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Section A-Research paper

PROTEIN DEGRADATION OF FISH AND SHRIMP MUSCLE DURING PRESERVATION

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Abstract
Protein plays an important role in deterioration of fish and shrimp during preservation. An experiment was conducted to evaluate the protein degradation in muscle tissue of three shrimp species *Penaeus monodon*, *Penaeus indicus*, *Metapenaeus dobsoni* and fish *Upeneus vittatus*. Amount of protein estimated at weekly intervals of 49 days. The results of the present study were revealed that the maximum percentage degradation of insoluble proteins of 72.82% was recorded in *P. indicus*, whereas minimum percentage of insoluble proteins of 57.1% was reported in *M. dobsoni* after 49 days of preservation. Similarly with reference to degradation of soluble proteins the maximum percentage of 62.9% was reported in *U. vittatus* and minimum of 60% was recorded in *P. monodon* after 49 days of preservation.
Keywords: Degradation, soluble proteins, insoluble proteins, fish, shrimp.

Introduction

Fish and shrimps are an excellent food source for man and provides proteins, fats, minerals, and vitamins. It is easily digestible due to low percentage of connective tissue; fish flesh contains all essential amino acids, and provides Calcium, Magnesium, Potassium, Iodine and phosphorous. However, fish and shrimps' spoils quickly due to high water content in its body and must properly preserved so that it reaches the consumer in good condition. Method employed for preservation should be such that there is minimum loss of flavor, taste, odor, and nutritive value of the fish. As an abundant and renewable source of cheap, high quality protein fish is the ideal answer to the problem of protein malnutrition in many developing countries. But being a perishable commodity, fish must be processed and preserved properly for ensuring its optimum utilization. For this clear idea about the nature and composition of the different species of fishes and shell fishes is essential. Recent advances in the biochemistry of sea foods have been summarized well by the American chemical society (Flick and Martin, 1992).

Proteins are the most abundant and important constituents of fish muscle, constituting more than 50% of its dry weight. Changes in the muscle proteins during processing and preservation directly affect the texture of the processed fish product. In addition to that as enzymes fish muscle proteins are play an important role in deciding the post mortem and deteriorative changes in all muscle constituents. Proteins like myoglobin found in muscles and are determine the color of the fish muscle. Fish muscle proteins are basically similar to meat proteins in many respects. But for several reasons, fish proteins have gained attention in recent days. The different species of fish show wide variations in their composition. Within a single species itself there are the inevitable variations due to season, size, sex, maturity, nutritional status and various environmental factors. All these are indispensable for the systematic studies on the composition of different species of fish. As the most important muscle constituent, affecting the quality of

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processed fishery products, studies of muscle proteins were gained importance in terms of dietary research. In this context present study is aimed to investigate the changes occurred in protein content in muscle tissue of three shrimp species and one fish species such as *Penaeus monodon, Penaeus indicus, Metapenaeus dobsoni*, and *Upeneus vittatus*. In recent times the research on protein oxidation in aquatic products like fish, shrimp, crab, shellfish, etc tends to increased (Maeda *et al.,* 2022). Compared to the volume of work reported on meat proteins, very little information is available in literature on composition and changes of fish and shell fishes of tropical waters. Connell (1961) reported that the fish muscle proteins are similar to meat proteins in many respects but it is not behaved in the same way as mammalian or avian muscle proteins. Dyer (1967) also has expressed the same opinion; hence more attention is needed to the research on the composition and processing characteristics of the muscle proteins of different edible fishes and shell fishes.

Several authors have provided information pertains to fish muscle proteins and their changes during processing and preservation (Dyer and Dingle, 1961; Connell, 1962, 1968). Devadasan (1981) reported on nutritive value of fish protein content during preservation and processing. Gopakumar (2000) provided information regarding the fish spoilage. Benjakul and Bauer (2000) described about the enzymatic changes in cod muscle proteins. Spoilage proceeds as series of changes complex enzymatic changes that started at the time of fishing as reported by Burt (2003). Eddin and Tahergorabi (2017) reported about the shrimp processing and preservation. Arancibia *et al.,* (2015) reported about the shrimp quality deterioration during storage. Malva *et al.,* (2018) reported on methods involved for the extraction of muscle proteins from fish muscle. Bao *et al.,* (2020) reported on protein degradation in fish black carp muscle during preservation in cold storage. Peng *et al.,* (2022) reported about the spoilage mechanism and preservation technologies on the quality of shrimp. Sun *et al.,* (2023) studied on protein changes during preservation of *Litopenaeus vannamei* and in this study changed proteins were identified by proteomic analysis.

Materials and Methods

The present research work was carried out in the department of Zoology, Andhra University, Visakhapatnam, during the months of January to February 2023. The fish and shrimp samples were collected from landings of fishing Harbor of the Visakhapatnam and brought to the laboratory of the department of Zoology, Adhara University, Visakhapatnam. The samples were preserved in deep freezer at 0^0C and samples were analyzed at weekly twice. Total duration of the study period is 49 days i.e. 7 weeks. *Peanaeus monodon, Penaeus indicus, Metapenaeus dobsoni and Upeneus vittatus* were chosen as an experimental animal for the evaluation of protein degradation in muscle tissue. Standard methods were followed for the preparation of tissue hominization etc. For studies on quantitative estimation proteins by Lowry *et al.,* (1951) method was adopted. For the determination of qualitative study of protein the method of Dong *et al.,* (2021) was followed.

Results

Proteins play an important role in the body building of any organism and they are much essential nutrients. In continuous preservation, the total protein values were degraded due to the microbial contamination and enzymatic action due to autolysis. The preserved shrimps and fish samples of *P. monodon, P. indicus, P. dobsoni* and fish *Upeneus vittatus* were estimated at weekly intervals and the results were presented in the (Table 1 and 2).

It is evident from the result that the total protein content of shrimp and fish were gradually decreased, when the preservation time increased. The degradation of soluble and water insoluble proteins were observed in species of shrimps *P. monodon, P. indicus, M. dobsoni* and fish *U. vittatus* for 49 days of preservation.

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Table 1. Protein degradation in different shrimp species and fish during preservation

		Duration of preservation							
S/N	**Name of the fish**	**Fresh**	**After 7 days**	**After 14 days**	**After 21 days**	**After 28 days**	**After 35 days**	**After 42 days**	**After 49 days**
1	***Penaeus mondon***								
	Insoluble protein	4.60	3.75	3.2	3.0	2.95	2.35	1.80	1.55
	Soluble protein	2.50	1.80	1.75	1.6	1.45	1.35	1.25	1.00
	Total protein	7.1/ 100mg	5.55/ 100mg	4.95/ 100 mg	4.6/ 100 mg	4.40/ 100mg	3.70/ 100mg	3.05/ 100mg	2.55/ 100mg
2	***Penaeus indicus***								
	Insoluble protein	4.8	3.35	3.3	3.0	2.75	2.7	2.0	1.25
	Soluble protein	2.4	2.26	1.7	1.5	1.35	1.25	1.2	0.95
	Total protein	7.2/ 100mg	5.61/ 100mg	5.0/ 100mg	4.5/ 100mg	4.1/ 100mg	3.95/ 100mg	3.2/ 100mg	2.20/ 100mg
3	***Metapenaeus dobsoni***								
	Insoluble protein	4.55	3.35	3.25	3.00	2.90	2.5	1.85	1.45
	Soluble protein	2.60	2.00	1.70	1.55	1.35	1.30	1.20	1.00
	Total protein	7.15/ 100mg	5.35/ 100mg	4.95/ 100mg	4.55/ 100mg	4.20/ 100mg	4.05/ 100mg	3.60/ 100mg	2.95/ 100mg
4	***Upeneus vittatus***								
	Insoluble protein	4.6	3.60	3.35	3.00	2.90	2.5	1.85	1.45
	Soluble protein	2.7	1.95	1.65	1.60	1.55	1.4	1.15	1.00
	Total protein	7.3/ 100mg	5.55/ 100mg	5.00/ 100mg	4.60/ 100mg	4.45/ 100mg	3.9/ 100mg	3.00/ 100mg	2.45/ 100mg

Percentage of Protein Degradation during Preservation

Penaeus monodon

The protein degradation of *P. monodon* was observed for 49 days of duration, for this at weekly intervals the degradation of protein was estimated. Taking into consideration percentage wise degradation of 18.47% was observed for 7 days preserved sample for insoluble protein. Similarly, 30.47% was observed after 14 Days, 34.7%, 35.81%, 48.90%, 60.80% and 66.03% were observed after 21, 28, 35, 42 and 49 days of preservation period. The decreasing in insoluble protein is high when compare to total soluble protein (Table 2).

For soluble protein these are 28% was observed after 7 days followed by 30%, 36%, 42%, 46% 50% and 60% were observed for 14, 21, 28, 35, 42 and 49 days of preservation period respectively (Table 2).

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Table 2. Percentage of protein degradation in different shrimp species and fish during preservation

		Duration of preservation						
S/N	**Name of the fish**	**After 7 days**	**After 14 days**	**After 21 days**	**After 28 days**	**After 35 days**	**After 42 days**	**After 49 days**
1	***Penaeus mondon***							
	Insoluble protein	18.47	30.47	34.7	35.81	48.90	60.80	66.03
	Soluble protein	28	30	36	42	46	50	60
2	***Penaeus indicus***							
	Insoluble protein	27.1	28.2	34.7	40.20	41.30	56.50	72.82
	Soluble protein	10	32	40	46	50	52	62
3	***Metapenaeus dobsoni***							
	Insoluble protein	26.3	28.5	34	37.30	39.50	47.20	57.10
	Soluble protein	23.1	34.6	4.3	48	50	53.8	61.5
4	***Upeneus vittatus***							
	Insoluble protein	21.7	27.1	34.7	36.9	45.6	59.7	68.4
	Soluble protein	27.7	38.8	40.7	42.5	48.1	57.4	62.9

Penaeus indicus

The protein degradation of *P. indicus* was observed for 49 days of duration, for this at weekly intervals the degradation of protein was estimated. Taking into consideration percentage wise degradation of 27.1% was observed after 7 days preserved sample for insoluble protein. Similarly 28.2% was observed after 14 days, 34.7%, 40.2% , 41.3%, 56.5% and 72.82% were observed after 21, 28, 35, 42 and 49 days of preservation period (Table 2).

For soluble protein these are 10% was observed after 7 days followed by 32%, 40%, 46%, 50%, 52% and 62% were observed in 14, 21, 28, 35, 42 and 49 days of preservation period respectively (Table 2).

Metapenaeus dobsoni

The protein degradation of *Metapenaeus dobsoni* was observed for 49 days of duration, for this at weekly intervals the degradation of protein was estimated. Taking into consideration percentage wise degradation of 26.3% was observed for 7 days preserved sample for insoluble protein. Similarly, 28.5% was observed after 14 days, 34%, 37.3%, 39.5%, 47.2 % and 57.1% were observed after 21, 28, 35, 42 and 49 days of preservation period (Table 2).

For soluble protein decrease 10% was observed after 7 days followed by 23.1%, 34.6%, 40.3%, 48%, 50%, 53.8% and 61.5% were observed for 14, 21, 28, 35, 42 and 49 days of preservation period respectively (Table 2).

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Upeneus vittatus

The protein degradation of *Upeneus vittatus* was observed for 49 days of duration, for this at weekly intervals, the degradation of protein was estimated. Taking into consideration percentage wise degradation of 21.7% was observed for 7 days preserved sample for insoluble protein. Similarly 27.1% was observed after 14 days, followed by 34.7%, 36.9% 45.6%, 59.7% and 68.4% were observed after 21, 28, 35, 42 and 49 days of preservation period (Table 2).

For soluble protein these are 27.7% was observed after 7 days followed by 38.8%, 40.7%, 42.5%, 48.1%, 57.4% and 62.9% were observed for 14, 21, 28, 35, 42 and 49 days of preservation period respectively (Table 2). Whereas species wise degradation of insoluble proteins taken into consideration the maximum of 72.82% was observed in *P. indicus.* The minimum value of 57.1% degradation of insoluble protein was recorded in *M. dobsoni* after 49 days of preservation. The maximum value of 62.9% degradation of soluble protein was reported in *U. vittatus* and minimum value of 60% degradation of soluble protein was identified in *P. monodon* after 49 days of preservation (Table 1).

Discussion

From the food technological point of view changes of muscle proteins during frozen storage is most important and interesting aspect of the biochemistry of fish proteins. Maximum research work was attempted in this field and reported by number of workers. Peng *et al.,* (2022) provided detailed information on spoilage mechanism and preservation technologies on the quality of the shrimp. The major noticeable change in frozen stored fish is the development of tough texture; this is because of protein denaturation. Protein denaturation in frozen fish has three important aspects 1) Effect on protein structure. 2) Changes in muscle protein during frozen storage and 3) the influence of other tissue constituents on the protein structure. The sarcoplasmic protein is not affected to any significant extant during freezing and frozen storage of fish. In cod fish up to two years the albumin fraction remained unaffected as reported by Dyer (1953). In other species of fishes like, halibut and rose fish the albumin fraction remained unaffected during frozen storage (Dyer *et al.,* 1956). Similar results were reported by other workers also (Dingle and Dyer, 1961). But the results of Tomlinson and Geiger (1963) are deviated from the earlier reports. Careche *et al.,* (1998) studied the influence of frozen storage temperatures on the aggregation of myofibrillar proteins of cod. They observed that in fish stored at -20^0C there was a greater loss of protein than fish stored at -3^0C. According to Hu *et al.,* (2022) Ice crystal formation was responsible for the protein denaturation and microbial activity would lead to the deterioration of quality of aquatic products. Zhu *et al.,* (2022) gave explanation about changes in the spatial configuration of proteins that affect the water-holding capacity of muscles and the edible quality of aquatic products. It is evident from the present results that the total protein content of shrimp and fish were gradually decreased, when the preservation time increased. Myofibrillar proteins are perhaps the most important group of proteins as they are responsible for the textural qualities of fish like fibrousness, water holding capacity, gel forming ability, plasticity etc., Denaturation of these proteins directly result in deterioration of fish texture. Myofibrillar proteins are soluble in salt of high ionic strength and are relatively more easily denatured (Gopakumar, 2002). In the present study when species wise degradation of insoluble proteins taken into consideration the maximum of 72.82% was observed in *P. indicus.* The minimum value of 57.1% degradation of insoluble protein was recorded in *M. dobsoni* after 49 days of preservation. The maximum value of 62.9% degradation of soluble protein was reported in *U. vittatus* and minimum value of 60% degradation of soluble protein was identified in *P. monodon* after 49 days of preservation.

Conclusion

Proteins are an important constituent of fish and shrimp muscle, constituting more than 50% of its dry weight. Changes in the muscle proteins during processing and preservation directly affect the texture of the processed fish and shrimp product. In addition to as enzymes they play a major

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role in deciding the post mortem deteriorative changes in all muscle constituents. Experiment was conducted and evaluated the protein degradation of selected species of shrimp and fish.

References

1. Arancibia, M.Y., López-Caballero, M.E., Gómez-Guillén, M.C. and Montero, P. 2015. Chitosan coatings enriched with active shrimp waste for shrimp preservation. Food Control, 54: 259-66
2. Bao, Y., Wang, K., Yang, H., Regenstein, J.M., Ertbjerg, P. and Zhou, P. 2020. Protein degradation of black carp (*Mylopharyngodon piceus*) muscle during cold storage. Food Chemistry, 308: 125576.
3. Benjakul, S. and Bauer, F. 2000. Physicochemical and enzymatic changes of cod muscle proteins subjected to different freze±thaw cycles. Journal of the Science of Food and Agriculture, 80: 1143-1150.
4. Burt, J.R. 2003. Hypoxanthine a biochemical index of fish quality. Process Biochemistry, 11(10): 23-25.
5. Careche, M., Del Mazo, M.L., Torrejón, P. and Tejada, M. 1998. Importance of frozen storage temperature in the type of aggregation of myofibrillar proteins in cod (*Gadus morhua*) fillets. Journal of Agricultural and Food Chemistry, 46(4): 1539-1546.
6. Connell, J.I. 1962. Fish muscle proteins. In: Hawthorn I, Leitch JM (eds) Recent advances in food sciences, vol I. Butterworths, London, pp 136–146.
7. Connell, J.I. 1968. Freezing and frozen storage effect on protein of fish muscle. In: Hawthorn J, Rolfe EJ (eds) Low temperature biology of foodstuffs. Pergamon Press, Hungary, pp 333–358.
8. Connell, J.J. 1961. The relative stabilities of the skeletal-muscle myosins of some animals. Biochemical Journal, 80(3): 503.
9. Devadasan, K. 1981. Oxidation of residual lipids in fish protein concentrates and its effect on the nutritional quality of the protein, Fishery Technology, 18(2): 71.
10. Dong, X., Wang, J. and Raghavan, V. 2021. Impact of microwave processing on the secondary structure, in-vitro protein digestibility and allergenicity of shrimp (*Litopenaeus vannamei*) proteins. Food Chemistry, 337: 127811.
11. Dyer, W.J. 1953. Main problems of fish protein denaturation. Proc. Symposium on Cured and Frozen Fish Technol. Swed. Inst. Food Preserv. Research (Göte borg) Publ. No. 100 (Chap. VII), 12 pp.
12. Dyer, W.J. 1967. Frozen fish muscle—Chemical changes and organoleptic quality. Cryobiology, 3(4): 297-305.
13. Dyer, W.J. and Dingle, J.R. 1961. Fish proteins with special reference to freezing. In: Fish as food. I. Production, biochemistry and microbiology. Academic Press, New York, pp 275–327.
14. Dyer, W.J., Morton, M.L., Fraser, D.I. and Bligh, E.G. 1956. Storage of frozen rosefish fillets. Journal of the Fisheries Board of Canada, 13(4): 569-579.
15. Eddin, S.A. and Tahergorabi, R. 2017. Application of a surimi-based coating to improve the quality attributes of shrimp during refrigerated storage. Foods, 6(9): 76.
16. Flick, G.J. and Martin, R.E. 1992. Advances in seafood biochemistry. Technomic Pub. Co., 1992.

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17. Gopakumar K. (Ed.). 2002. Text Book of Fish Processing Technology. ICAR.

18. Gopakumar, K. 2000. Enzymes and Enzyme products as Quality Indices. Seafood Enzymes, pp 337-363. Harrd, N.F. and Simpspn, B.K., (Eds). Marcel Dekker, Inc.New York, Basel, U.S.A.

19. Hu, R., Zhang, M. and Fang, Z. 2022. A novel synergistic freezing assisted by infrared pre-dehydration combined with magnetic field: Effect on freezing efficiency and thawed product qualities of beef. Food and Bioprocess Technology, 15(6): 1392-1405.

20. Lowry, O., Rosebrough, N., Farr, A.L. and Randall, R. 1951. Protein measurement with the Folin phenol reagent. Journal of Biological Chemistry, 193(1): 265-275.

21. Maeda, N., Dulko, D., Macierzanka, A. and Jungnickel, C. 2022. Analysis of the factors affecting static in vitro pepsinolysis of food proteins. Molecules, 27(4): 1260.

22. Malva, A.D., Albenzio, M., Santillo, A., Russo, D., Figliola, L., Caroprese, M. and Marino, R. 2018. Methods for extraction of muscle proteins from meat and fish using denaturing and nondenaturing solutions. Journal of Food Quality, 2018, 1-9.

23. Peng, S., Wei, H., Zhan, S., Yang, W., Lou, Q., Deng, S. and Huang, T. 2022. Spoilage mechanism and preservation technologies on the quality of shrimp: An overview. Trends in Food Science and Technology, 129: 25-37.

24. Sun, K., Pan, C., Chen, S., Wu, H., Liu, S., Hao, S. and Xiang, H. 2023. Effect of water change on quality deterioration of Pacific white shrimp (*Litopenaeus vannamei*) during partial freezing storage. Food Chemistry, 416: 135836.

25. Tomlinson, N. and Geiger, S.E. 1963. The bound nucleotides of freshly frozen and severely denatured frozen lingcod muscle. Journal of the Fisheries Board of Canada, 20(1): 187-194.

26. Zhu, X., Yuan, P., Zhang, T., Wang, Z., Cai, D., Chen, X. and Goff, D. 2022. Effect of carboxymethyl chitosan on the storage stability of frozen dough: State of water, protein structures and quality attributes. Food Research International, 151: 110863.