Fishery Technology 53 (2016) : 205 - 210

Effect of Different Processing Methods on the Texture of Black Tiger (*Penaeus monodon*) and Pacific White Shrimp (*Litopenaeus vannamei*)

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Abstract

Shrimp is one of the most popular seafood around the world. Sensory characteristics, especially textural parameters are major concerns of consumers for fish and shellfish. For this reason, it is important to measure the effect of the processing methods on texture. This study reports the effect of various processing methods on the instrumental texture profile of pacific white shrimp (*Litopenaeus vannamei*) and black tiger shrimp (*Penaeus monodon*). Hardness 1 of *L. vannamei* decreased during blanching, cooking and steaming whereas in *P. monodon* the reverse was true. Similar to hardness 1, in cooked *L. vannamei* hardness 2 value decreased but it increased in cooked *P. monodon*. Increase in chewiness in *P. monodon* was observed during cooking and blanching but in *L. vannamei,* chewiness decreased during cooking and blanching but increased during microwave cooking. Variation in textural parameters was observed with different processing methods and different shrimp species.

Keywords: *Penaeus monodon, Litopenaeus vannamei,* textural properties, processing techniques

Introduction

Shrimp is one of the most important seafood products worldwide (Oosterveer, 2006) and a major export earner in Indian seafood industry. Increase in demand in the export market led to industry-based monoculture of pacific white shrimp (*L. vannamei*) and black tiger shrimp (*P. monodon*). Shrimp are generally processed as fresh or as value-added products for export. Quality changes in the texture still occur during processing and storage. Postmortem texture in shrimp muscle is one of the main factors, which decides its quality.

Texture Profile Analysis (TPA) is a technique commonly used in the food industry for the evaluation of food texture. The TPA includes application of controlled force to the product in response with time. Instrumental TPA has been widely used to evaluate the texture of various food products as it correlates with sensory characteristics (Lau et al., 2000).

Various food preservation techniques have been utilized to improve safety and to extend the shelf life of fish, including icing, freezing, chemical preservation, salting and smoking. Fresh shrimps have firm texture which turns mushy during storage (Pornrat et al., 2007). Most foods have unique morphological characteristics which depend on the chemical and biophysical characteristics (Bourne, 1986).

Sensory characteristics are one of the major concerns of consumers. For this reason, it is important to measure the impact of the preservation methods on the texture. In this study, variations in textural attributes such as hardness, cohesiveness, springiness, gumminess and chewiness have been evaluated for two commercially important shrimps with respect to different processing techniques.

Received 02 April 2016; Revised 04 July 2016; Accepted 27 July 2016

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Material and Methods

Fresh *L. vannamei* and *P. monodon*, with size 40–50 count, procured from the farms of West Godavari district of Andhra Pradesh were washed with chilled water (~4°C), deheaded, peeled and immediately subjected to further processing.

Before instrumental texture profile analysis, shrimp species were divided into 8 different lots consisting of 5 samples in each lot. The first two abdominal segments were considered as anterior part and last two abdominal segments were considered as posterior part for the TPA analysis.

Beheaded and peeled shrimp sample were used for TPA. Both species were heated at 100ºC for one minute after beheading and peeling. The samples were frozen in air blast freezer and kept in deep freezer (-20ºC) for 48 h before analyzing the textural properties. Texture profile analysis of chilled samples was carried out for 48 h chill stored samples maintained in the chiller at 2ºC. Precooked/ blanched samples were prepared by heating at 70ºC for one min. The samples were fried at 190-200ºC in edible vegetable oil for one minute. Microwave cooking was carried out with an adjusted electric output power at 600 W and operating frequency 2450 MHz for one minute. Steam cooking was carried out at 100ºC for one minute. All the processed shrimp samples in peeled and beheaded condition were further subjected to instrumental texture profile analysis.

The texture of the samples was assessed objectively using Food Texture Analyser (Lloyd Instruments LRX plus, Lloyd Instruments Ltd., Hampshire, UK). It imitates the human biting at specified force (Bourne, 1978). Two cycle compression test was used. A cylindrical probe of 50 mm diameter equipped with 50 N load cell was used in the study to assess the texture profile of uniformly cut samples (2 cm^3). Texture measurement consisted of compression of samples two times consecutively by a cylindrical probe having a diameter of 50 mm and a test speed of 12 mm min^{-1} to a sample height of 40% to cause deformation of the sample. Force by time data from each test was used to calculate mean values for the TPA parameters. The instrument generates a curve showing load resulting from deformation. Hardness (N), Cohesiveness, springiness (mm), chewiness (kgf.mm) and gumminess (kgf) of the fish muscle were calculated as defined in the texture analyser user manual. Data was subjected to ANOVA by statistical software, SPSS version 16.0 (SPSS, Inc., Chicago, USA). Duncan's multiple range tests was used to find out the significant difference between mean values of experimental data at 5% significance level.

Results and Discussion

Hardness is a mechanical textural attribute relating to the force required to compress the sample (Manju et al., 2007; Nollet & Toldra, 2010). Hardness 1 and hardness 2 values are given in Table 1 and 2 respectively. For *L. vannamei*, hardness 1 of fresh and

Table 1. Effect of various processing methods on hardness 1 (N) of *L. vannamei* and *P. monodon*

Sample	*L. vannamei*		*P. monodon*	
	Anterior	Posterior	Anterior	Posterior
Fresh	24.44±3.67^a	16.97±4.89^a	15.56±5.18^b	25.93±3.80^a
Cooked	13.16±2.92^c	10.25±1.42^b	27.17±5.95^a	16.89±4.64^b
Frozen	16.16±5.60^b	14.15±4.22^a	10.24±2.43^c	10.39±2.27^c
Chilled	19.63±5.32^b	16.97±5.29^a	9.40±2.28^c	5.85±1.43^c
Blanched	17.11±4.94^b	9.87±2.91^b	27.87±6.29^a	7.84±1.19^c
Fried	6.54±3.13^d	2.22±0.34^c	14.01±1.89^b	9.06±1.32^c
Microwave cooked	24.85±7.45^a	11.27±1.22^b	18.35±3.16^b	13.24±3.76^b
Steamed	16.50±4.82^b	9.07±2.39^b	17.27±6.20^b	16.25±1.85^b

Results are average of five determinations, Mean ± SD; Value with different superscripts in a row differ significantly ($p<0.05$)

Table 2. Effect of various processing methods on hardness 2 (N) of *L. vannamei* and *P. Monodon*

Sample	*L. vannamei*		*P. monodon*	
	Anterior	Posterior	Anterior	Posterior
Fresh	15.33±2.61^a	8.83±3.39^a	9.48±2.57^b	14.62±2.09^a
Cooked	9.02±2.07^b	6.71±0.81^a	19.99±5.09^a	10.95±3.24^b
Frozen	9.09±3.69^b	6.55±1.47^a	5.82±1.52^c	6.31±1.81^c
Chilled	11.49±3.99^b	9.97±4.28^a	5.93±1.41^c	3.13±0.80^c
Blanched	9.99±2.81^b	5.34±1.80^b	18.4±3.76^a	4.40±0.73^c
Fried	4.65±2.00^c	1.52±0.21^c	9.34±0.95^b	5.98±0.61^c
Microwave cooked	18.25±5.30^a	7.65±1.36^a	12.76±2.17^b	9.14±2.84^b
Steamed	9.46±2.95^b	4.46±1.86^b	11.25±4.24^b	10.28±1.13^b

Results are average of five determinations, Mean ± SD; Value with different superscripts in a row differ significantly ($p<0.05$)

microwave cooked samples for anterior region was significantly higher compared to that for other processing techniques ($p<0.05$). Hardness 1 values for *P. monodon* showed no significant difference between fresh, fried, microwave cooked and blanched samples for anterior region and between frozen, chilled, blanched and fried samples for posterior region ($p<0.05$). Similar results for hardness of cooked tiger shrimp have been reported by Erdogdu & Balaban (2000). *P. monodon*, chilled and blanched samples showed significantly lower hardness 2 values ($p<0.05$) for the posterior region. Lower hardness values may be attributed to the weakened endomysium as part of the connective tissue and also due to degradation in the Z-line of myofibrils (Masniyom et al., 2005) during processing. Food proteins change their structure during processing which define their final characteristics, adequacy of method and consumer acceptability. Heating affect the fish muscle texture. Dunajski (1979) reported that cooking of fish muscle at about 60°C leads to the loss of original structure of collagen fibers and they become solubilised and thus any textural changes above this temperature are solely due to the heat denaturation of myofibrillar proteins. Martin Xavier et al. (2013) reported reduced hardness values during precooking of mackerel. Tanaka et al. (1985) compared the firmness of mackerel canned at three different retort temperatures of 110, 115 and 120°C and reported that thermal processing at higher temperature produce firmer products.

Cohesiveness is a mechanical textural attribute related to the degree to which a food can be deformed before it breaks. The cohesiveness values for *L. vannamei* and *P. monodon* samples are given in the Table 3. The cohesiveness values of the samples were in the range of 0.19 to 0.42. The highest value obtained was for fried *L. vannamei* posterior samples and the lowest value obtained was for fresh and frozen *L. vannamei* posterior samples. A value of 1 indicates total elasticity and a value of 0 indicates that the sample did not recover at all (Manju et al., 2007). Similar values for cohesiveness were reported by Latip et al. (2013) for bighead carp stored at chilled conditions. *L. vannamei* anterior region, cooked and fried samples showed significantly higher cohesiveness than all other samples ($p<0.05$). *P. monodon*, cooked samples exhibited significantly higher cohesiveness values in anterior region whereas for posterior region, significantly higher values were observed in microwave cooked samples ($p<0.05$). The different values for cohesiveness may be a result of change in the internal bonding of fish muscle during processing.

Springiness is a mechanical textural attribute related to the rapidity and degree of recovery from a deforming force (Rahman & Al-Mahrouqi, 2009). Variations in the springiness values as a function of processing techniques for *L. vannamei* and *P. monodon* samples are presented in the Table 4. *L. vannamei,* microwave cooked samples exhibited significantly higher cohesiveness values ($p<0.05$) for the posterior region. For anterior samples of *P. monodon*, significantly higher values were observed for microwave cooked and steamed samples whereas fresh and cooked samples of *P. monodon* exhibited significantly higher springiness values. The lower springiness may be due to reduced

Table 3. Effect of various processing methods on cohesiveness of *L. vannamei* and *P. monodon*

Sample	*L. vannamei*		*P. monodon*	
	Anterior	Posterior	Anterior	Posterior
Fresh	0.23±0.01^{c}	0.19±0.04^{b}	0.30±0.12^{b}	0.20±0.03^{d}
Cooked	0.33±0.02^{b}	0.35±0.05^{a}	0.40±0.03^{a}	0.33±0.03^{a}
Frozen	0.24±0.04^{c}	0.19±0.04^{b}	0.24±0.07^{d}	0.25±0.06^{c}
Chilled	0.25±0.03^{c}	0.21±0.04^{b}	0.26±0.06^{c}	0.25±0.06^{c}
Blanched	0.26±0.03^{c}	0.26±0.03^{b}	0.27±0.04^{c}	0.29±0.04^{b}
Fried	0.39±0.06^{a}	0.42±0.05^{a}	0.33±0.02^{a}	0.34±0.04^{a}
Microwave cooked	0.41±0.10^{a}	0.39±0.12^{a}	0.38±0.08^{a}	0.37±0.03^{a}
Steamed	0.25±0.02^{c}	0.23±0.02^{b}	0.30±0.02^{b}	0.30±0.09^{b}

Results are average of five determinations, Mean ± SD; Value with different superscripts in a row differ significantly ($p<0.05$)

Table 4. Effect of various processing methods on springiness (mm) of *L. vannamei* and *P. monodon*

Sample	*L. vannamei*		*P. monodon*	
	Anterior	Posterior	Anterior	Posterior
Fresh	3.28±0.27^{a}	1.53±0.18^{b}	3.37±0.24^{b}	2.34±0.18^{a}
Cooked	3.11±0.10^{a}	1.59±0.10^{a}	3.62±0.22^{a}	2.32±0.10^{a}
Frozen	3.27±0.28^{a}	1.64±0.12^{a}	3.33±0.26^{b}	1.60±0.10^{b}
Chilled	3.13±0.37^{a}	1.61±0.16^{a}	3.36±0.13^{b}	1.57±0.06^{b}
Blanched	3.15±0.48^{a}	1.79±0.14^{a}	3.17±0.31^{c}	1.75±0.03^{b}
Fried	3.18±0.16^{a}	1.69±0.05^{a}	3.10±0.21^{d}	1.66±0.10^{b}
Microwave cooked	3.29±0.23^{a}	2.05±0.79^{a}	3.45±0.20^{a}	1.68±0.11^{b}
Steamed	3.35±0.48^{a}	1.72±0.19^{a}	3.41±0.13^{a}	1.67±0.11^{b}

Results are average of five determinations, Mean ± SD; Value with different superscripts in a row differ significantly ($p<0.05$)

elasticity of samples during processing by different techniques as elasticity at first deformation is springiness (Manju et al., 2007).

Gumminess is a characteristic of semisolid foods with a low degree of hardness and high degree of cohesiveness (Casas et al., 2006). The values for gumminess of the samples are given in Table 5. From the table it can be seen that microwave-cooked anterior samples of *L. vannamei* and cooked anterior samples of *P. monodon* had higher gumminess values and fried samples of posterior region of *L. vannamei* and chilled samples of posterior region of *P. monodon* had lower values. The higher gumminess has arisen from a higher hardness value (Rahman & Al-Mahrouqi, 2009). Affected texture of anchovy by different cooking methods was observed by Uran & Gokoglu (2014).

Chewiness is the mouth feel sensation of laboured mastication due to sustained, elastic resistance from the fish the product of gumminess and springiness (Casas et al., 2006). The results for chewiness of shrimps are given in Table 6. For *L. vannamei*, microwave cooked samples showed significantly higher chewiness than other samples for both anterior as well as posterior region ($p<0.05$). *P. monodon*, cooked samples showed significantly higher chewiness than other samples for both anterior as well as posterior region ($p<0.05$). Lower

Table 5. Effect of various processing methods on gumminess (kgf) of *L. vannamei* and *P. monodon*

Sample	*L. vannamei*		*P. monodon*	
	Anterior	Posterior	Anterior	Posterior
Fresh	5.58±1.02^b	3.25±0.96^b	4.21±0.99^c	5.04±0.90^a
Cooked	4.35±0.94^b	3.55±0.35^b	11.05±3.08^a	5.53±1.12^a
Frozen	3.86±1.40^b	2.53±0.35^b	2.56±1.32^d	2.54±0.63^b
Chilled	4.83±0.95^b	3.51±1.35^b	2.38±0.65^e	1.44±0.47^c
Blanched	4.60±0.70^b	2.53±0.64^b	7.05±1.27^b	2.29±0.49^c
Fried	2.47±0.88^c	0.94±0.18^d	4.63±0.53^c	3.08±0.41^b
Microwave cooked	10.09±3.42^a	4.43±1.62^a	6.92±1.52^b	4.86±1.33^a
Steamed	4.18±1.23^b	2.08±0.67^c	5.17±1.80^c	4.85±1.37^a

Results are average of five determinations, Mean ± SD; Value with different superscripts in a row differ significantly ($p<0.05$)

Table 6. Effect of various processing methods on chewiness (kgf. mm) of *L. vannamei* and *P. monodon*

Sample	*L. vannamei*		*P. monodon*	
	Anterior	Posterior	Anterior	Posterior
Fresh	18.46±4.56^b	5.05±1.83^b	14.24±3.81^c	11.85±2.49^a
Cooked	13.54±3.21^b	5.69±0.87^b	40.55±13.44^a	12.86±2.90^a
Frozen	12.74±4.92^b	4.15±0..69^b	8.75±5.28^d	4.10±1.25^b
Chilled	14.87±0.80^b	5.70±2.38^b	8.01±2.40^d	2.28±0.77^b
Blanched	13.23±1.80^b	4.58±1.42^b	22.38±4.73^b	4.02±0.91^b
Fried	7.80±2.50^c	1.59±0.31^c	14.29±1.71^c	5.13±0.79^b
Microwave cooked	33.37±12.63^a	9.82±7.11^a	24.11±6.52^b	8.13±1.93^a
Steamed	14.14±5.30^b	3.67±1.58^b	17.80±6.58^b	8.22±2.86^a

Results are average of five determinations, Mean ± SD; Value with different superscripts in a row differ significantly ($p<0.05$)

values of chewiness indicated softening of muscle during processing (Manju et al., 2007).

In this study, variations in the textural variables namely hardness, cohesiveness, springiness, gumminess and chewiness as a function of processing method employed and sampling region have been observed for two commercially important shrimp species. Among the different cooking methods improved texture was observed in microwave cooking followed by blanching and steaming. Fried samples had least textural values compared to all the other cooking methods. The study would be useful for processors in order to process shrimp products with special reference to textural requirements of consumers. Further research is required in the field of functional properties to correlate with variations in texture.

Acknowledgments

We express our sincere thanks to the Director, ICAR-Central Institute of Fisheries Technology, Cochin for the encouragement and granting permission to publish this research article.

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