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Quality Evaluation of High Pressure–Processed Edible Oyster (*Crassostrea madrasensis*) during Chilled Storage

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Abstract

The effect of high pressure on changes in quality of oyster meat subjected to 300 MPa pressure during chilled storage at 2±1°C was evaluated. 100g of depurated and shucked oyster meat was packed under vacuum in EVOH multilayer pouches. The packed pouches were then subjected to 300 MPa pressure with a holding time of 5 min at 25°C. A control was also maintained without pressure treatment. The pressure-treated oyster and control were further stored at 2±1°C. The pH, thiobarbituric acid value (TBA), total volatile nitrogen (TVB-N) and free fatty acid value (FFA) showed an increasing trend during storage for both control and pressure-treated samples. Total plate count decreased after pressure treatment but showed an increase during storage. On the basis of microbiological and chemical parameters evaluated, it was found that high pressure-processed oyster meat had a shelf life of 27 days whereas control was acceptable up to 15 days only during storage at 2±1°C.

Key words: High pressure processing, oyster meat, chill storage

Introduction

High pressure processing (HPP) of food can be conducted at ambient or refrigerated temperatures, thereby eliminating cooking effects and off-flavors. The technology is highly beneficial for heat sensitive products which have to be processed at low temperatures. Among the different non-thermal techniques in vogue today, HPP is popular due to its food preservation capacity and its ability to achieve interesting functional properties (Leadley & Williams, 1997). HPP machines with capability of operating in the pressure range of 400-700 MPa (Farr, 1990) and capacities ranging up to 900 kg per batch are available. Since HP processing mainly affects the non-covalent bonds, the quality characteristics of foods such as color, flavor and vitamins remain unaffected (Knorr, 1993).

HPP can be used to extend shelf life of products and it can be used to eliminate pathogens like *Escherichia coli, Salmonella* and *Listeria* and spoilage bacteria without affecting color and flavor of the product. HPP is also used worldwide in shell fish processing for 100 % shucking of meat from the shells and for reducing the microbial risks during raw seafood consumption. HPP process inactivates vegetative microorganisms and reduces bacterial contamination and pathogens (Ohshima et al., 1993). High pressure promotes enhanced shelf life without affecting, chemical, microbiological and sensory characteristics while inactivating pathogens present in the samples (Capri et al., 1995).

Oysters are commercially produced and marketed in different countries, especially in the United States of America. Besides microbial preservation and shelf-life extension, high pressure treatment helps in easy shucking of oyster meat out of their shells which is favorable. Cruz-Romero et al., (2007) compared the physical and biochemical changes in oysters subjected to high-pressure treatment at 260 MPa for 3 min or heat treatment (cool pasteurization (CP) at 50°C for 10 min or traditional pasteurization (TP) at 75°C for 8 min) on the shucking yield and reported that HP treated oysters were best among the three. They also reported that the oyster samples had a low initial microbial count and did not reach spoilage levels during four weeks storage in any of the pressure-treated samples. The sensory panel found the appearance of the pressure-treated samples (>400 MPa) to be more acceptable than controls. The

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panel also found that raw odour did not significantly change up to two weeks storage. High pressure processing application at 400 MPa has resulted in 5-log reduction of target microorganisms in oysters and enabled 41 days of storage at 2^0C (Lopez-Caballero et al., 2000a). Studies revealed that the optimum shucking pressures that caused minimum changes to pacific oyster appearance are in the range of 240 to 275 MPa (He et al., 2002). High pressure treatment of oysters resulted in a more round and juicy appearance when compared to the control, and similar results have been reported by Lopez-Caballero et al., 2000b). This is because of the increased moisture due to the rearrangement of the water molecules in the pressurized oysters. Hoover et al, (1989) have reported enhancement of flavor in oysters due to the uptake of salt from the surrounding water and (Hayashi, 1992) has found that the raw taste was maintained after high pressure treatment.

In oyster muscle, 207 – 310 MPa pressure for 1 and 2 min was found to reduce the initial microbial load by 2 to 3 Log_{10} and the microbial count remained reduced throughout the storage study (He et al., 2002). Cruz-Romero et al., (2008a) have reported that a pressure treatment of 270-300 MPa could eliminate the *Vibrio parahaemolyticus* in oysters without adversely affecting the sensory properties. A treatment of 200 MPa for 10 log at 25°C achieved greater than 10 min reductions in the same pathogen (Berlin et al., 1999) whereas (Cook, 2003) found that a treatment of 300 MPa with 3 min hold time at 28°C gave a 6 log reduction in homogenised oysters. Taking these findings into consideration, the pressure target for the shelf life studies was arrived at 300 MPa with a hold time of 5 min and temperature 30°C so as to destroy the harmful pathogens while at the same time retaining the sensory scores. Hence, attempts were made to evaluate the shelf life of high pressure-processed edible oyster meat during chilled storage at 2±1°C.

Materials and Methods

Live oysters were harvested from the Vembanad reservoir, Kollam, Kerala and the meat was shucked immediately under hygienic conditions. The meat was then packed in low density polythene pouches and transported to the laboratory in iced condition. It was later washed with potable water and then 100g each was vacuum (Sevana Quick Seal Machine, India) packed in EVOH (Ethylene-vinyl alcohol copolymers) films. After packing, the samples were divided into two batches of which one was control and the other was subjected to a single high pressure treatment of 300 MPa for 5 min at 25°C.

High pressure-processing of the samples was carried out in a HP machine (Stansted Fluid Power Ltd, Stansted, Essex, and UKModel No FPG71009/2C). The pressure vessel was of 2L capacity(570 mm length, 70 mm diameter), 30% monopropylene glycol in water was used as the pressure transmitting liquid. The temperature of high pressure transmission fluid inside the pressure chamber during pressurization was monitored through a K-type thermocouple. Processing was done at 300 MPa with a holding time of 5 min at a temperature of 25°C. After depressurization, the samples were stored immediately in ice at 1:1 ratio in insulated boxes and samples pressure-treated were drawn periodically for analysis. Sampling was done in triplicate and mean values were taken. The untreated lot kept in iced condition acted as control.

pH was measured by using a glass electrode digital pH meter (Cyberscan 510, Eutech Instruments, Singapore) as described in APHA (1998). TVB-N was determined by the micro-diffusion method (Conway, 1962). TBA value was determined as described by Tarladgis et al., (1960) and free fatty acid content by AOAC (2002) and total plate count by ICMSF, (2001). Statistical analysis was carried out by using SAS. 9.2. Sampling was done in triplicate and mean values were taken.

Results and Discussion

The initial pH values were 6.12 and 6.28 in control and 300 MPa samples respectively (Fig 1). The pH values reached a level of 6.44 on the 15th day of storage in control samples whereas pH of 300 MPa treated samples reached 6.48 on the 30th day of storage. pH values were above 6 which indicated its fresh condition and similar findings have been reported by (Cruz-Romero et al., 2004 and Cruz-Romero et al., 2007). An increase in pH values was noticed after high pressure treatment and the results are in agreement with findings of Cheah & Ledward (1997). Similar results were reported in headless prawns (Ginson et al., 2012). The increase in pH is due to pressure-induced unfolding of protein and ionisation of denatured protein (Yamamoto et al., 1994). An increasing trend in pH was observed both in control and treated samples during storage due

to the production of volatile base compounds by bacterial activity (Grigorakisa,et al., 2003). A significant difference in pH value was observed in control samples on the 3rd day and in HPP - treated samples on the 9th and 18th day of storage.

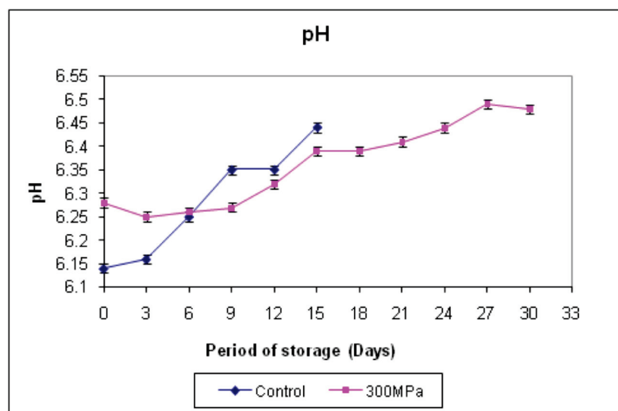

Fig. 1. Changes in pH values during chilled storage

Changes in TVB-N values are given in Fig 2. There was a marginal decrease after high pressure processing when compared to control samples. The initial value of control was 13.94 and that of pressure-treated meat was 12.56 which increased gradually during the storage period. The final values after the storage period were 24.68 for control and 27.14 for pressure-treated oysters. There was a significant difference in the control value on the 6th day whereas no difference was observed in the treated samples. TVB-N values of the treated and control oyster were relatively lower at the end of the shelf-life period mainly because the oyster muscle contains glycogen that gets converted into lactic acid.

Free fatty acids content of the 300 MPa treated oyster meat increased to 4.56 mg % oleic acid after pressure treatment, where it was 3.2mg % oleic acid in the untreated oyster. The values gradually increased in both the samples during storage. On the 15thday when the untreated samples were rejected the values were 11.56 mg % oleic acid and on the 30th day when the 300 MPa treated samples were rejected the values were 14.56 mg % oleic acid respectively. FFA has an important role in fish muscle lipid oxidation enhancement (Mackie, 1993) and is strongly correlated with off-odour development. Pressure treatment (up to 300 MPa) is thought to have a significant effect on the FFA content of chill stored HHP-treated fish samples. Initial higher

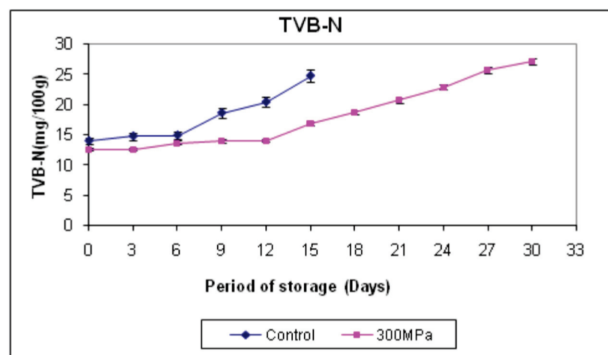

Fig. 2. Changes in TVB-N values during chilled storage

mean values of FFA were found in salmon, turbot, and carp fillets (Sequeira-Muñoz et al., 2006) treated under pressure conditions (up to 300 MPa) when compared to control samples. With increase in storage time, lower FFA values were observed for HP - treated meat. FFA has been reported to be produced during the initial period of chill storage due to the action of enzymes like lipases and phospho-lipases. Later, microbial activity gains importance and FFA formation is then mostly due to bacterial catabolic processes.

The changes in TBA values during chilled storage are given in Figure 4. The initial TBA values for high pressure-treated and control samples were 0.045 and 0.043 mg malonaldehyde kg^{-1}. respectively. High pressure treatment resulted in higher lipid oxidation when compared to control samples. The values for high pressure-treated oyster meat and control samples were 0.7 and 0.1 mg kg^{-1} malonaldehyde at the end of storage, which are much below the limit of rejection. TBA values are significantly different on the 9th day for control and on the 12th day for

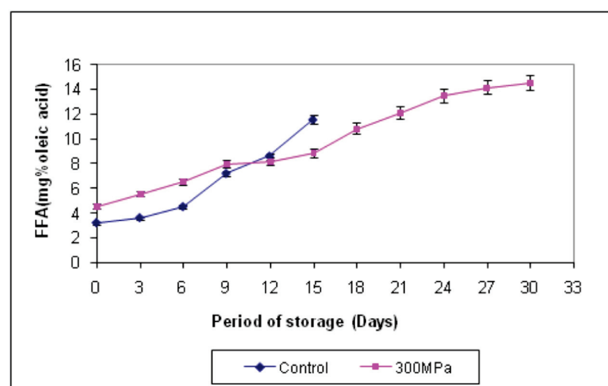

Fig. 3. Changes in free fatty acid values during chilled storage

pressure-treated samples. The higher values in pressure-treated meat is mainly due to the fact that during high pressure treatment there is a possibility for the cell structure to break and make available intercellular lipid deposits for oxidation. The accelerated lipid oxidation during high pressure may also be due to the auto oxidation of fat which is accelerated by the release of metal ions from the denatured haem protein. (Tanaka et al., 1991). Lipid oxidation was also reported (Yagiz et al., 2007) in trout dark muscle at pressure levels beyond 300 MPa and by Chevalier et al., (2001) where levels of 200 MPa for 30 min duration increased lipid oxidation in turbot muscle and in cod muscle (Angsupanich & Ledward, 1998). The presence of metal ions like Fe and Cu in fish muscles also enhanced oxidation.

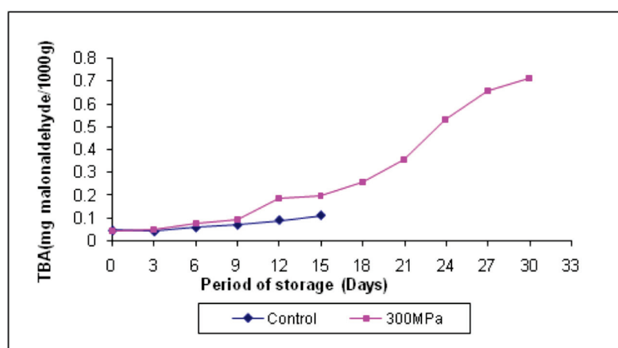

Fig. 4. Changes in TBA values during chilled storage

Changes in total plate count for control and high pressure-treated oysters during storage period at 2°C is given in Fig. 5. The initial count of 5.1cfu/g increased to 7.05 cfu/g after 15 days of storage whereas in the case of treated oysters there was a initital reduction to 3.82 cfu/g immediately after pressure treatment, which reached to the limit of 7 cfu/g after 27 days of storage whereas the control reached the limit after 18 days. A reduction in the bacterial count has been observed for headless prawns with increasing pressure treatment (Ginson et al., 2012). Bacterial load reduction is due to breakdown of plasma membrane, denaturation of proteins and alteration in the permeability of the cell wall of microorganisms (Chong & Cossius, 1983). During iced storage an increasing trend of TBA was observed in both control and pressure-treated samples. This result is in agreement with Montero et al. (2001) for HP - treated *Penaeus japonicus* after 35 days of storage.

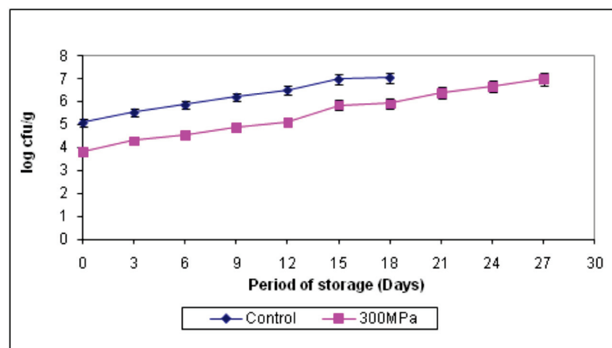

Fig. 5. Changes in Total Plate countvalues during chilled storage

Conclusion

The study concluded that high pressure processing is an effective non thermal processing technique for retarding the microbiological and chemical changes that occur during storage. Here, high pressure processed oyster samples exhibited lower values of pH, TVBN and total plate count during chilled storage. Higher values of TBA and FFA indicated that pressure treatment marginally enhanced lipid oxidation in the oyster meat within the rejection levels. Pressure treatment enhanced the shelf life of the oyster meat during chilled storage with control having a shelf life of 15 days and high pressure-treated meat was acceptable upto 27 days.

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