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Effect of vacuum packaging on quality changes of refrigerated Jinga shrimp *Metapenaeus affinis* muscle

Yunes Rashidi, Mehran Javaheri Baboli, Abolfazl Askary Sary

Department of Fisheries Science, College of Agricultural Sciences and Natural Resources, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran. Corresponding author: M. Javaheri Baboli, mehranjavaheri@gmail.com

Abstract. *Metapenaeus affinis* is one of the economically valuable species of Persian Gulf and Oman Sea and is of high nutritional value. In this research chemical composition and spoilage indicators of vacuum packed shrimp muscle including total lipids (TL), moisture, total protein, total ash, peroxide value (PV), thiobarbituric acid (TBA), total volatile bases nitrogen (TVN), and pH during a period of 18 days were examined at a cold temperature. To carry out the experiment sampling was done in seven steps (0, 3, 6, 9, 12, 15, 18 days) and the results showed that the rate of PV index in the first day increased from 0.93 meq/kg to 2.09 meq/kg. TVN indicator increased from 10.02 mg/100 g muscle to 26.83 mg/100 g muscle in the 18th day. Lipid and protein content significantly decreased during the period ($P<0.05$). Thiobarbituric acid (TBA) index increased from 0.59 mg MDA/kg to 1.53 mg MDA/kg in the 18th day. In general, according to the results, the maintenance period of vacuum-packed muscles at cold temperature was determined to be 12 days.
Key Words: chemical composition, spoilage indicators, shelf life, refrigeration, temperature, *M. affinis.*

Introduction. Due to being rich in proteins, fat-soluble vitamins, omega-3, polyunsaturated fatty acids, shrimp is highly important in human diet and has drawn many attentions towards itself (Javaheri Baboli & Velayatzadeh 2013). Thus, it plays an important role in human nutrition as one of the animal protein sources.

With regard to increasing growth of population around the world particularly in developing countries and providing healthy protein for people, development of fisheries is considered as one of the most important sectors in ensuring the food supply needed for society. That is why aquaculture is in progress in Iran and other countries and consequently different methods of maintenance and distribution such as packing of aquatic products is increasing in Iran.

Shrimp and other aquatic organisms are protein sources for humans and they are highly perishable. The quality of these food sources decreases because of biochemical reactions (changes in the structure of fats, proteins and formation of lots of compounds and microbial spoilage) and consequently their taste and nutritional value decline too. Continuous research has been offered to improve protection methods and to prolong retention time and safety of various fishery products (Shirazinejad & Noryati 2010) including long term conservation methods such as ice-making, cooled sea water (Rajesh et al 2002) and various packing methods one of which is vacuum packaging. Vacuum packaging is a method through with the air is emptied out of the bag and then it is packed completely (Arashisar et al 2004).

There are different methods to maintain the food which are mainly used to remove microorganisms. Vacuum packing is a method to delay the spoilage of fish and shrimp products which keeps the shrimp non-perishable for a longer time and maintains the overall quality of shrimp muscle. Vacuum packaging may be defined as the packaging of a product in a high barrier package from which air is removed to prevent growth of

aerobic spoilage organisms, shrinkage, oxidation and color deterioration (Goncalves & Ribeiro 2008). Some research has claimed that storing fish under vacuum delays bacterial growth and increases the shelf life (Sawant et al 2012).

This research aimed to determine the maintenance period of jinga shrimp, *Metapenaeus affinis* (Nirmal & Benjakul 2011) through vacuum packing at cold temperature and also to measure the rate of moisture, lipid, protein, ash , peroxide value, thiobarbituric acid (TBA), total volatile bases nitrogen (TVN) and pH vacuum packed shrimp muscle at cold temperature.

Material and Method

Sample preparation. Fresh jinga shrimp, *M. affinis* was caught (100 kg) in the Persian Gulf near Hendijan (in Khuzestan Province, Southwest Iran). The shrimp used for this study had a weight of 10 g and were transported packed in ice to laboratory in insulated box. The treatment process involved washing with tap water and beheading and peeling is done prior packaging. Fillets weighing approximately 250 g were placed in vacuum bag (15 cm × 25 cm). All samples were stored at 4°C and subjected to chemical analysis in seven steps 0, 3, 6, 9, 12, 15, 18 days. The chemical parameters include proximate composition, Thiobarbituric Acid (TBA), Total Volatile Base Nitrogen (TVN), Peroxide Value (PV) and pH.

Chemical analyses. Moisture, Lipid, protein and ash content of fish by AOAC method (Horwitz 1956) was estimated. Peroxide value (PV) content was determined in the lipid extract by the Egan et al (1997) method. Thethiobarbituric acid (TBA) (Mg malondialdehyde kg-1 flesh muscle) was determined in a 5% trichloracetic acid extract according. 10 g sample was blended with 20 mL distilled water and pH of the homogenate was measured using a pH meter by immersing the electrodes well inside the blend. The instrument was set using a standard pH buffer. For determination of total volatile nitrogen the magnesium oxide method was used Samples were blended with magnesium oxide and distilled into boric acid. The boric acid was titrated to its original with strong acid (H_2SO_4) at low concentration to determine the amount of the base distilled, which correlated to the total volatile nitrogen as described by AOAC (Horwitz 1956).

Statistical analysis of data. The mean and standard deviation were calculated for all parameters. Results were subjected to one-way analysis of variance followed by Duncan's entire comparison test ($P<0.05$), using a software SPSS 16.0. for all statisticals to determine significant differences among treatment means. All data are presented as the mean±SD.

Results

Chemical test results

Moisture. The amount moisture in zero day was 77% in muscle of *M. affinis* which increased to 79.41% in 18th day (Figure 1). There was a significant difference between the moisture content 0 to 18th days of maintenance in refrigerator ($P<0.05$) (Figure 1).

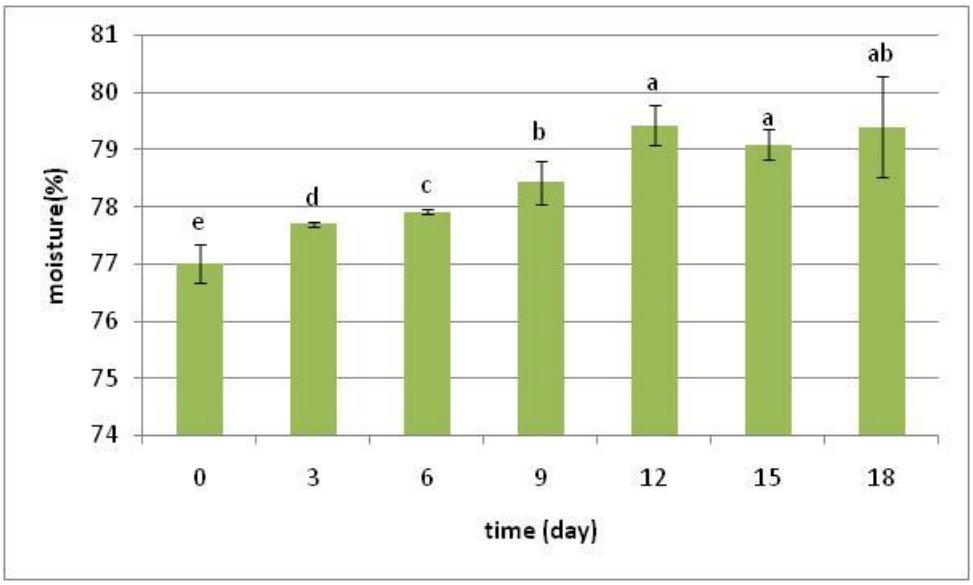

Figure 1. Mean changes of total moisture (Mean±SD) in jinga shrimp muscle under vacuum packaging during cold storage for 18 days. Different letters in the same row indicate significant differences (P<0.05).

Protein. During the maintenance of *M. affinis* muscle in refrigerator the rate of protein changed from 20.5% recorded in the first day to 18.05% in the 18th day (Figure 2). There was a significant difference between the rate protein content in 0 to 18th days (Figure 2).

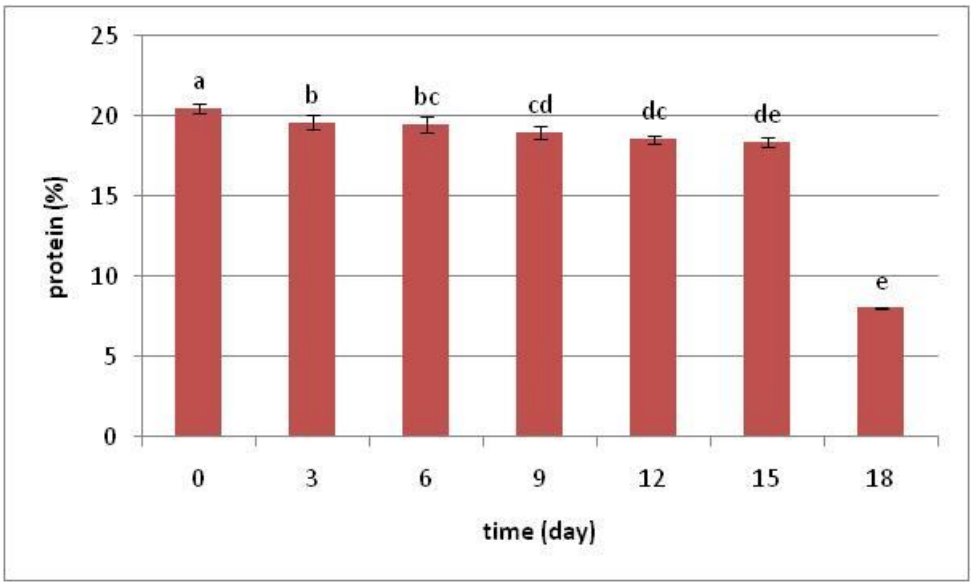

Figure 2. Mean protein (Mean±SD) in jinga shrimp muscle under vacuum packaging during cold storage for 18 days. Different letters in the same row indicate significant differences (P<0.05).

Lipid. The rate of lipid during the maintenance had a decreasing trend and reduced from 1.54% in 0 day to 0.75% in the 18th day. Results showed a significant difference at 95% level since 0 to 18th days (Figure 3).

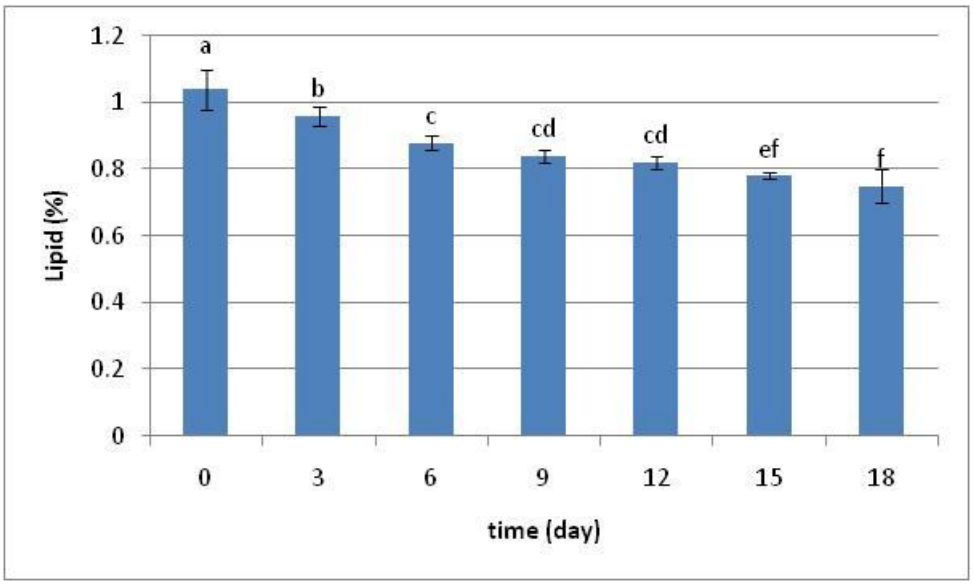

Figure 3. Mean lipid (Mean±SD) in jinga shrimp muscle under vacuum packaging during cold storage for 18 days. Different letters in the same row indicate significant differences (P<0.05).

Ash. The rate of ash in *M. affinis* muscle was about 79% to 52% which had a decreasing trend during 18 days of maintenance in refrigerator (Figure 4). There was a significant difference between ash amounts during different days (Figure 4).

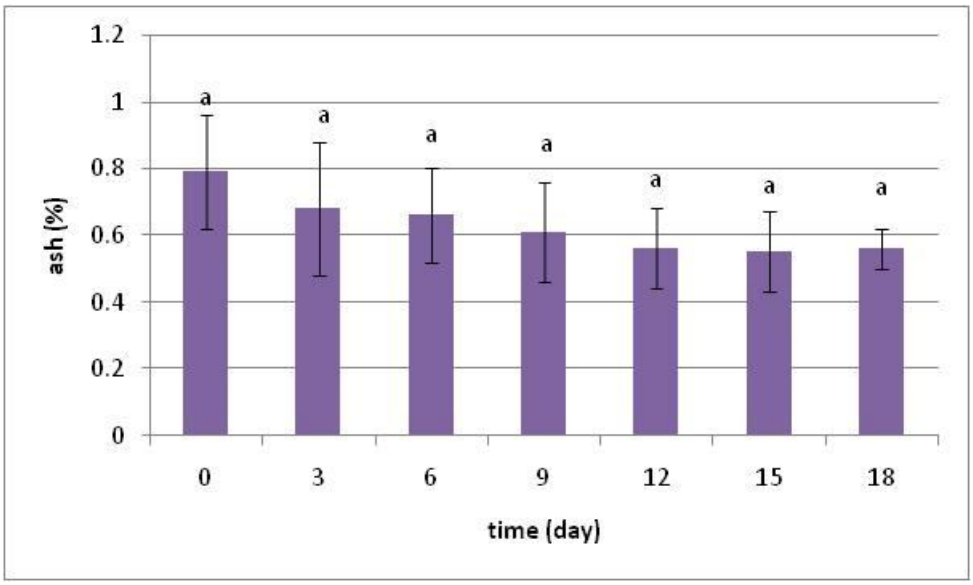

Figure 4. Mean ash (Mean±SD) in jinga shrimp muscle under vacuum packaging during cold storage for 18 days. Different letters in the same row indicate significant differences (P<0.05).

Chemical spoilage indicators

Thiobarbituric acid (TBA). TBA indicator was used as a method of measuring secondary compounds of lipid oxidation spoilage which was 0.59 mg MDA/kg for the *M. affinis* muscle in 0 day and 1.53 mg MDA/kg in the 18th day. There was a significant difference at level 95% (Table 1).

Peroxide value (PV). The rate of value in *M. affinis* muscle was 0.93 to 2.09 meq/kg (Table 1). This amount had an increasing trend in 0 to 9th day so that the difference was significant and afterward it had a decreasing trend.

Table 1

Chemical spoilage indicator in muscle of *Metapenaeus affinis* under vacuum packaging during cold storage for 18 days. Different letters in the same row indicate significant differences (P<0.05)

Parameters	*Storage time (days)*						
	0	*3*	*6*	*9*	*12*	*15*	*18*
TBA (mg MDA/kg)	0.59 ± 0.026^{f}	0.70^{e}± 0.037	0.77 ± 0.015^{e}	0.89 ± 0.026^{d}	1.05 ± 0.081^{c}	1.22 ± 0.036^{b}	1.53 ± 0.047^{a}
PV (meq/kg)	0.93 ± 0.04^{f}	1.37 ± 0.06^{e}	2.60 ± 0.10^{d}	2.50 ± 0.04^{a}	2.29 ± 0.6^{b}	2.19 ± 0.05^{bc}	2.09 ± 0.7^{cd}
TVN (mg N/100 g)	10.02 ± 0.15^{a}	12.99 ± 0.02^{b}	15.00 ± 0.43^{c}	17.06 ± 0.19^{d}	18.95 ± 0.29^{c}	21.76 ± 0.56^{f}	26.84 ± 1.47^{g}

TBA – Thiobarbituric acid, PV - Peroxide value, TVN - Total volatile base nitrogen.

Total volatile base nitrogen (TVN). The rate of TVN in the muscle of *M. affinis* had an increasing trend and increased from 10.02 mg nitrogen to 26.84 mg N/100 g of muscle which showed a significant difference at 95% level (Table 1).

Discussion

Aquatic products, as shrimp, are more susceptible to oxidation spoilage due to lack of instability of chemical compounds of body such as proteins and unsaturated fats compared with mammals (Fox et al 2011). Reduction of quality of fish and shrimps during the refrigerating period has been demonstrated in previous studies and researchers believe that the most important reason of inclined quality is changes of muscle fat in aquatic organisms (Boran et al 2006).

Moisture. The rate of moisture in white shrimp muscle ranged from 77.54% in the first day to 80.83% in the 18th day (Figure 1) which showed a significant difference at 95% level.

Sawant et al (2012) in a research about the effect of vacuum packing on shelf life of frozen shrimp muscle reported that the rate of moisture in a period of 167 days was 83.35% and the results were consistent with present research. The amount of moisture is one of the effective factors in bacterial growth in foods (Sawant et al 2012). According to Cyprian et al (2013) the grades of quality of muscle tissue during the maintenance is associated with the release and existence of moisture.

pH. pH of shrimp muscle is 7, but after its death pH remarkably changes based on the season and species and several other factors (Sallam 2006). In this research the amount of pH in vacuum conditions was 5.94% in the first day and after 18 days it had an increasing trend and reached 6.38%. In a research carried out by Ozogul et al (2004) about the effects of atmospheric and vacuum packing on chemical and microbiological changes of tiger shrimp (*Penaeus monodon*) the amount of pH changed from 6.8% in the first day to 7.5% in the 18th and had an increasing trend. In study on determining the maintenance time of farmed tiger shrimp reported that the amount of pH ranged from 6.7 to 7.2% which showed an increasing trend and the obtained results were consistent with the results of the present research. The reason of pH increase has been proved to be related to production of basic compounds such as ammonia, dimethylamine, trimethylamine, and biogenic amines resulting from muscle spoilage (Goulas & Kontominas 2006).

Total lipid. Fat changes and spoilage are the most important factors declining the quality of shrimp and its products. In this research the fat indicator in Jinga shrimp changed from 1.04 in the first day to 0.75 in the 18th day which showed a significant difference at 95% level (Figure 2).

Sawant (2012) showed that the rate of lipid changed from 2.89% to 1.28% under vacuum packaging in the 165th day which had a significant decreasing trend.

Protein. Millamena et al (1996) estimated the rate of protein of fresh shrimp of *P. monodon* to be 17.71%. Ozogul et al (2004) studied the effects of atmospheric and vacuum packing on chemical and microbiological changes of Sardines and reported that the rate of protein in a 12-day period changed from 21% to 17% which had a decreasing trend and was consistent with the results of the present research. The decrease of protein could be related to the removal of tissue fluids during the maintenance time. Degradation of muscle protein might be caused by either endogenous or microbial proteases during refrigerated storage (Masniyom et al 2002).

Thiobarbituric acid. TBA indicator is used for measuring carbonyl compounds which appear during secondary lipid oxidation. In this study, the rate of thiobarbituric acid during an 18-day period changed from 0.59 mg MDA/kg in 0 day to 1.53 mg MDA in the 18th day which showed a significant difference at 95% level (Table 1).

Manju et al (2007) studied the effects of vacuum packing on baleen fish in a 42-day period and showed that the rate of TBA changed from 1.2 mg MDA in the first day to 2.2 mg MDA in the 42nd day which showed an increasing trend.
TBA values in tilapia packed with vacuum, air and MAP conditions was observed in all samples when the storage time increased, indicating that lipid oxidation took place during storage (Masniyom et al 2002).

The permissible amount of TBA has been reported to be 1 to 2 mg MDA/kg (Goulas & Kontominas 2006). Considering the lipid spoilage trend, lack of increase of TBA over the standard amount might be due to interactions between malondialdehyde, amino nucleosides, nucleic acids, proteins, and other aldehydes which appear at the end of lipids oxidation. Of course these interactions vary in different species of aquatic organisms (Sawant et al 2012).

Peroxide. The rate of peroxide is one of the important indicators of primary products of lipid spoilage in fish and shrimp muscle (Bocker et al 2008). Peroxide in the flesh and sea products has adverse effects such as reduction of digestive enzymes of the consumer on flesh and decreased absorption of nutrients by the consumer. In addition, large amounts of peroxide will damage epithelial cells and intestinal tissues; however, peroxide does not make any changes in organoleptic properties of flesh.

The rate of peroxide in present study during a period of 18 days was 0.89 meq/kg of flesh in 0 day and after 18 days it reached 2.16 meq/kg of muscle which showed a significant difference. The increase of peroxide could be due to high levels of unsaturated fatty acids in shellfish tissue membranes which result in aquatic organisms processing and lipid oxidation. Peroxide index normally shows primary lipid oxidation particularly hydro peroxides (Vafakhah et al 2014). The decrease of peroxide can be due to omission of oxygen in vacuum packing and auto-oxidation of free fatty acids to peroxide (Kaur et al 2012).

We propose the following PV scale as a basis for determining the freshness of fish: PV = 0-2 mmol of O_2/kg - very good, PV = 2-5 mmol of O_2/kg - good, PV = 5-8 mmol of O_2/kg - acceptable, PV=8-10 O_2/kg - altered.

Total volatile nitrogen. TVN index includes Trimethylamine and ammonia which is produced due to bacterial spoilage and its amount is used as an index for evaluating the quality and durability of sea products (Masniyom et al 2002).

The amount of TVN in present study increased showed a significant difference during 18 days and this amount in 0 day was 9.78 mg N/100 g of the sample and in 18th day it was 27/34 mg N/100 g of shrimp muscle. Furthermore, Ozogul et al (2004) studied the effect of atmospheric packing on chemical and microbiological changes of black tiger shrimp and reported that the rate of TVN changed from 12.9 mg N/00 g of muscle to 40.2 mg after 17 days which had an increasing trend. Masniyom et al (2002) reported samples kept under vacuum packaging where the TVB content reached 25 mg/100 g after twelve days of storage.

TVB usually includes trimethylamine, dimethylamine, ammonia and other volatile basic nitrogenous compounds associated with fishery product spoilage Thus, an increase in TVB content indicated the stage of substantial spoilage of the muscle. Masniyom et al (2002) and Goulas & Kontominas (2006) studied the maintenance time of mackerel (*Scomber japonicus*) and stated that the rate of TVN had an increasing trend. The increase of TVN indeed during the maintenance time is due to bacterial spoilage and internal enzymes activities (Chomnawang et al 2007). Acceptable amount of TVN in the muscle and flesh of aquatic animals is 30 to 35 mg per 100 g of muscle (Erkan et al 2007).

Conclusions. During a period of 18 days at cold temperature (refrigeration) the amount of TVN was acceptable for the 1st to the 12thand it was unusable afterward. The amount of peroxide was usable too until the 18th day, but the rate of TBA has shown an increasing trend until the 18th day. In general and with regard to all aspects, it has been acceptable until the 12th day and afterward it had a poor quality.

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Authors:
Yunes Rashidi, Islamic Azad University, College of Agricultural Sciences and Natural Resources, Department of Fisheries Science, Ahvaz Branch, Iran, Ahvaz, Golestan Street, Farhangshahr Square, Postal Code: 68875-61349 P. O. Box 1915, e-mail: younes.rashidi65@yahoo.com
Mehran Javaheri Baboli, Islamic Azad University, College of Agricultural Sciences and Natural Resources, Department of Fisheries Science, Ahvaz Branch, Iran, Ahvaz, Golestan Street, Farhangshahr Square, Postal Code: 68875-61349 P. O. Box 1915, e-mail: mehranjavaheri@gmail.com
Abolfazl Askary Sary, Islamic Azad University, College of Agricultural Sciences and Natural Resources, Department of Fisheries Science, Ahvaz Branch, Iran, Ahvaz, Golestan Street, Farhangshahr Square, Postal Code: 68875-61349 P. O. Box 1915, e-mail: askary_sary@yahoo.com

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