dipping solutions of WSC and tea polyphenols were as follows: control (not treated with WSC or TPs), treatment-1 (10 g/L of WSC) and treatment-2 (1 g/L of tea polyphenols + 10 g/L of WSC) (Li *et al*., 2021; Zhang *et al*., 2022). The fresh hairtails were decapitated, finned, gutted and severed, obtaining a uniform size of 5 cm × 3 cm. A total of 600 hairtail fillets were randomly and equally assigned to three groups. The hairtail fillets were immersed in the corresponding dipping solutions at 4 °C for 1 h. Afterwards, surface impregnation solution was drained at 4 °C, and then the hairtail fillets were refrigerated at 4 °C for 12 days.

Microbial growth in hairtail fillets was measured according to the plate count agar method (Zhang *et al*., 2022). Six hairtail fillet samples were used to determine the number of microorganisms. The total colony was recorded and expressed as log colony-forming unit (CFU)/g.

Six hairtail fillet samples were used to determine TVB-V in accordance with the acid-base titration methods of Huang *et al*. (2012) and pH by using a pH meter (PH400EX, Hangzhou Meinite Automation Instrument Co., Ltd., China) in accordance with a previously reported method (Duan *et al*., 2010). The colour was recorded using a colorimeter (CS-100A, Minolta Co., Ltd., Japan). The colour parameters were L* (brightness), a* (red/green) and b* (yellow/blue). The total colour difference (ΔE) of the hairtail fillets was calculated in accordance with Equation 1.

$$\Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

where ΔL^*, Δa^* and Δb^* indicate the differences amongst the lightness, red/green and yellow/blue of the sample and standard, respectively.

For sensory evaluation 12 trained research workers (2 h for each training, six times in total session) majoring in food technology. The products tested were safe for consumption. Six hairtail fillets were subjected to steaming for 5 min and then sensory evaluation, and the 1–9 description hedonic scale was used to evaluate the overall likeness score (Li *et al*., 2013).

All experiments were replicated six times. All data were expressed as mean ± standard error. One-way analysis of variance and Tukey Kramer multi-range test were used for statistical analysis of all data.

Results and discussion

Figure 1 shows the effect of WSC- based coatings incorporated with TPs on TVC, TVB-N, pH, colour and overlikeness of hairtail during refrigeration. The initial TVC values in hairtails in control group, treatment-1 group and treatment-2 group were 3.1, 2.6 and 2.2 CFU/g. The differences in initial TVC values in hairtails amongst the control, treatment-1 and treatment-2 groups could be due to the antibacterial activity of WSC-based coatings (Liu *et al*., 2009) and TPs (Yang *et al*., 2020). The TVC in hairtails in control improved and exceeded the first-class national standard maximum value of TVC (4.0 CFU/g) after 4 days. The TVC in hairtails in treatment-1 group improved steadily during refrigeration and exceeded the first-class national standard maximum value of TVC (4.0 CFU/g) after 8 days. Nevertheless, the TVC in hairtails in treatment-2 group increased slowly during refrigeration and did not exceed the first-class national standard maximum value of TVC after 12 days.

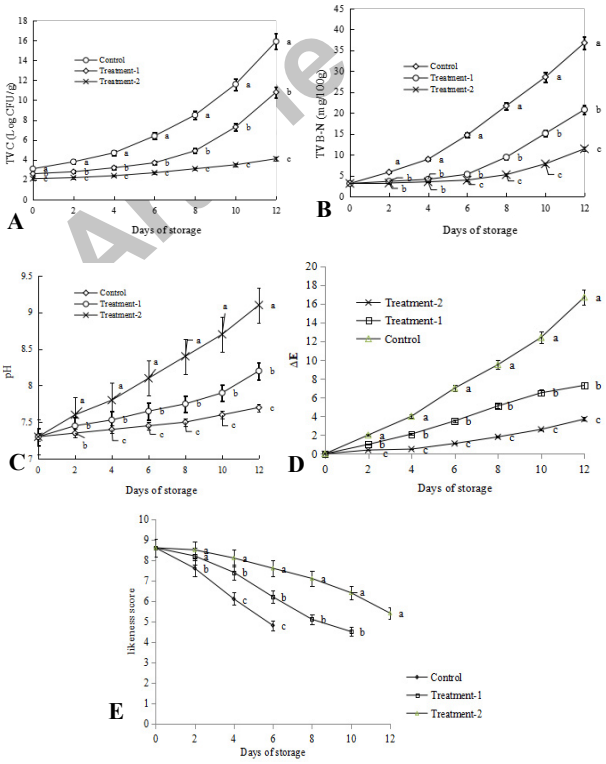

Fig. 1. Effect of WSC- based coatings incorporated with TPs on total viable count (A), TVB-N content (B), pH (C), colour (D), and overall likeness (E) of hairtail (*Trichiurus lepturus*) during refrigeration. Control: purified water; treatment-1: 1% WSC; treatment-2: 0.1% tea polyphenols + 1% WSC. Values are the mean ± SE (n = 6). Vertical bars represent standard error.The difference between the values labelled with different alphabets at the same storage duration was statistically significant ($P < 0.05$, Tukey-Kramer's multiple range test).

The TVB-N lsevel is positively related to the growth of spoilage microorganism and the activities of endogenous enzymes; thus, TVB-N is an indicator of food spoilage (Zhang *et al*., 2022). The TVB-N value

of hairtails in the control increased sharply during refrigeration ($P < 0.05$) and exceeded the first-class national standard maximum value of TVB-N (13 mg/100 g) after 4 days (Fig. 1B). The TVB-N in hairtails of the treatment-1 group increased steadily during refrigeration and exceeded the first-class national standard maximum value of TVB-N after 8 days of refrigeration. However, the TVB-N in hairtails of the treatment-2 group increased slowly during refrigeration and still did not exceed the first-class national standard maximum value of TVB-N after 12 days of refrigeration. The results indicated that WSC-based coatings incorporated with TPs effectively suppressed TVB-N formation; this effect could be due to the antibacterial activity of WSC-based coatings (Niu *et al*., 2009) and TPs (Yang *et al*., 2020) as well as the antioxidant activity of TPs (Yan *et al*., 2020). Similar to TVC, the difference between treatment-1 and treatment-2 and the ratio of treatment-1/treatment-2 for TVB-N did not change until day 6 but improved from day 8. If the results on treatment 2 were due to the additive effects of WSC and TPs, then the difference between treatment-1 and treatment-2 could be because of the antioxidant activity and antibacterial activity of TPs (Yan *et al*., 2020; Yang *et al*., 2020).

Spoilage bacteria produce many enzymes that are responsible for the decomposition of proteins, leading to the increase in TVB-N and pH. Therefore, pH is an indicator of food spoilage (Zhang *et al*., 2022). The initial pH value of hairtails in all groups was 7.31 ± 0.27 mg/100 g (Fig. 1C). However, the pH values of hairtails in the treatment-1 and treatment-2 groups were significantly lower than those of treatment groups during refrigeration (Fig. 1C). This difference could also be because of the antibacterial activity of WSC (Niu *et al*., 2009) and TPs (Yang *et al*., 2020). The pH values of hairtails in control, treatment-1 and treatment-2 increased from 7.31 ± 0.27 to 9.1 ± 0.42, 8.2 ± 0.33 and 7.7± 0.0.31, respectively, after 12 days of refrigeration (Fig. 1C). The difference in pH value between treatment-1 and treatment-2 did not change until day 6 but improved from day 8. However, the ratio of treatment-1/treatment-2 was maintained at the same level during 12 days of refrigeration.

The surface of fresh fish skin is silver gray and glossy. But the spoiled hairtail has a layer of yellow substance attached to its silver luster due to lipid oxidation. Therefore, colour is another indicator of food spoilage. The ΔE values of hairtails in all groups increased steadily during refrigeration (Fig. 1D). However, the ΔE values of hairtails in treatment groups group were lower than those of treatment groups during refrigeration (Fig. 1D). This could also be due to the antibacterial activity of the antibacterial activity of WSC (Niu *et al*., 2009) and TPs (Yang *et al*., 2020) as well as the antioxidant activity of TPs (Yan *et al*., 2020). The difference between (treatment-1/treatment-2) for ΔE values increased during refrigeration. The difference between treatment-1 and treatment-2 groups first as for pH could be due to the antioxidant activity and antibacterial activity of TPs (Yan *et al*., 2020; Yang *et al*., 2020), if the results on treatment-2 were due to synergistic effects of WSC and TPs.

Figure 1E presents the effects of WSC-based coatings incorporated with TPs on the sensory quality of hairtails during refrigeration. The overall likeness scores of steamed hairtails were evaluated at 0, 2, 4, 6, 8, 10 and 12 days during refrigeration. No evident differences in the initial overall likeness scores were observed amongst all groups. After 6 days of refrigeration, the overall likeness score of hairtails in the control group decreased to unacceptable levels (overall likeness score of 5.0). However, after 12 days of refrigeration, the overall likeness score of hairtails in the treatment-2 group maintained acceptable levels. The high sensory qualities of the treated hairtails could be related to the antibacterial activity of WSC (Niu *et al*., 2009) and TPs (Yang *et al*., 2020) as well as the antioxidant activity of TPs (Yan *et al*., 2020).

Conclusion

WSC-based coatings incorporated with TPs effectively suppressed microbial growth, the increase in pH values and TVB-N values and the deterioration in the sensory quality of hairtails during refrigeration. Based on the TVC, TVB-N and overall likeness score, treatment with WSC-based coatings incorporated with TPs extended the shelf life of hairtails at least 6 days. The results indicated that WSC-based coatings incorporated with TPs might be a practical way to inhibit spoilage of hairtails with extended shelf life.

DECLARATIONS

Acknowledgments

This research was supported by a project funded by the Priority Academic Program Development (PAPD) of Jiangsu Higher Education Institutions.

Statement of conflict of interest

The authors have declared no conflict of interest.

References

Abdelhady, E.M., Mostafa, N.Y., El-Magd, M.A. and Kirrella, G.A., 2023. *Pakistan J. Zool.,* **55***:* 2295-2302. https://doi.org/10.17582/journal.pjz/20220315170358

Alzahani, F. and El-Magd, M.A., 2024. *Pakistan J.*

Zool., **56**: 523-531. https://doi.org/10.17582/journal.pjz/20220407050442

Duan, J.Y., Cherian, G. and Zhao, Y.Y., 2010. *Fd. Chem.,* **119**: 524–532. https://doi.org/10.1016/j.foodchem.2009.06.055

Huang, J., Chen, Q., Qiu, M. and Li, S., 2012. *J. Fd. Sci.,* **77**: C491-C496.

Jabbin, H., Arshad, A.M., Mehmood, N., Hassan, W., Shah, S.Z.H. and Siddique, F., 2023. *Pakistan J. Zool.,* **55**: 371-377. https://doi.org/10.17582/journal.pjz/20190519170504

Li, F.H., Wu, S.J. and Xu, B., 2021. *LWT-Fd. Sci. Technol.,* **147**: 111595. https://doi.org/10.1016/j.lwt.2021.111595

Li, M., Wang, W., Fang, W. and Li, Y., 2013. *J. Fd. Prot.,* **76**: 1377-1383. https://doi.org/10.4315/0362-028X.JFP-12-516

Luan, L.L., Fu, S.L., Yuan, C.H., Ishimura, G., Chen, S.G., Chen, J.C. and Hu, Y.Q., 2017. *Int. J. Fd. Prop.,* **20(sup1)**: S992-S1000. https://doi.org/10.1080/10942912.2017.1325903

Memon, K.H., Liu, Q., Kalhoro, M. Ali., Chang, M.S., Baochao, L., Memon, A.M., Hyder, S. and Tabassum, S., 2016. *Pakistan J. Zool.,* **48***: 829-837.*

Moran, H.B.T., Turley, J.L., Andersson, M. and Lavelle, E.C., 2018. *Biomaterials,* **184**: 1-9. https://doi.org/10.1016/j.biomaterials.2018.08.054

Niu, M., Liu, X.G., Dai, J.M., Jia, H.S., Wei, L.Q. and Xu, B.S., 2009. *Carbohydr. Polym.,* 78: 54-59.

Panhwar, S.K., Dong, Z.Y., Gao, T.X., Ping, Wang, P, Zhiqiang, Han, Z.Q., Wang, Z.M. and Wang, Y., 2018. *Pakistan J. Zool.,* **50**: 1-5. https://doi.org/10.17582/journal.pjz/2018.50.1.1.5

Ruiz-Rico, M., Sancenon, F. and Barat, J.M., 2023. *LWT Fd. Sci. Technol.,* **173**: 114373. https://doi.org/10.1016/j.lwt.2022.114373

Semedo T.W.P., Dong, S.Y., Jin, W.Y., Yang, Y.H., Han, K.N., Zha, F.C., Zhao, Y.H. and Zeng, M.Y., 2018. *Fd. Res. Int.,* **103**: 390-397. https://doi.org/10.1016/j.foodres.2017.10.063

Sun, P., Chen, Q., Fu, C.H., Xu, Y., Sun, R.L., Li, J.C., Yu, H.Q., Zhang, C., Liu, Y., Ye, Z.J., Tian, Y.J. and Heino, M., 2020. *Fish. Oceanogr.,* **29**: 470-483. https://doi.org/10.1111/fog.12490

Xin, K.Q., Liang, J., Tian, K., Yu, Q.L., Tang, D.F. and Han, L., 2023. *LWT Fd. Sci. Technol.,* **173**: 114277. https://doi.org/10.1016/j.lwt.2022.114277

Yan, Z.M., Zhong, Y.Z., Duan, Y.H., Chen, Q.H. and Li, F.N., 2020. *Anim. Nutr*., **6**: 115-123. https://doi.org/10.1016/j.aninu.2020.01.001

Yang, C., Lu, J.H., Xu, M.T., Shi, X.C., Song, Z.W., Chen, T.M., Herrera-Balandrano, D.D., Zhang, Y.J., Laborda, P., Shahriar, M. and Wang, S.Y., 2022. *LWT Fd. Sci. Technol.,* 163: 2022. https://doi.org/10.1016/j.lwt.2022.113551

Yang, H., Y., Li, Q.Y., Yang, L. L., Sun, T., Li, X. P., Zhou, B. and Li, J.R., 2020. *Int. J. Fd. Sci. Tech.,* **55**: 3542-3552. https://doi.org/10.1111/ijfs.14687

Zhang, H.X., Zheng, Y. and Li, R.M., 2022. *Fd. Chem.,* **390**: 133206. https://doi.org/10.1016/j.foodchem.2022.133206