The Pharma Innovation Journal 2023; 12(4): 2071-2077

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(4): 2071-2077

www.thepharmajournal.com
Received: 01-02-2023
Accepted: 04-03-2023

Chande NS
Student Post Graduate, Institute of Post-Harvest Technology and Management, Killa-Roha, Raigarh, Maharashtra, India

Patange SB
Associate Dean, Head, Department of Meat Poultry and Fish, Post Graduate Institute of Post-Harvest Technology and Management, Killa-Roha, Raigarh, Maharashtra, India

Chavan DR
Student Post Graduate, Institute of Post-Harvest Technology and Management, Killa-Roha, Raigarh, Maharashtra, India

Bhujbal PK
Student Post Graduate, Institute of Post-Harvest Technology and Management, Killa-Roha, Raigarh, Maharashtra, India

Dalavi PD
Student Post Graduate, Institute of Post-Harvest Technology and Management, Killa-Roha, Raigarh, Maharashtra, India

Corresponding Author:
Chande NS
Student Post Graduate, Institute of Post-Harvest Technology and Management, Killa-Roha, Raigarh, Maharashtra, India

Effect of individual quick freezing on performance, storage and frozen storage characteristics of white-leg shrimp (*Litopenaeus vannamei*)

Chande NS, Patange SB, Chavan DR, Bhujbal PK and Dalavi PD

Abstract
White-leg shrimp (*Litopenaeus vannamei*) is an important cultured species, accounting for more than 53% of the total production of farmed crustaceans and their production and consumption are increasing notably every year. The experiment entiltled "Effect of individual quick freezing on performance, storage and frozen storage characteristics of white-leg shrimp (*Litopenaeus vannamei*)*"* was conducted factorial completely randomized design (FCRD) for different parameters with 5 main treatments *viz.* T_1 raw, T_2 with glaze (20%)+ IQF freezing, T3 treated with NaCl (2%) + STPP (3%) + glaze (20%)+ IQF freezing, T_4 Treated with NaCl (2%) + STPP (3%)+ blanching (75 °C) +IQF freezing + glaze(20%) and T_5 treated with NaCl (2%) + STPP (3%)+ cooking (95 °C)+ IQF freezing + glaze (20%) and frozen storage at – 18 °C for 120 days were analyzed for changes in physical, biochemical, microbiological and sensory parameters. It was observed that samples with pretreatment of NaCl (2%) + STPP(3%) + blanching ((75 °C) +IQF freezing + glaze (20%) and with NaCl (2%) + STPP (3%)+ cooking (95 °C)+ IQF freezing + glaze (20%) were opted the best treatment during frozen storage of 120 days and changes into the core parameters i.e. protein, fat, ash, moisture, drip loss, NPN, TVB-N, TMA-N and total plate count were observed decreasing trend with respect to other treatments.

Keywords: IQF, frozen storage and freezing

Introduction
White-leg shrimp (*Litopenaeus vannamei*) is an important cultured species, accounting for more than 53% of the total production of farmed crustaceans (FAO 2018) [7], and their production and consumption are increasing notably every year. Shrimps are considered perishable due to easy loss of freshness during storage and distribution, especially when transported with the viscera intact. Various enzymatic and bacterial activities occur in the shrimp during storage and distribution, leading to spoilage accompanied by the production of unpleasant odor, discoloration, and chemical changes in the meat (Du *et al*. 2015 and Ginson *et al*. 2013) [5, 11]. The reduction of unpleasant odour, occurrence of black spots, and meat softening are principle sensory and biochemical quality index features due to their close correlations with decreases in freshness (Du *et al*. 2015) [5]. Unpleasant odour is known to be caused by aldehydes, ketones, trimethylamine, ammonia, and volatile sulfur compounds produced by degradation of lipids and proteins by microorganisms (Ocano-Higuera *et al*. 2011, Tsironi *et al*. 2009, Du *et al*. 2015 and Jaffres *et al*. 2011) [29, 40, 5, 16]. Black spots occur mostly due to discoloration, which is a defect caused by the activity of tyrosinase during storage (Mu *et al*. 2012, Tsironi *et al*. 2009) [22, 40]. The decomposition and softening of meat due to a rapid freshness drop is a result of protein degradation caused by microorganisms (Dai *et al*. 2016) [6]. White-leg shrimps (*Litopenaeus vannamei, formerly Penaeus vannamei*), also known as Pacific white shrimp, are native to the Eastern Pacific, from Sonora in Mexico to Northern Peru (Holthuis, 1980) [13]. To maintain quality of seafood some additives have been widely used. The ability of muscle to absorb & added water during processing& capacity of retaining the water after cooking & freezing are the important factors governing quality of seafood & seafood products. Moisture content generally influence meat juiciness, tenderness & mouthfeel (Ogawa *et al*., 1994) [30]. Salt and phosphates are commonly used in combination to exploit their synergistic action (Murphy & Zerby, 2004) [24] At present, it has become the popular and major species of shrimp cultured worldwide. The shrimp is an excellent source of protein and essential high-unsaturated fatty Acids (Feliz *et al*., 2002; Yanar and Celik, 2006) [8, 42]. Besides, the white shrimp is a good source of minerals and vitamins such as calcium, iron,

zinc, copper, vitamin B12 and essential amino acids (Yanar and Celik, 2006) [42]. Sodium tri-polyphosphate from a light film around the shrimp, holding moisture in. This decreases the moisture loss and improves yield as well as overall physical appearance. Use of sodium tripolyphosphate must be in accordance with good manufacturing practice, maximum level in the final product is 5g/kg or in combination (*Codex alimentarius* standard). Usually abbreviated IQF, is a freezing method used in food processing industry. Products commonly frozen with IQF technologies are typically smaller pieces of food products and can range from all types of berries, fruits and vegetables diced or sliced, seafood such as shrimps and small fish, squids, meat, poultry and even pasta, cheese and grains. Products that have been subjected to IQF are referred to as Individually Quick Frozen or IQF. (Alfaro and Danilo, 2017) [2] Another significant advantage of IQF technology is its ability to separate units of the products during freezing, which produces higher quality product compared to block freezing.

Blanching: It is a unit operation previous to freezing, canning, drying in which substances are hotted for the purpose of inactivating enzymes; modifying texture; conserving colour, flavour and nutritive value and removing trapped air. (De Corcuera *et al*. 2004) [4].

Cooking: Cooked shrimp are still raw, however, they are cooked quickly in order to preserve their sweet and delicate flavours.

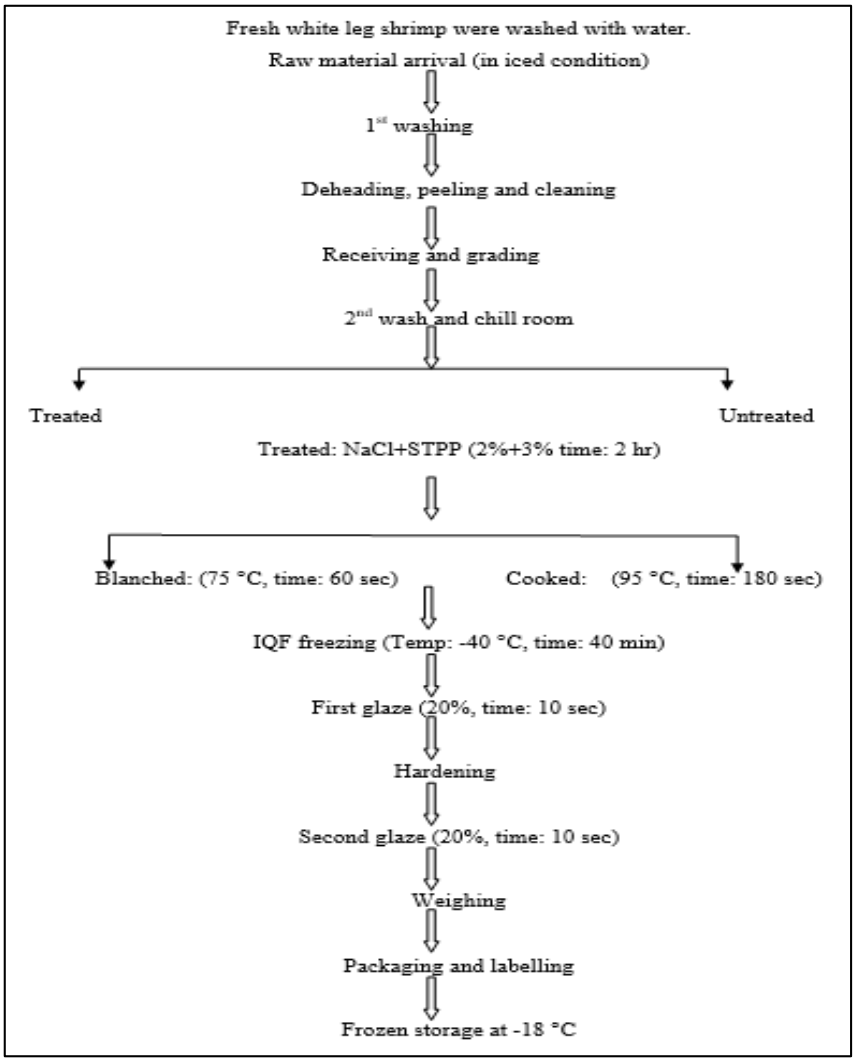
The present study was undertaken for the following objectives:

1. To study the effect of treatment (NaCl (2%) +Sodium tri-polyphosphate (3%) on physical characteristics and frozen storage performance of peeled devined tail-on white-leg shrimp.
2. Effect of blanching (75 °C), cooking (95 °C) and glazing on freezing and frozen storage characteristics of white-leg shrimp.

Material and Methods

White-leg shrimp (*Litopenaeus vannamei*) were procure from the market. The white-leg shrimp were taken to the factory. The samples were then washed and peeled, undeviened and tail-on divided into 5 different treatments as T_1, T_2, T_3, T_4 and T_5 firstly the raw sample (T_1) were frozen by IQF. Then the remaining samples were treated with NaCl (2%) And STPP (3%) for 2 hrs. T_1 raw sample, T_2 with glazed (20%), T_3 NaCl (2%) + STPP (3%) + glazed (20%), T_4 NaCl (2%) + STPP (3%) + glazed (20%) + blanched (75 C) and T5 NaCl (2%) + STPP (3%) + glazed (20%) +cooked (95 C) + IQF freezing. At last all samples were put into separate LDPE packates according to their treatments and packed in a corrugated fibre board & kept in frozen storage – 18 °C for 120 days.

Procedure for Individual quick freezing of white leg shrimp



Methods of Analysis

The stored samples were analyzed for different proximate, biochemical, microbiological quality and sensory parameters at 0 day (day of storage) and regular interval of every 15 days from the day of storage.

Proximate chemical composition

Proximate chemical composition analysis of shrimp samples including to tal ash, moisture, crude protein and crude fat contents were determined according to method of AOAC (2000) section 923.03, 925.09, 979.09 and 4.5.01, respectively. Crude protein amd crude fat were analyzed using kjeldahl block digestion and steam distillation (2200 kjeltec Auto distillation, Foss Tecator AB, Hoganas, Sweden) and Soxhlet extraction (Sox tec service unit 1046, Foss Tecator AB apparatus, respectively.

Colour

Konica minolta colour reader was used. The Color readings were expressed by machine (L*, a* and b*) system (Marc et *et al*., 2018) [11]. L*, a* and b* indicate the whiteness/darkness, which could be white. The minimum for L* would be zero, which could be black. The axes have no numerical limits. Positive a* is red and negative of a* is green. Positive of b* is yellow and negative of b* is blue. The Color of the samples was evaluated after 10 min cooling at room temperature.

Drip loss

Take a sample day 0 were individually weighed and recorded as initial weight (W1).The samples were then placed in sealed polyethylene plastic bags, vacuum-packaged, placed within a container and were stored in a chiller at 4 degrees. After 1 and 7d of storage, the samples were immediately removed from bags, gently blotted dry, weighed and recorded as W2 (final weight).The percentage of drip loss was calculated and expressed as the percentage of differences of sample initial weight. The sample weight after 1 and 7d of storage was divided by sample initial weight (Honikel 1998) [14].

Sensory evaluation

Samples were subjected to sensory evaluation after brining. The fillets were kept out of the packet at room temperature for half an hour and then used for brining for sensory evaluation. Carried out for 5 minutes and allowed to cool down and then give it to the panel for sensory analysis.10 member's panel composed of students and faculty conducted sensory evaluation. Each panel list was asked to evaluate the characteristics like Appearance, colour, texture, odour, flavour, and overall acceptability of each sample on 9– point hedonic scale (Ranganna, 1986) [34]. 1 very poor and 9 excellent.

Statistical Evaluation

The data were analysed to test significant differences by applying an analysis of variances (ANOVA) tool available in MS-Excel 2010. The significant differences were tested by 5% level of significance and are mentioned as $p<0.05$ for significant differences (Panse and Sukhatme, 1989) [33]. The experimental data was analysed statistically using Factorial Completely Randomized Design (FCRD).

Results and Discussion

Proximate Composition

The results of proximate composition of white-leg shrimp are presented in Table 1.

Table 1: Proximate composition of IQF white-leg shrimp stored at -18 °C for 4 months [initial (0) day]

Treatment	Moisture	Fat	Ash	Protein	Non protein nitrogen (NPN)
T_1	74.66	1.21	1.46	19.33	0.755
T_2	74.66	1.21	1.46	19.33	0.754
T_3	78.00	1.21	1.46	19.63	0.754
T_4	73.33	1.21	1.33	19.27	0.751
T_5	73.00	1.21	1.23	19.22	0.748

Table 2: Proximate composition of IQF white-leg shrimp stored at -18 °C for 4 months [final (120) day]

Treatment	Moisture	Fat	Ash	Protein	Non protein nitrogen (NPN)
T1	73.00	1.20	1.46	16.22	0.751
T2	73.33	1.21	1.36	16.56	0.752
T3	76.33	1.21	1.43	18.54	0.751
T4	71.66	1.21	1.26	18.24	0.749
T5	71.33	1.21	1.16	17.66	0.746

Moisture decreases slightly at the end of storage period. Thermal denaturation of proteins and shrinkage of fiber could lead to loss of moisture (Niamnuy *et al*. 2007) [25]. When the temperature of muscle was higher than 60 °C, the connective tissue network and the muscle fibers began cooperatively shrink longitudinally, and the extent of shrinkage increased with increasing temperature, thus causing the increase water loss during cooking (Tornberg, 2005) [39]. The decrease of WHC is often described as the effect on denaturation of myofibrillar protein in the muscle during cold storage. Selvaraj *et al*. (1991) [35] also reposted a gradual decrease in moisture content of squid during frozen storage. In case of fat Ghaly (2010) [9] reported that the moisture content of prawn tissue decreases with blanching and cooking. The observed decreases in lipid content, during the ice storage may also be due to auto oxidation and hydrolysis of shrimp lipids. T Sironi *et al*. (2009) [40] reported that the storage reduced the lipid oxidation in shrimp and lower deep frozen temperature has more significant inhibitory effect. With respect to ash it slightly decreasing at end of storage period. Similar results observed by jeyakumari *et al*. (2018) [17]. There is increase in protein and NPN at the end of a storage period of 120 days.

Drip loss

The mean value of treatments for drip loss content in all treatments was observed 11.69% on initial (0) day while at the final (120) day of storage period the drip loss content was observed to be 1.07%. Thus, it was clear from the data that drip loss varied with different treatments. Similar results were observed by Suyani *et al*. (2019) [37] at any given time frozen storage STPP treated shrimp showed lower drip loss as compare to control sample. Sutton (1969) [38] has found that STPP definitely reduces the drip loss during frozen storage. also Warrier *et al*. (1975) [41] found that the treatment of muscle with sodium tri-polyphosphate could reduce the level of hydrolytic enzymes released into the drip. Pre-treatments in sodium chloride or sodium tri-polyphosphate were found to reduce the drip loss and to maintain good quality of fish during frozen storage.

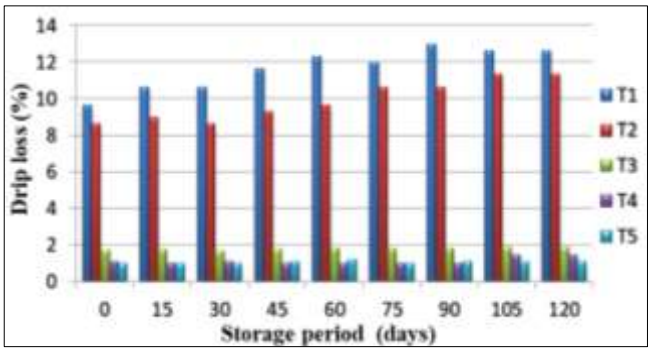


Fig 1: Effect of IQF treatment on drip loss of white-leg shrimp during frozen storage

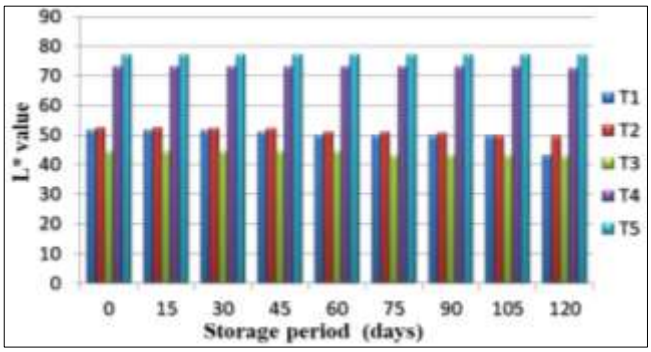


Fig 2: Effect of IQF treatment on L*value of white-leg shrimp during frozen storage

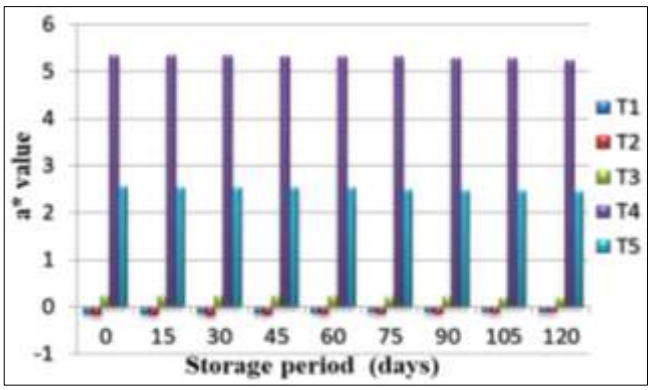


Fig 3: Effect of IQF treatment on a* value of white-leg shrimp during frozen storage

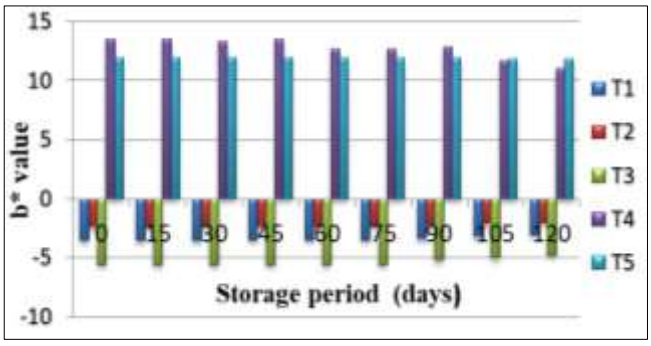


Fig 4: Effect of IQF treatment on b* value of white-leg shrimp during frozen storage

Colour values decreased as storage period increased. The treatment conditions greatly influenced the colour of shrimp. An increase in L* is anticipated with cooking at 60 and 70 °C during the early stage. Oxidation and browning resulted in a decrease during the later stage for temperatures higher than 80 °C, The pink/red color of shrimp is due to the presence of the carotenoid astaxanthin, obtained from ingestion of carotenoid-containing marine plants (Muriana *et al*. 1993.

TVB-N

There is a significant increase of TVBN values which varied with different treatments. TVB-N increase in the present study may be due to the action of autolytic enzymes and spoilage bacteria. Similar observations were recorded by Benjakul *et al*. (2003) [3]. A level of 30 mg N/100g was acceptable for consumption of shrimp Lopez-cabellero *et al*. (2007) [20]. Similar results were observed by Lee and Um (1995) [19] that TVBN increased from initial 5 mg/100g to 14.8 mg/100g after 8 months by storing shrimp at -18 °C.

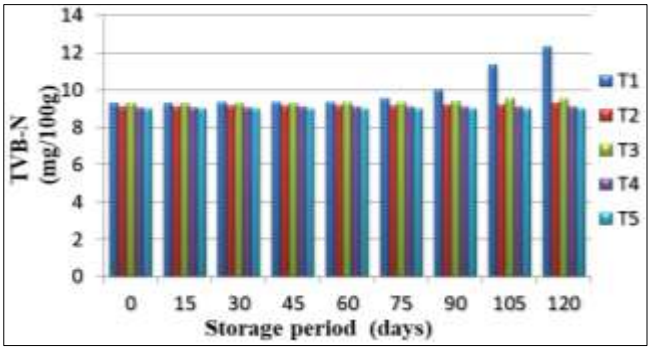


Fig 5: Effect of IQF treatment on TVB-N content of white-leg shrimp during frozen storage

TMA-N

There is a significant increase of TMAN values which varied with different treatments. TMA increased gradually in both the samples during frozen storage (Selvaraj *et al*., 1991) [35]. TMA is a typical fishy odour component produced by trimethylamine oxide (TMAO) due to bacterial action and is also occasionally present in fresh meat (Olafsdottir *et al*. 1997) [32]. DMA is produced by the degradation of TMAO and the decomposition of amino acids, and ammonia is mainly produced by the decomposition of amino acids due to the action of bacteria (Huss. 1995) [15]. Among these volatile nitrogen compounds, TMA is occasionally used as a freshness judgment criterion for fish. The TMA value for the initial decomposition baseline in fish is well known to be 3 mg/100 g (Song *et al*. 2005) [36]. Okpala *et al*. (2014) [31] reported a significant increase in TMA values during iced storage of Pacific white shrimp. Lu *et al*. (2011) reported that the TMA value increased from an initial 7.93 mg/100g to 16.06 mg/100g after 14 days of shrimp storage at 37 °C.

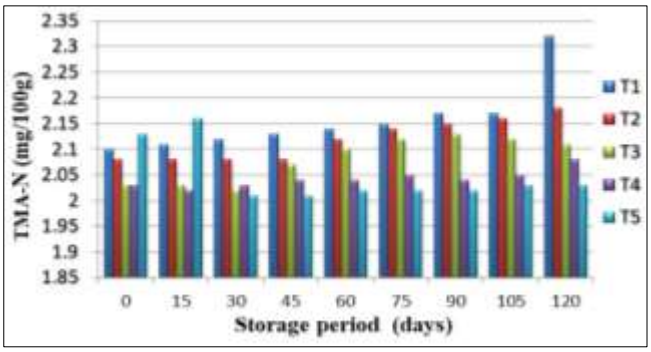


Fig 6: Effect of IQF treatment on TMA-N content of white-leg shrimp during frozen storage

The results clearly revealed that the microbial growth was more with increasing storage period. Similar increment on total bacterial load in at low temperature storage was reported by (Lawire, 1998: Obemeta *et al*. 2011) [18, 28]. The reason for microbial growth promoting effect of moisture on microbes in meat stored in chiller thid due to less acid enzymatic reaction of fish flesh.

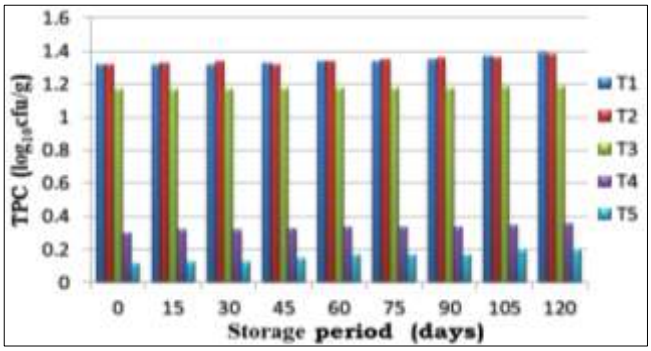


Fig 7: Effect of IQF treatment on total plate count of white- leg shrimp during frozen storage

Sensory analysis

The shrimp samples stored at – 18 °C condition for 4 months showed different performance in sensory score. The shrimp sample of T4 and T5 obtained the highest sensory score for colour (8.75 and 8.70), texture (8.6 and 8.7), odour (9.0 and 9.0) as well as overall acceptability (8.8 and 8.8) respectively.

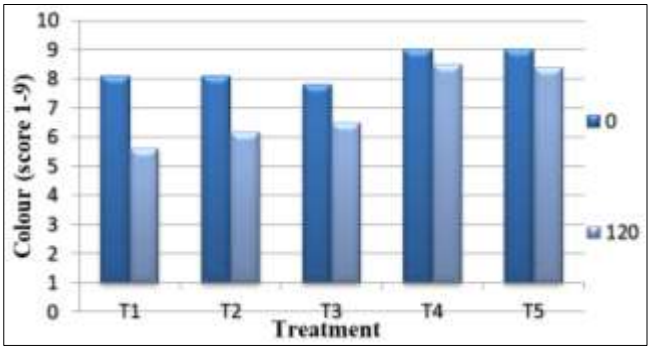


Fig 8: Effect of IQF treatment on Colour of white-leg shrimp during frozen storage

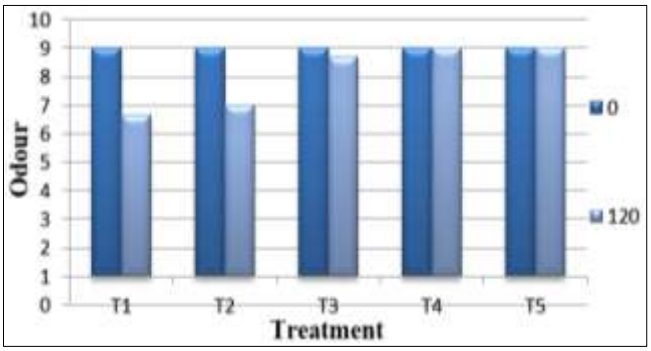


Fig 9: Effect of IQF treatment on odour of white-leg shrimp during frozen storage

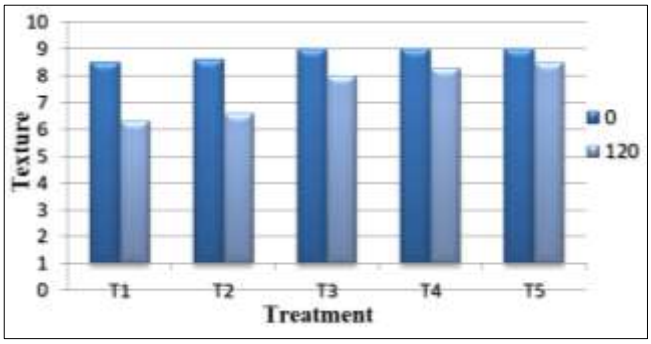


Fig 10: Effect of IQF treatment on texture of white-leg shrimp during frozen storage

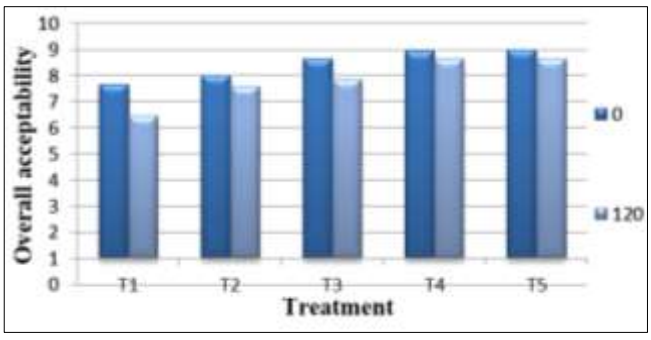


Fig 11: Effect of IQF treatment on overall acceptability of white-leg shrimp during frozen storage

Conclusion

Present investigation concluded that different treatments to shrimp prior to freezing have an additional effect on storage performance in relation to proximate, biochemical, microbiological parameters on final (120) days of storage. Thus, the study suggest that the shrimp should be given pre-treatment of NaCl + STPP + Balnching (75 °C) +glazing (20%) + IQF freezing (-40 °C) and NaCl + STPP + Cooking (95 °C) + Galzing (20%) + IQF freezing (-40 °C) to improves their storage performance as well as organoleptically accepted till the 120 days of storage period.

References

1. AOAC. Official methods of analysis of AOAC international, 17th edn. AOAC International, Md., USA; c2000.
2. Alfaro D. IQF (Individually quick frozen); c2017. Available at https://www.thespruceeats.com/what-does-iqf-mean9957192017.
3. Benjakul S, Visessanguan W, Thongkaew C, Tanaka M. Comparative study on physicochemical changes of muscle proteins from some tropical fish during frozen storage. Food Research International. 2003;36(8):787-795.
4. De Corcuera JIR, Cavalieri RP, Powers JR. Blanching of foods. Encyclopedia of agri, food and biological engineering. Marcel Dekker, New York City, NY, USA;

c2004. p. 1-5.
5. Du L, Chai C, Guo M, Lu X. A model for discrimination freshness of shrimp. Sens Biosensing Res. 2015;6:28-32.
6. Dai Q, Cheng JH, Sun DW, Zhu Z, Pu H. Prediction of total volatile basic nitrogen contents using wavelet features from visible/near-infrared hyperspectral images of prawn (*Metapenaeus ensis*). Food Chem. 2016;197(15):257-265.
7. FAO. The state of world fisheries and aquaculture 2018-meeting the sustainable; c2018.
8. Feliz GLA, Gatlin MD, Lawrence LA, Velazquez PM. Effect of dietary phospholipid on essential fatty acid requirements and tissue lipid composition of *Litopenaeus vannamei* juveniles. Aquacult. 2002;207:151-167.
9. Ghaly AE, Dave D, Budge S, Brooks MS. Fish spoilage mechanisms and preservation techniques. American journal of applied sciences. 2010;7(7):859.
10. Ghaly AE, Ramakrishnan VV, Brooks MS, Budge SM, Dave D. Fish processing wastes as a potential source of proteins. Amino acids and oils: A critical review. J Microb. Biochem. Technol. 2013;5(4):107-129.
11. Ginson J, Kamalakanth CK, Bindu J, Venkateswarlu R, Das S, Chauhan OP, *et al*., Changes in K value, microbiological and sensory acceptability of high pressure processed Indian white prawn (*Fenneropenaeus indicus*). Food and Bioprocess Technology. 2013;6(5):1175-1180.
12. Gunasekaran P. Laboratory Manual in Microbiology, New Age International Publishers, Madurai, India; c1995.
13. Holthuis LB. FAO species catalogue. Vol.1. Shrimps and prawns of the world. An annotated catalogue of species of interest to fisheries. FAO Fisheries Synopsis, no. 125. FAO, Rome, 1980, 271.
14. Honikel KO. Reference methods for the assessment of physical characteristics of meat. Meat science. 1998;49(4):447-457.
15. Huss HH. Quality and quality changes in fresh fish. FAO Fisheries Technical Paper 348, Sub- committee on Fish Trade, Food and Agriculture Organization of the United Nations; c1995.
16. Jaffres E, Lalanne V, Mace S, Cornet J, Cardinal M, Sérot T, *et al*., Sensory characteristics of spoilage and volatile compounds associated with bacteria isolated from cooked and peeled tropical shrimps using SPME–GC–MS analysis. International Journal of Food Microbiology, 2011;147(3):195-202.
17. Jeyakumari A, Debbarma J, Remya S, Ravishankar CN, Zynudheen AA, Ninan G, *et al*., Quality Changes of White Shrimp (*Litopenaeus vannamei*) Treated with Potassium Sorbate and Sodium Metabisulphite: A Comparative Study; c2018.
18. Lawrie RA. The storage and preservation of meat II. Moisture control. In: Lawrie's Meat Science, 6th Edn; c1998. p. 191-194.
19. Lee YC, Um YS. Quality determination of Shrimp (Penaeus japonicus) during iced and frozen storage. Korean J Food Sci Tech. 1995;27(4):520-4.
20. Lopez-Caballero ME, Martinez-Alvarez O, Gomez-Guillen MC, Montero P. Quality of thawed deepwater pink shrimp (*Parapenaeus longirostris*) treated with melanosis-inhibiting formulations during chilled storage. Int. J Food Sci. 2007;42:1029-1038.
21. Marcet I, Alvarez C, Paredes B, Rendueles M, Diaz M. Transparent and edible films from Uiltrasound-Treated egg Yolk Granules. Food and bioprocess technology. 2018;11(4):735-747.
22. Mu HL, Chen HJ, Fang XJ, Mao JL, Gao HY. Effect of cinnamaldehyde on melanosis and spoilage of Pacific white shrimp (*Litopenaeus vannamei*) during storage. J Sci Food Agric. 2012;92(10):2177–2182.
23. Muriana FJ, Ruiz-Gutierrez V, Gallardo-Guerrero ML, Minguez-Mosquera MI. A study of the lipids and carotenoprotein in the prawn, Penaeus japonicus. The Journal of Biochemistry. 1993;114(2):223-229.
24. Murphy MA, Zerby HN. Prerigor infusion of lamb with sodium chloride, phosphate, and dextrose solutions to improve tenderness. Meat science. 2004;66(2):343-349.
25. Niamnuy C, Devahastin S, Soponronnarit S. Quality changes of shrimp during boiling in salt solution. Journal of food science. 2007;72(5):S289-S297.
26. Nair MR. Recent advances in fish processing and product development; c1988.
27. Niamnuy C, Devahastin S, Soponronnarit S. Quality changes of shrimp during boiling in salt solution. Journal of food science. 2007;72(5):S289-S297.
28. Obemeata O, Nnenna FP, Christopher N. Biological assessment of stored Tilapia. Afric. J Food Sci. 2011;5(4):242-247.
29. Ocano-Higuera VM, Maeda-Martínez AN, Marquez-Ríos E, Canizales-Rodríguez DF, Castillo-Yanez FJ, Ruíz-Bustos E, *et al*. Freshness Assessment of Ray Fish Stored in Ice by Biochemical, Chemical and Physical Methods. Food Chem. 2011;125:49-54.
30. Ogawa M, Tamiya T, Tsuchiya T. Structural changes of carp myosin during heating. Fisheries Science. 1994;60(6):723-727.
31. Okpala COR, Choo WS, Dykes GA. Quality and shelf life assessment of Pacific white shrimp (*Litopenaeus vannamei*) freshly harvested and stored on ice. LWT-Food Science and Technology. 2014;55(1):110-116.
32. Olafsdottir G, Martinsdóttir E, Oehlenschläger J, Dalgaard P, Jensen B, Undeland I, *et al*., Methods to evaluate fish freshness in research and industry. Trends in food science & technology. 1997;8(8):258-265.
33. Panse VS, Sukhatme PV. Statistical methods for agriculture workers, Indian council of agricultural research, New Delhi; c1989.
34. Ranganna S. Handbook of analysis and quality control for fruit and vegetable products. Tata McGraw-Hill Education; c1986.
35. Selvaraj P, Jasmine JI, Jeyachandran P. Effect of ascorbic acid dip treatment on frozen storage of squid (*Loligo duvaucelii*, oribigny). Fish Technol. 1991;2:117-121.
36. Song HN, Lee DG, Han SW, Yoon HK, Hwang IK. Quality changes of salted and semi-dried mackerel fillets by UV treatment during refrigerated storage. Korean J food cook sci. 2005;21(5):662-668.
37. Suyani NK, Rathore SS, Vandarwala UG, Patel K, Rana RJ. Physical, chemical and sensorial quality evaluation of phosphate treated and non-treated PUD shrimp (*Litopenaeus vannamei*) samples. International Journal of Fisheries and Aquatic Studies. 2019;7(5):296-299.
38. Sutton AH, Main G, Ronald A. An instrument for counting the larvae of the prawn, Palaemon serratus and the brine shrimp, Artemia salina. Laboratory practice.

1969;18(4):433-436.
39. Tornberg EVA. Effects of heat on meat proteins–Implications on structure and quality of meat products. Meat science. 2005;70(3):493-508.
40. Tsironi T, Dermesonlouoglou E, Giannakourou M, Taoukis P. Shelf life modelling of frozen shrimp at variable temperature conditions. LWT-Food Science and Technology. 2009;42(2):664-671.
41. Warrier SBK, Gore MS, Kumta US. Fish muscle structural proteins; c1975.
42. Yanar Y, Celik M. Seasonal amino acid profiles and mineral contents of green tiger shrimp (Penaeus semisulcatus De Haan, 1844) and speckled shrimp (*Metapenaeus monoceros* Fabricus, 1789) from the Eastern Mediterranean. Food Chemistry. 2006;94(1):33-36.