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The effect of different thawing methods on chemical properties of frozen pink shrimp (*Penaeus duorarum*)

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Abstract:

BACKGROUND: Freezing is a common way and one of the best methods of seafood preservation for long periods of time; however, the freeze thawing process may influence the quality of food. **OBJECTIVES:** Oxidation and denaturation of proteins, sublimation and recrystallization of ice crystals can cause changes in the quality of the frozen products. This study was aimed to evaluate the effect of three different thawing methods including microwave, refrigerator, and water thawing on the quality of pink shrimp (*Penaeus duorarum*). **METHODS:** For this purpose, the pink shrimps were hunted from Persian Gulf. Then, 200 g of peeled undeveined shrimps were frozen in vacuum-packed polyethylene bags at -40°C. The samples were transferred to Kerman Veterinary School and were kept at -18°C freezer. After four days, the shrimp were defrosted by three mentioned methods. Three cycles of freezing and defrosting with four days intervals were performed. Percentage of thawing loss (%TL), thiobarbituric acid (TBA), total volatile base (TVB), and salt-soluble protein (SSP) were detected at each freeze-thaw cycle. **RESULTS:** An increase in the freeze-thaw cycles increased TBA and TVB value slightly and significantly decreased the SPP value ($p<0.05$). Microwave thawing method gave the samples with the highest thawing loss in comparison to the other methods in each freeze-thaw cycle ($p<0.05$). A significant increase was seen in TBA value in water and microwave thawing methods in comparison to refrigerator thawing method ($p<0.05$). Refrigerator thawing method had higher SSP value in comparison to the other thawing methods ($p<0.05$). Likewise, there was no significant difference between three mentioned methods in TVB value ($p>0.05$). **CONCLUSIONS:** The obtained results showed that refrigerator thawing method had lower effect in decreasing chemical quality of the pink shrimp than two other methods, and multiple freeze-thawing processes caused some deleterious effects on the quality of the frozen shrimps.

Introduction

The flesh of shrimp after death is still active and biochemically alive. The organic decomposition or change of shrimp body composition may be triggered by various factors, i.e. enzymes and microbiological activities (Pedraja, 1970; Sirintra et al., 2007). To reduce the problem, muscle should be frozen, stored on ice or refrigerated. Freezing is more effective for preservation over long periods of time (Santos-Yap, 1995; Lourdes et al., 2007). Although freezing is an effective method of preserving foods, some deterioration in frozen food quality occurs during storage.

During thawing, foods are damaged by the chemical, physical, and microbiological changes. The extent of quality loss depends on many factors, including the rate of freezing and thawing, storage temperature, temperature fluctuations, freeze-thaw abuse during storage, transportation, retail display, and consumption (Giddings, 1978; Sebranek, 1982; Srinivasan et al., 1997; Jun et al., 2012). During frozen storage of shrimp and other shellfish products, the quality changes caused by oxidation, denaturation of proteins, sublimation, and recrystallization of ice crystals are predominant (Londahl, 1997; Sirintra et al., 2007). These agents can result in off-flavors, rancidity, dehydration, weight loss, loss of juiciness, drip loss, and toughening (Bhobe et al., 1986; Londahl, 1997, Pisal et al., 2007a), as well as microbial spoilage and autolysis (Bhobe, 1986).

A better knowledge of the effects of freezing-thawing treatments on the texture of shrimp muscles would provide producers and processors with a more efficient way to market their product. The present research was undertaken to evaluate and compare the effect of three freezing-thawing protocols including microwave, refrigerator, and water thawing on the chemical properties of the pink shrimp.

Materials and Methods

Study design: This research was performed on the shrimps hunted from Persian Gulf .The samples were transferred with ice to the laboratory of Qeshm Soza, a seafood processing factory, Qeshm city, Iran. 200g of peeled undeveined shrimps (PUD) were frozen in vacuum-packed polyethylene bags at -40°C for 24h. Then, samples were transferred to Kerman Veterinary School while kept in -18°C in freezer during transferring and saving processes. After four days, defrosting was done by three methods as follow; microwave, refrigerator, and water thawing. Three cycles of freezing and defrosting with four days intervals were done. For this purpose, 50g of the samples were taken for the test and the rest of the shrimps were frozen again at -18°C (Mansouri-Najand, 2012).

Defrosting methods: A) Microwave thawing. The samples were placed in a dish and were adjusted in microwave (LG Co., Korea) on automatic defrosting of marine food. Time was set based on the weight of the samples automatically that was between 1 to 2 minutes and the samples were deforested without being cooked.

B) Water thawing: The samples were placed in water at the temperature of 25°C. After 30 min, the temperature of the samples reached 25°C and defrosting was completed.

C) Refrigerator thawing: The samples were placed in sterile dish in refrigerator at 5-6°C. After 5 hours, the samples were deforested.

These three methods of deforesting were repeated in three groups with the interval of 4 days in 3 cycles.

Chemical analysis: The samples were analyzed for percentage of thawing loss, thiobarbituric Acid (TBA), total volatile base (TVB), and salt-soluble protein (SSP).

A) Thawing loss determination. The thawing loss of the thawed shrimps was determined from the known weights of shrimps before and

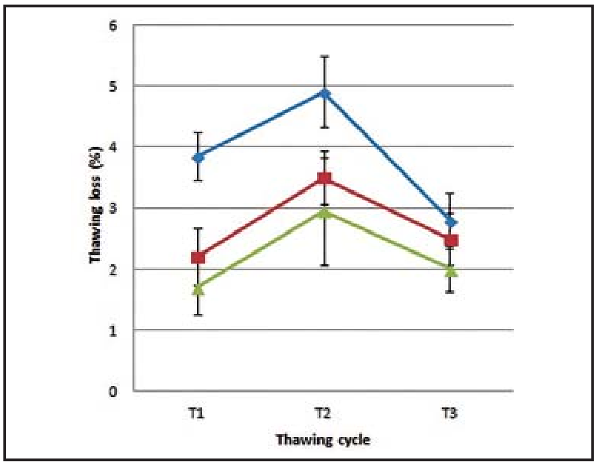

Figure 1. Changes of thawing loss during thawing cycles due to different thawing methods. Bars represent the mean± S.E. from triplicate determinations. Microwave thawing ◆ Water thawing ■ Refrigerator thawing ▲

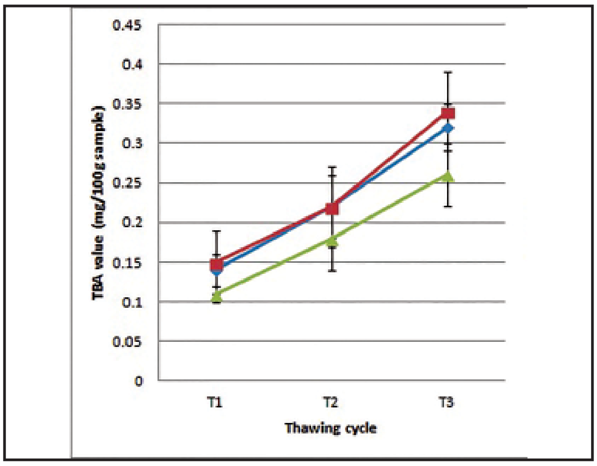

Figure 2. Changes of TBA during thawing cycles due to different thawing methods. Bars represent the mean± S.E. from triplicate determinations. Microwave thawing ◆ Water thawing ■ Refrigerator thawing ▲

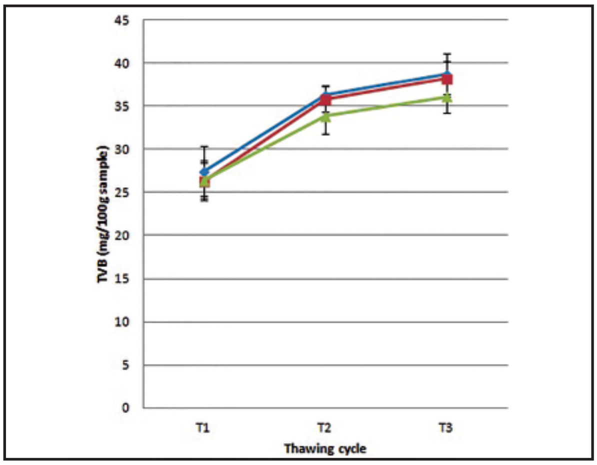

Figure 3. Changes of TVB during thawing cycles due to different thawing methods. Bars represent the mean± S.E. from triplicate determinations. Microwave thawing ◆ Water thawing ■ Refrigerator trawing ▲

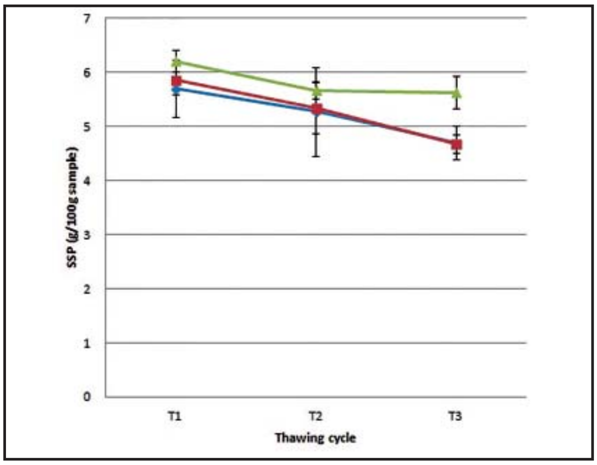

Figure 4. Changes of SSP during thawing cycles due to different thawing methods. Bars represent the mean± S.E. from triplicate determinations. Microwave thawing ◆ Water thawing ■ Refrigerator trawing ▲

after thawing and expressed as (AOAC, 1995).

Percentage of thawing loss: B) Thiobarbituric acid (TBA) value determination. Oxidative rancidity, measured as thiobarbituric acid (TBA) reactive substances, was determined by the method described by Pearson (1976). During lipid oxidation, malonaldehyde (MA) is formed as a result of the degradation of polyunsaturated fatty acids. In this assay, the MA is reacted with thiobarbituric acid (TBA) to form a pink MA-TBA complex that is measured spectrophotometrically at its absorption maximum at 538 nm.

C) Total volatile base (TVB) determination. Total volatile base in the samples was determined according to the method described by Marine Fisheries Research Department (MFRD, 1987).

D) Salt-soluble protein (SSP) determination. Myofibrillar proteins such as myosin and actin are the major proteins in the marine muscles that are soluble in 3-5% salt solutions. The SSP was extracted according to the method of MFRD (1987).

Statistical analysis: The T-Test was used to compare data in the three groups. Evaluation

Table 1. The mean ± S.E. of thawing loss (TL %), thiobarbituric acid (TBA), total volatile base (TVB) and salt-soluble protein (SSP) of the pink shrimp. Different alphabetic letters show significant difference ($p<0.05$) between the three experimental groups.

	TL (%)			**TBA (mg/100g)**			**TVB (mg/100g)**			**SSP(mg/100g)**		
	T1	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**
Microwave thawing method	3.85 ± 0.39^{a}	4.90± 0.58^{a}	2.80± 0.45^{a}	0.14± 0.02^{a}	0.22± 0.04^{a}	0.32± 0.03^{a}a	27.48± 2.90^{a}	36.33± 1.14^{a}	38.73± 2.35^{a}	5.70± 0.53^{a}	5.28± 0.82c	4.70± 0.31^{d}
Water thawing method	2.21± 0.47^{b}	3.50± 0.44^{b}	2.50± 0.43^{b}	0.15± 0.04^{a}	0.22± 0.05^{a}	0.34± 0.05^{a}	26.35± 2.31^{a}	35.86± 1.46^{a}	38.21± 2.02^{a}	5.86± 0.27^{a}	5.35± 0.47^{c}	4.69± 0.17^{d}
Refrigerator thawing method	1.70± 0.43^{b}	2.95± 0.88^{b}	2.01± 0.37^{b}	0.11± 0.01^{b}	0.18± 0.04^{b}	0.26± 0.04^{b}	26.43± 2.07^{a}	33.93± 2.21^{a}	36.11± 1.87^{a}	6.21± 0.20^{b}	5.67± 0.16^{e}	5.63± 0.30^{f}

of significant difference between the means of different experimental groups was performed using one way analysis of variance (One-way ANOVA) followed by the Tukey test as post hoc. Values were expressed as means±S.E.M (standard error of mean). $p<0.05$ was considered to be statistically significant.

Results

The results of the present study are shown in Table 1. As shown in Table 1, an increase in the freeze-thaw cycles resulted in an increase in TBA and TVB value and a significant decrease in SPP value ($p<0.05$). Microwave thawing method gave the samples with the highest thawing loss in comparison to the other methods in each freeze-thaw cycle ($p<0.05$) (Fig. 1). A significant increase is seen in TBA value in water and microwave thawing methods in comparison to refrigerator thawing method ($p<0.05$) (Fig. 2). Also, refrigerator thawing method has higher SSP value in comparison to the other thawing methods ($p<0.05$), and there is no significant difference between microwave thawing and water thawing methods in SSP value ($p>0.05$) (Fig. 4). Likewise, there is no significant difference between three mentioned methods in TVB value ($p>0.05$) (Fig. 3). In the present study, the quality of the frozen samples was also determined from the TVB values; whereas, there was no significant difference in this parameter between the experimental groups.

Discussion

This study showed that the refrigerator thawing had the lowest effect in decreasing chemical quality of the pink shrimp in comparison with the other methods. Enhancement of water vaporization in shrimp meat by using microwave could cause a rapid heating in samples; therefore, in comparison to other methods, microwave thawing gave the samples higher thawing loss. As a result of frozen and unfrozen phases and also no uniformity of distribution of lipids, frozen foods do not have any homogeneous texture. These components differ greatly in their abilities to absorb radiofrequency energy and this tends to cause overheating of some areas before other areas become thawed (Fennema et al., 1975; Sirintra et al., 2007). Therefore, this results in the high drip loss from the microwave thawing samples. Although microwave thawing produces fast thawing, it might cause pronounced protein denaturation and destabilization. It is also an undesirable method to thaw shrimps due to the asymmetric shape of the samples (Srinivasan et al., 1997; Sirintra et al., 2007). Moreover, for fresh foods that texture is important, it seems that a slow thawing process in cool environment is preferable because it allows time for diffusion to take place in the thawed tissues and the water may return to its original positions in the tissues (Jul, 1984; Hui et al., 2013).

In the present study, the shrimps thawed under the microwave and water had a higher

TBA value than those thawed under refrigerator temperature ($p \leq 0.05$). It is likely due to the fact that high energy generating under the microwave thawing and high temperature in water thawing might activate the lipid oxidation in the shrimps and thus gave a higher TBA value than those thawed in the refrigerator. Siu and Draper (1978) described that lipolysis also occurred at the higher temperature. Although cooking was the most common method used to avoid enzymatic deterioration during frozen storage, the extent of lipid oxidation in cooked meat can be related to the intensity of the heat treatment. In a study on malonaldehyde (MA) content of retail meats and fish by Siu and Draper (1978), 38% of the fresh meat samples had MA content less than 1µg/g whereas cooking increases MA in most meat samples.

Our results showed an increase in the number of freeze-thaw cycles resulted in increasing TBA value. Repeated melting during thawing and reformation of ice crystals during freezing in multiple freeze-thaw situations is clearly detrimental to muscle tissues by causing mechanical damage to cell membranes and the loss of water holding capacity (Srinivasan et al., 1997; Pisal et al., 2007b). This could be due to the release of oxidative enzymes and prooxidants from various ruptured cellular organelles. Moreover, the removal of shrimp shell that contained phenolic antioxidants eliminates the oxidation protection of the samples (Srinivasan et al., 1998; Pisal et al., 2007b).

In the present study, the quality of the frozen samples was also determined from the TVB values; whereas, there was no significant difference in this parameter between the experimental groups. The level of TVB as freshness indicator increases with spoilage due to either bacterial or enzymatic degeneration (Ozogul et al., 2000). Sirintra et al. 2007 showed that thawing methods did not increase TVB to unsuitable value for consumption.

The shrimps thawed under the refrigerator method had a slightly higher SSP in comparison to other methods ($p > 0.05$). The denaturation of the muscle proteins can decrease SSP. SSP reduction can be due to the denaturation of proteins that occurred by the interaction of the free fatty acids with SSP and the consequent lower solubility of proteins (Verma et al., 1994; Hui et al., 2013). Moreover, the toughness of frozen shrimp was attributed to myosin denaturation, as well as cross-linking and aggregation of myofibrillar proteins (Sikorski, 1977; Pisal et al., 2007b; Hui et al., 2013; Sirintra et al., 2007). Therefore, when the SSP in shrimp decreases the cutting force of the shrimp muscle also increases.

Conclusion: Food safety and sensorial qualities are major concerns of consumers; therefore, it is important to measure the impact of the preservation methods on desirable food characteristics. The results showed that the refrigerator thawing is the best method and multiple freeze-thawing processes caused some deleterious effects on the quality of the frozen shrimps. Hence, it is important to prevent temperature fluctuations during transportation and storage to avoid the freezing and thawing effects and maintain the quality of the frozen shrimps.

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