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Yield and Quality of Pacific white shrimp *Litopenaeus vannamei* (Boone, 1931) in response to different Killing Methods

T. H. Bhat, Md. Aman Hassan, M. K. Chouksey, A. K. Balange and B. B. Nayak*
ICAR-Central Institute of Fisheries Education, Versova, Mumbai - 400 061, India

Abstract

The present study compares the differences in the effect of two methods of slaughtering i.e. by cold shock in ice water slurry (hypothermia) and by taking out of water (asphyxia) on the quality of white shrimp (*Litopenaeus vannamei*). Yield, proximate composition, pH, calcium ATPase activity, texture and colour parameters were compared. No significant differences were found in the yield, proximate composition, pH and calcium ATPase activity between the shrimp killed by the two different methods. Texture and colour were found to vary significantly ($p<0.05$). Texture parameters such as hardness (6900.80±484.93 g), resilience (0.45±0.02), springiness (0.83±0.02) and chewiness (2502.50±148.69) of shrimp killed by hypothermia were found to be better than the shrimp killed by asphyxia (hardness 6144.90±456.74, resilience 0.35±0.01, springiness 0.77±0.02 and chewiness 1803.50±154.64). Similarly colour of the shrimp killed by hypothermia was found to be better than that killed by asphyxia. Therefore it can be concluded that the ice- water immersion method is better for the killing of pacific white shrimp *L. vannamei* as far as texture and colour are concerned.

Keywords: Quality evaluation, hite leg shrimp, killing methods

Introduction

The shrimp industry contributes significantly to seafood export from India. The country's marine product exports were USD million 5511.12 during 2014–2015 with a major contribution of 67.3% from the frozen shrimp. This significant increase in the export of seafood was due to the introduction of *L. vannamei* for culture in India. The *L. vannamei* shrimp production has increased by 90 % from 91,171 mt in 2012–2013 to 175,071 MT in 2013–2014 (MPEDA, 2014). Shrimp is an excellent source of protein containing all the essential amino acids (Cao et al., 2009; Oksuz et al., 2009). Its flesh is low in saturated fatty acids and contains high amounts of unsaturated fatty acids (HUFA) such as eicosapentaenoic (20:5n3, EPA) and docosahexaenoic (22:6n3, DHA) acids (Puga-Lopez et al., 2013). It is also a good source of iron, zinc, copper, calcium and vitamin B12 (Roy et al., 2009).

L. vannamei, commonly known as pacific white shrimp is a popular and valuable species for cultivation due to its characteristic taste and fast growth rate. From the consumer point of view the most important quality parameters are colour and texture (Trisoni et al., 2009) and the acceptability of shrimp depends on these organoleptic characteristics. Quality of shrimp is greatly affected by the method of handling such as catching, killing, transportation and storage. Humane slaughter of food animal is an important consideration while killing the fish after harvest. Parisi et al. (2002) found dipping in ice water as a suitable method for killing edible sized sea bass for which individual killing is not feasible. Use of ice-water immersion method for killing marine fish is not advised because of the osmotic shock caused by lower salinity caused by melting ice (Fu et al., 2014). Among cultivable shrimp species, *L. vannamei* stands out due to its survival and growth both in marine as well as in fresh water environment (Araneda et al., 2008) and is highly priced in the market. The quality of flesh of shrimp affects its

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**E-mail: nayakbb@gmail.com*

demand and market price and sometimes its quality decreases due to inappropriate handling and storage. Therefore the present study was undertaken to look into the effect of killing methods on the quality of the shrimp meat.

Materials and Methods

Pacific white shrimps (*L. vannamei*) with a count of 30-35 shrimp kg^{-1} were harvested from a private shrimp farm located at Saphale, district Palghar of Maharashtra state, India. Shrimp were transported to the laboratory in live condition in a plastic tank which was supplied with air using aerator. Upon reaching the laboratory, the shrimp were segregated into two groups. One lot was killed by immersing in ice water slurry. Care was taken to keep temperature at 0°C by adding sufficient quantity of ice. Second lot was killed by taking shrimp out of water and allowed to die. After killing, the shrimps were preserved with ice (shrimp to ice ratio 1:1) in an insulated ice box. Analysis was carried out within one hour from the time of killing.

After beheading and peeling, the dressed yield of shrimp in percentage was calculated by weighing the shrimp before and after dressing using the following formula.

$$\% \text{ Yield} = \text{Final Weight} / \text{Initial Weight} \times 100$$

The moisture, crude protein, crude fat and ash of shrimp sample were analyzed according to the methods of AOAC (2010). Tissue sample of 5 g was blended in 45 ml distilled water using homogeniser and then the pH was measured using digital pH meter.

Calcium ATPase enzyme activity was measured by using the method of Naguchi & Matsumoto (1970). About 1 g samples of meat was macerated in 10 ml, 0. 2 M Glycine - NaOH buffer, pH 9.2 and the slurry was filtered through Whatman no. 1 filter paper and the filtrate was used as enzyme solution. The reaction mixture comprised of 0.06 ml of ATP (0.05 M) solution, 0.4 ml calcium chloride (0.1 M), and 2 ml Glycine-NaOH buffer (0.2 M, pH 9.2). Afterwards 0.4 ml of enzyme was added to reaction mixture and incubated for 5 min at 27°C. The reaction was stopped by adding 2 ml of 15% Trichloro acetic acid (TCA). The mixture was filtered through Whatman no. 1 filter paper, and the inorganic phosphorus content was determined by the method of Taussky & Shorr (1952). To the 3 ml filtrate, 2 ml freshly prepared ferrous sulphate – ammonium molybdate solution (10%) was added. The intensity of the colour developed was measured at 660 nm (Thermo Spectronic, Great Britain, UK). The liberated inorganic phosphorus was calculated using standard curve obtained by using potassium di- hydrogen phosphate as a standard. The ATPase enzyme activity was expressed as mg Pi / min / mg Protein.

Texture profile analysis of shrimp blanched and cooked at different stages of rigor was done using TA.XT2i Texture analyzer (Stable Microsystems, UK). It was done by compressing the sample twice using the 36mm probe. Test conditions used were as, pre-test speed 2.0 mm s^{-1}, test speed1.0 mm s^{-1}, post-test speed 10.0 mm s^{-1}, Distance 6.0 mm,Time 5s, Load cell 50 kg and Force 10 g.

The colour of shrimp blanched and cooked at different stages of rigor was determined using Lab Scan XE Instrument (Hunter Lab Scan XE, USA) which gives acceptance level based on L* a* and b* respectively. These values correspond to lightness, redness and yellowness respectively. The instrument was calibrated first with a black tile followed by white tile standard, both centrally placed over the sample port until the instrument completed the calibration process. Whole shrimp was placed on the port for colour analysis.

SPSS version 16 was used for analysing the data obtained for various parameters. One-way analysis of variance (ANOVA) was done. Significance of differences was established at pd^0.05 using Duncan's test.

Results and Discussion

The yield data of the beheaded peeled pacific white shrimp is presented Fig. 1. Yield was found to be 48% in case of hypothermic shock and 47% in asphyxia. However results did not differ significantly at 5% level of significance. Yield is an important factor from the economic point of the view, as it affects the demand and utilisation of the product. Our results are lower than the earlier report of Mehta & Nayak (2017) who reported peeled and deveined yield for *L. Vannamei* as 53%.

Data pertaining to proximate composition of pacific white shrimp killed by hypothermia and asphyxia is presented in Table 1. Proximate composition of white shrimp did not differ significantly by the

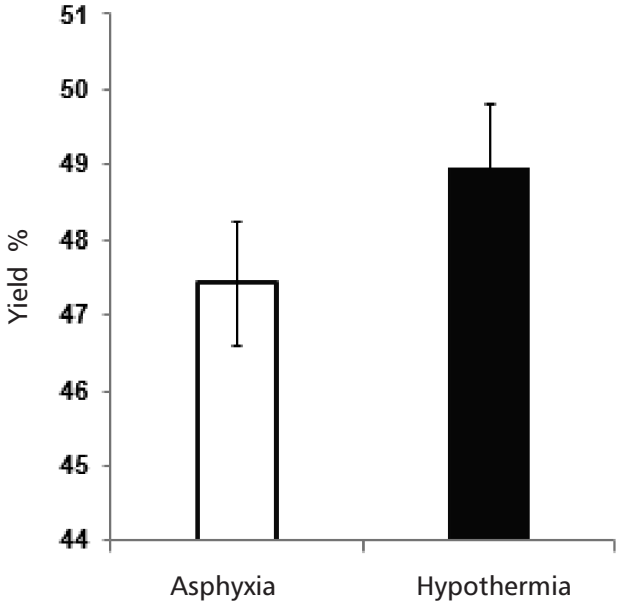

Fig. 1. Yield data of pacific white shrimp killed by hypothermia and asphyxia

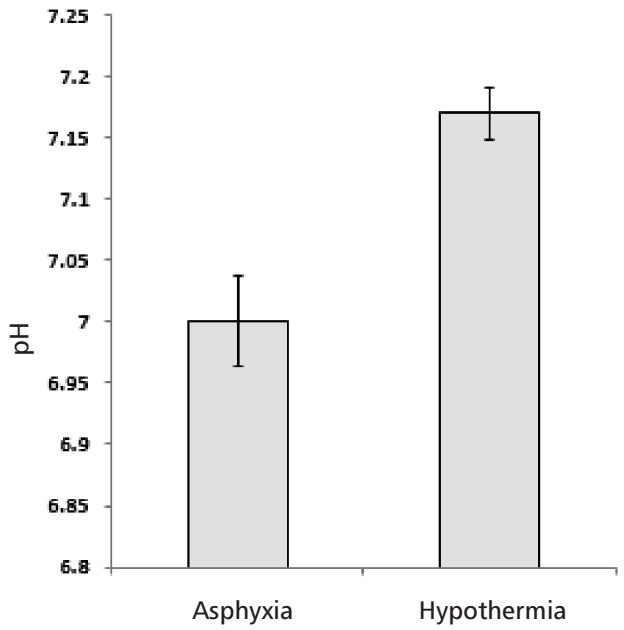

Fig. 2. pH data of pacific white shrimp killed by hypothermia and asphyxia

method of killing employed. Similar findings were reported by Fu et al. (2014). So it can be concluded that killing method does not affect the proximate composition.

There were no significant differences in the pH values (Fig. 2) between the shrimp killed by either of the methods. pH is an important indication of the biochemical processes in the muscle. Low pH immediately after slaughter is caused due to the antemortem struggle that results in the production of lactic acid (Fraser et al., 1965). The lowering of post mortem pH affects various quality aspects of the muscle, like texture, water binding capacity and resistance to microbial growth (Lougovois & Kyrana, 2005). In the present study there was no significant difference among the pH of the shrimps processed by two different slaughter methods.

Data pertaining to calcium ATPase activity of the shrimp killed by asphyxia and hypothermia is presented in Fig. 3. From the data we can say that calcium ATPase activity of the shrimp killed by hypothermia and asphyxia did not vary. Calcium ATPase activity indicates the stability of myofibrillar protein. Decrease in the calcium ATPase activity indicates the denaturation of the protein especially myofibrillar protein. Calcium ATPase activity is considered as an indicator of myosin integrity (Roura & Crupkin, 1995) which in turn is a quality index. There was no significant difference in the calcium ATPase activity indicating that both the methods of slaughtering were comparable and do not affect the biochemical properties of the shrimp muscle.

Table 1. Proximate composition (%) pacific white shrimp killed by Hypothermia and Asphyxia. Data are presented as mean with standard error

Treatment	Moisture	Crude protein	Crude fat	Ash
Asphyxia	77.20±0.79	18.59±0.30	1.61±0.01	1.52±0.02
Hypothermia	76.47±0.82	18.77±0.32	1.61±0.01	1.53±0.02

Means in the same column with different superscript are significantly different ($p<0.05$).

Table 2. TPA data of pacific white shrimp killed by asphyxia and hypothermia. Data are presented as mean with standard error

Treatment	Hardness (g)	Resilience	Springiness	Chewiness
Asphyxia	6144.90^{a}±456.74	0.35^{a}±0.01	0.77^{a}±0.02	1803^{a}.50±154.64
Hypothermia	6900.80^{b}±484.93	0.45^{b}±0.02	0.83^{b}±0.02	2502^{b}.50±148.69

Means in the same column with different superscript are significantly different ($p<0.05$).

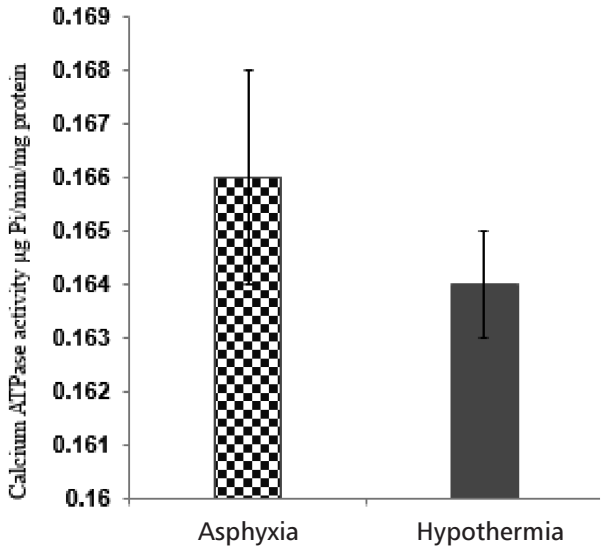

Fig. 3. Calcium ATPase data of pacific white shrimp killed by hypothermia and asphyxia

Texture profile data of the shrimp killed by asphyxia and hypothermia is presented in Table 2. Significant difference was found in harness, resilience, springiness and chewiness of the shrimp killed by two different methods. Higher values were found for these parameters in case of shrimp killed by hypothermic shock. Erickson et al. (2008) found that texture becomes soft during storage due protein denaturation. Avila-Villa et al. (2012) found stress of the shrimp leading to decrease in TPA parameters.

Table 3. Colour data of pacific white shrimp killed by asphyxia and hypothermia. Data are presented as mean with standard error.

Treatment	L*	a*	b*
Asphyxia	40.72^{a}±0.99	-0.77^{a}±0.06	-2.57^{a}±0.34
Hypothermia	45.84^{b}±0.44	-0.18^{b}±0.15	-1.91^{b}±0.30

Means in the same column with different superscript are significantly different ($p<0.05$)

Since significant difference was found in the TPA parameters of the shrimp processed by two slaughtering methods it can be concluded that ice water immersion method is comparatively better for the slaughter of pacific white shrimp.

Colour is an important factor that determines the consumer acceptability of the shrimp. Colour of the shrimp changes with the storage time and can be used a freshness indicator. Colour data pertaining to the shrimp killed by hypothermia and asphyxia is presented in Table 3. Significantly higher L*, a* and b* was found in the shrimp killed by hypothermia. It has been reported that ante-mortem stress affects the quality of the flesh during storage and processing and product development (Poli et al., 2005). Colour of raw shrimp has been considered as an important characteristic, of quality (Erickson et al., 2007) Several studies have reported the effect of different factors on the colour such as heating (Benjakul et al., 2008), dietary products (Parisenti et al., 2011).

Both slaughtering methods (hypothermia and asphyxia) methods resulted in the same beheaded and peeled yield, proximate composition, pH and calcium ATPase activity. However, killing method had an impact on the texture and colour of the shrimp muscle. Colour and texture are the two main factors considered by the consumers while purchasing shrimp and hence it can be seen that killing of shrimp by immersion in ice can be adopted for better consumer acceptance and increased revenue.

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