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Research Article

Physicochemical, Proximate Composition, Microbiological and Sensory Analysis of Farmed and Wild Harvested White Shrimp *Litopenaeus vannamei* (Boone, 1931) Tissues

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Abstract: Physicochemical, proximate composition, microbiological and sensory analysis of farmed and wild harvested white shrimp *Litopenaeus vannamei* muscle were compared. The cultured white shrimp were obtained of two farms, whereas the wild shrimp were collected off the coasts of Sinaloa and Nayarit, Mexico. Both, the farmed and wild white shrimp muscle, supplied a good source of protein and polyunsaturated fatty acids. The physicochemical composition, microbiological and sensory properties could be associated to their origin and handling. The wild shrimp tended to have a better proximate composition than the farmed shrimp, due to the availability of a greater diet variety in their environment.

Keywords: Lipid, prawn, protein, quality, tissue

INTRODUCTION

In Mexico, the main shrimp cultivated is the Pacific white *Litopenaeus vannamei*, although other shrimp species are also cultured such as the blue shrimp *Litopenaeus stylirostris* and the brown shrimp *Farfantepenaeus californienses*, but in less proportion. The native shrimp species of Gulf of Mexico, still does not had demonstrated their feasibility of culture. Shrimp production is the main aquaculture activity in México, which contributes with 45.9% of the total volume production, compared with other important aquatic species such as tilapia and oyster that represent 25 and 19.9%, respectively (Ponce-Palafox *et al*., 2011).

White shrimp (*L. vannamei* Boone, 1931) is one of the world's most popular shellfish and is mainly consumed in the North, Latin America, Europe and Asian countries. In Mexico, shrimp occupy the second place in the national fishery production and the first place in economic value. The shrimp catching in 2010, reached 167,015 metric tons being the states of Sinaloa, Sonora, Tamaulipas and Nayarit were the most important. In this year, the shrimp culture contributed with 104,612 metric tons and the white shrimp *L. vannamei* was the most important species (CONAPESCA, 2009). The shrimp growth period in Mexican farms range from 90 to 180 days, with one or three annual harvests and the commercial capture period of white shrimp in Mexico is from September to March.

The shrimp is an excellent source of protein and essential High-Unsaturated Fatty Acids (HUFA) such as eicosapentaenoic (20: 5n3, EPA) and docosahexaenoic (22: 6n3, DHA) acids (Feliz *et al*., 2002; Yanar and Celik, 2006). Besides, the white shrimp is a good source of minerals and vitamins such as calcium, iron, zinc, copper, vitamin B_{12} and essential amino acids (Dong, 2001; Yanar and Celik, 2006). Its

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biochemical composition may be affected by several factors as the species, environmental factors, size, age, natural diet and feed composition (GrugerJr, 1967; Bandarra *et al*., 1997; Sriket *et al*., 2007a). The proximate composition of fatty acid profile, cholesterol and total carotenoid contents of shrimps change seasonally (Luzia *et al*., 2003; Yanar *et al*., 2006; Sriket *et al*., 2007b; Wua and Yang, 2011). However, little information regarding the physicochemical, proximate composition, microbiological and sensory properties of shrimps have been reported according to their origin and handling. The goal of this study was compare the properties of muscular tissue of wild and farm white shrimp from the Mexican Pacific States of Sinaloa and Nayarit.

MATERIALS AND METHODS

Sample preparations: White shrimp (*L. vannamei*), with the size of 100 shrimps/kg (10 g of average), were obtained from farms and fishing zones from Sinaloa and Nayarit states, Mexico, from March to November 2009. Twenty shrimp of almost equal size were separated monthly from the capture in each site, to perform the analysis. The cultured white shrimp were obtained from two farms (Guasave, state of Sinaloa and Tecuala, state of Nayarit) and collected using a cast net ½ inch mesh, 12 h before feeding. The wild white shrimp were collected off the coasts of Sinaloa (in front of Navachiste Bay, Guasave) and of Nayarit (in front of Boca de Cuautla-Novilleros, Tecuala) by capturing shrimp trawls known as "changos" and boats with outboard motor at between 10 and 20 m. After collection, each sample was placed in an airtight polyethylene bag and immersed in plenty of crushed ice until being transported to the Water Quality Laboratory and Food Regional Fisheries Research Center of Mazatlan, Sinaloa, Mexico. For every month the muscle, head and shell of the sampled shrimp were removed and kept in a freezer at -18°C until required for analysis during 24 h. The shrimps were deveined and the edible portions were ground to obtain uniformity. All peeled shrimp were composited, homogenized and analyzed. All analysis (physicochemical, proximate, microbiological and sensory), were determined with three replicates.

Physicochemical analysis: Shrimp muscle pH was determined with a pH meter (American Marine®, Ridgefield, C T, USA). About 5 to 10 g of sample homogenized in distilled water was equilibrated for 5 min at room temperature before obtaining the pH readings in triplicate. The % of chloride (NaCl) was obtained using 10 g of sample, 0.1 N solution of silver nitrate, HNO_3 and titrated with 0.1 M solution of ammonium thiocyanate. The TVB-N (Total Volatile Basic Nitrogen) was determined by Macro-Kjeldahl Method distillation technique. A quantity of 10 g of shrimp muscle was placed in a blender for homogenization. Analyses were performed in triplicate (SSA, 1995; NOM-129-SSA-1995).

Table 1: Sensory and quality attributes certain fresh whole shrimp (*L. vannamei*)

Score	Color	Odor	Firmness	Quality
1	Brown or black spots	Putrid	Very soft	Poor
2	Yellowish brown or pale brown	No putrid odor slightly	Slightly soft (convex)	Limit human consumption
3	Remaining non-fixed brightness	Good	Inelastic	Regular
4	Bright not fixed	Very good	Elastic	Good
5	Natural and bright	Excellent odor	Elastic and rigid	Very good

Proximate composition: Shrimp muscle was analyzed for moisture and ash content (AOAC, 2005; method, No. 92.05) and protein content was determined by the Kjeldahl method (AOAC, 2005; method, No. 2001, 11). These analyses were performed in triplicate. Crude lipid content was performed by acid digestion prior to petroleum ether extraction (b.p. 40-60ºC) in a Soxtec system (AOAC, 2005; method, No. 2003. 05). The values (triplicate) were expressed as % (wet weight basis).

Microbiological analysis: Microbiological analysis was performed according to the standard procedure for the enumeration and identification of microorganisms (BAM, 1998). The MPN technique was used to determine the level of fecal coliforms. The samples were homogenized in a blender using sterile physiological saline solution (0.85% NaCl solution). Total Coliform (TC) bacteria were assayed by the membrane filtration technique with m-Endo agar (Difco) and incubated for 24 h at 35°C. The standard M 7 h FC membrane filtration method was used to recover Fecal Coliforms (FC) at 41.5°C. Peptone (0.1%) was used for all serial dilutions. All assays were done according to APHA (1998).

Sensory analysis: The sensory attributes studied were odor, color and firmness. These sensory attributes and quality are defined and described in Table 1, according to Herrera-Ramírez *et al*. (2003). Initial sensory and quality evaluations were conducted to develop descriptors. Each panelist received WS (Sinaloa Wild shrimp), WN (Nayarit Wild shrimp), FS (Sinaloa Farm shrimp) and FN (Nayarit Farm shrimp) samples and they were asked to describe the odor, color, firmness and quality and state similarities and differences among the samples.

Two sensory panels were conducted to come up with ways of differentiating wild and farm shrimp (fresh) of Sinaloa and Nayarit state. One of the panels

included students and faculty from the Sinaloa University. The other panel included local-area chefs. The Sinaloa University students and faculty represented the average consumers/purchasers of shrimp. The chefs were used as the experts in the panel, with the assumption that they acquired proper training on what to look for in a shrimp sample in terms of flavor, firmness, appearance and aroma of shrimp. The first panel (chef) had a total of 45 participants. The second panel conducted (consumer) consisted of 98 students and faculty. During a sensory and quality session, each panelist analyzed all shrimp, under white light illumination and at room temperature.

Statistical analysis: Data were subjected to Analysis of Variance (ANOVA) and mean comparison was carried out using Tukey's Honest Significant Differences (Montgomery, 2005). Statistical analyses were performed using the Statistical Package for Social Science (SPSS 11.0 for windows, SPSS Inc., Chicago, IL). The level of significant for both, ANOVA and post-hoc analysis were of $p<0.05$.

RESULTS AND DISCUSSION

The pH, chloride (%) and Total Volatile Bases Nitrogen (TVB-N) concentrations of shrimp are shown in Table 2. These values were above pH 7.0, with a minimum of 7.16 for shrimp Farming in Sinaloa (FS), chlorides were less than 1% and the TVB-N fluctuated between 35.35±1.64 (FS) maximum and 32.34±1.03 (FN) minimum. Non-significant differences ($p<0.05$) were found for TVB-N between the wild and farmed shrimp, but significant higher pH and lower chlorides (%) were found in shrimp cultured in the state of Nayarit. The determination of TVB-N is an indicator of freshness commonly used in the trade (Storey *et al*., 1984). It determination quantifies the nitrogenous bases (trimethylamine, dimethylamine and ammonia) produced during spoilage of shrimp (Galleguillos, 1996). In this experiment the nitrogenous bases of the thawed shrimp head were of 17.76 mg/100 g fresh head, concentration near the content of that of anchovy (14 mgN/100 g) maintained at 20 to 28°C for 12 h before its processing into meal. In raw anchovy, concentrations greater than 30 mg TVB-N/100 g, have a significant negative effect on the meal consumption (Ricque *et al*., 1998). Biochemical alterations increase the pH of shrimp muscle, even under freezing conditions resulting in decreased product quality over time. This increment of pH value can be attributed to compounds accumulated from endogenous and microbial enzymatic reactions (Seabra *et al*., 2011). The results of pH in the fresh shrimp muscle were above 7.0, which agree with the findings reported by López-Caballero *et al*. (2007), Tsironi *et al*. (2009) and Seabra *et al*. (2011).

Table 2: pH, % total chlorine and nitrogen bases volatile composition of shrimp (*L. vannamei*) muscle

Parameter /source	WS	WN	FS	FN
pH	7.23±0.24[b]	7.25±0.21[b]	7.16±0.25[b]	7.38±0.08[a]
Chlorides (%)	0.72±0.20[a]	0.73±0.32[a]	0.76±0.19[a]	0.43±0.04[b]
TVB-N (mg/100 g)[1]	34.85±1.66[a]	33.79±2.03[a]	35.35±1.64[a]	32.34±1.03[a]

[1]: Volatile bases total nitrogen: WS = Sinaloa wild shrimp, WN = Nayarit wild shrimp, FS = Sinaloa farm shrimp, FN = Nayarit farm shrimp; Values are given as means±S.D. from triplicate determinations; Different superscripts in the same row indicate significant differences ($p<0.05$)

Table 3: Proximate composition (g/100 g) of white shrimp (*L. vannamei*)

Parameter /source	WS	WN	FS	FN
Moisture	73.91±1.06[a]	73.63±0.86[a]	73.14±1.23[a]	73.90±0.78[a]
Protein	20.04±0.93[a]	20.10±0.52[a]	19.99±0.74[a]	19.93±0.69[a]
Ash	2.26±1.66[a]	2.10±1.05[a]	2.20±0.88[a]	2.27±0.45[a]
Crude lipid	1.27±0.36[a]	1.32±0.37[a]	1.34±0.18[a]	1.31±0.48[a]

WS: Sinaloa wild shrimp; WN: Nayarit wild shrimp; FS: Sinaloa farm shrimp; FN: Nayarit farm shrimp; Values are given as means±S.D. from triplicate determinations; Different superscripts in the same row indicate significant differences ($p<0.05$)

The results of proximate composition are shown in Table 3. Non-significant differences were found in any of the measured parameters between groups. Shrimps had suitable moisture contents (73.14 to 73.91%). The protein was found as the major constituent, indicating that shrimp muscle can be a good source of amino acids. Crude protein levels showed a tendency to increase in wild shrimp. The ash content was higher in this study than from shrimp farmed in Songkhla and Suratthani provinces (Sriket *et al*., 2007b). Protein and fat contents of the edible part of our shrimp were slightly different from those found by Sriket *et al*. (2007b). Proximate compositions in shrimp muscle are affected by several factors such as species, growth stage, feed and season (Karakoltsidis *et al*., 1995). However, non-significant difference in terms of origin and place of samples had been reported. In our study, the proximate contents found for *L. vannamei* was within the range of other shrimp species (Diler and Ata, 2003; Oksuz *et al*., 2009; Turan *et al*., 2011).

The fecal coliform is present in the gut and feces of warm-blooded animals. Because the origins of fecal coliforms are more specific than the origins of the total coliform group, coliforms are considered a more accurate indication of animal or human waste than the total coliforms. The presence of fecal coliform is not permitted in the shrimp in Japan, USA and other European countries WHO (1995).

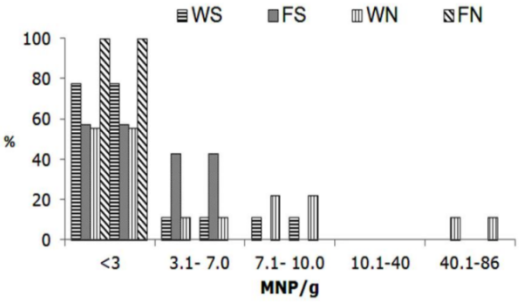

Fig. 1: Frequency (%) of fecal coliform in the white shrimp muscle

Table 4: Sensorial analysis of fresh white shrimp (*L. vannamei*)

Parameter /source	WS	WN	FS	FN
Color	4.75±0.12[a]	4.12±0.20[b]	4.07±0.25[b]	4.75±0.18[a]
Odor	5.00±0.17[a]	4.60±0.22[b]	4.50±0.24[b]	5.00±0.18[a]
Firmness	4.85±0.15[a]	4.21±0.12[b]	4.15±0.15[b]	4.85±0.15[a]
Quality	5.00±0.19[a]	4.50±0.26[a]	4.50±0.27[a]	5.00±0.19[a]

WS: Sinaloa wild shrimp; WN: Nayarit wild shrimp; FS: Sinaloa farm shrimp; FN: Nayarit farm shrimp; Values are given as means±S.D. from triplicate determinations; Different superscripts in the same row indicate significant differences ($p<0.05$)

Fecal coliforms were detectable in wild and farmed shrimps collected and their MPN/g counts ranged from <3 to 86 (Fig. 1). The MPN count of fecal coliform per gram of sample observed in different shrimp from the State of Sinaloa were between <3 to 10, while in those from the State of Nayarit were <3 to 86. The sanitary conditions of wild and farmed shrimp were best at Sinaloa state. Fecal coliform contents in shrimps vary depending on the sanitary and hygienic conditions of the landing centers or farm (Antony *et al*., 2002).

Iyer and Joseph (1995) reported that the incidence of total coliforms in cultured *P. indicus* was 230 MPN/g, while Jeyasekaran *et al*. (1990) reported >240 of MPN/g total coliform in tropical shrimps. The MPN/g fecal coliform counts of 11 to 240, 2 to >2400 and 0 to 1600, respectively in freshly caught penaeid shrimps were reported (Jeyasekaran *et al*., 1990; Karunasagar *et al*., 1992; Antony *et al*., 2002). Thus, the microbiological conditions of white shrimp obtaining in this study are well below those reported for other species.

In general, the shrimp have a bright natural color, odor and firmness (excellent elastic and rigid characteristics), presenting a very good overall quality (Table 4). The values found for color, odor, firmness and quality for shrimp *L. vannamei* were 4.75±0.18 (FN), 5.0±0.18 (FN), 4.85±0.15 (WS and FN) and 5.0±0.19 (WS and FN) maximum and 4.07±0.25 (FS), 4.6±0.22 (WN), 15.04±0.15 (FS) and 4.5±0.26 (WN) minimum, respectively. In relation to color (Smith, 1930) observed an expansion of the chromatophore pigment with heat and a contraction with cold. The results of sensorial analysis of fresh white shrimp, showed that there were non-significant differences ($p<0.05$) in the color of the samples, but there was a trend in the WS and FN groups to have the best color (natural and bright). Excellent odor was presented by WS and FN groups, which were significantly ($p<0.05$) better than for FS and WN. The handling and process of freezing and thawing negatively impacts the firmness of shrimp tissue, which results in a loss of integrity of muscle fibers (Sriket *et al*., 2007a). The results illustrates the decrease in firmness caused by handling fresh in all the groups; however, it can be seen that the WS and FN groups had higher firmness than the WN and FS groups ($p<0.05$). WN and FS showed less color scores than WS and FN ($p<0.05$). This result is in accordance with loss of total carotenoids (Seabra *et al*., 2011), which was delayed by keeping the shrimp in ice. Rancidity caused by lipid oxidation is a principal factor that contributes to reduce quality of frozen muscle products. These irreversible alterations contribute to the development of undesirable sensorial characteristics detected by consumers (Georgantelis *et al*., 2007). However, the quality of wild and farmed white shrimp in the states of Sinaloa and Nayarit, showed a quality of good to very good.

CONCLUSION

The results of our study suggested that muscle of wild and farmed white shrimp are a good source of protein and lipid. The differences in physicochemical compositions, microbiological and sensorial properties between groups might be associated with the origin and handling. There were non-significant differences ($p<0.05$) between wild and farmed shrimp, but the wild shrimp tend to have a better proximate composition than the farmed ones. This is due to the greater variety of foods available in their environment.

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