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Comparative Evaluation of Patties Prepared from Pacific White Shrimps (*Litopenaeus vannamei*) Grown in Inland Saline Water and Brackish Water Regimes during Frozen Storage

D M Affarin Tinku[a], K.A. Martin Xavier[a], Binaya Bhushan Nayak[a], V. Hari Krishna[b], Gopal Krishna[c], and Amjad Khansaheb Balange[a]

[a]Department of Post-Harvest Technology, ICAR-Central Institute of Fisheries Education, Mumbai, India; [b]Rohtak Regional Centre, ICAR-Central Institute of Fisheries Education, Haryana, India; [c]NAHEP -CAAST Project, ICAR-Central Institute of Fisheries Education, Mumbai, India

ABSTRACT

In this study, an attempt has been made to develop shrimp patties from inland saline water reared *vannamei* (ISRV) and compare its quality with that from brackish water reared *vannamei* (BWRV) under storage conditions at −18°C for 4 months. The patties prepared from ISRV had tantamount protein (21.69%), high ash (1.62%) and low fat (0.31%) content as compared with BWRV patties, which had protein, ash and fat content as 22.45%, 1.52% and 0.43% respectively. No significant difference was observed in sensory scores of the patties. Trimethylamine, total volatile base nitrogen, total viable bacterial count and staphylococcal count were significantly increasing during storage and are within the acceptable limits. Peroxide value and TBARS increased during storage and slightly higher values observed in ISRV. This study concluded that overall quality and shelf life of patties prepared from ISRV was comparable with BWRV and there is no significant effect observed under frozen conditions.

KEYWORDS

Inland saline water; shrimp patties; quality; frozen storage

Introduction

Litopenaeus vannamei is the main farmed species of high market value all over the world, with the global production of 41,68,417 tonnes in 2016 (FAO 2018). In general, this shrimp is reared in brackish water, which is the natural environment for its normal growth and survival. Presently, the inland aquaculture of shrimp in low salinity waters is widespread in many regions worldwide (Allan et al. 2009). The Pacific white shrimp (*Litopenaeus vannamei*) has become the candidate of choice for low salinity culture because of its ability to grow and survive in low salinity environments (Roy et al. 2010). The flavor of shellfish is derived from nitrogenous compounds and non-nitrogenous compounds. Nitrogenous compounds include free amino acids, nucleotides, low molecular weight peptides, and quaternary ammonium bases. Non-nitrogenous compounds include organic acids, sugars, and inorganic constituents, such as Na^+, K^+, Cl^-, and PO_4^{3-}. As free amino acids are major osmoeffectors in shrimp, they manipulate the flavor intensity (Hayashi et al. 1981). The ions in inland saline waters vary from marine waters, and so the shrimps live in a compromised environment, which is different from its natural environment. This affects the growth and quality of the shrimp (Roy et al. 2010). Javith et al. (2020) compared the meat quality composition of *Litopenaeus vannamei* reared in inland saline water and brackish water and reported that the amino acids arginine and glutamic acid, which are responsible for the seafood like flavor and sweet taste of crustaceans, were higher in the brackish water sample (1.66 and 3.42 g/100 g, respectively) than the inland saline water sample (0.98

CONTACT Amjad Khansaheb Balange amjadbalange@cife.edu.in Department of Post-Harvest Technology, ICAR-Central Institute of Fisheries Education, Versova, Mumbai 400061, India.

and 2.66 g/100 g, respectively). Studies have shown that consumers prefer shrimp cultured in seawater to those cultured in low salinity water because of superior qualities and flavor (Liang et al. 2008).

However, the quality and flavor of inland saline reared shrimp can be enhanced by value addition, which is the enhancement added to a product or service by a company before the product is offered to customers (MPEDA 2018). The increased interest in ready-to-eat products is the driving force for the success of the seafood product industry, and there is a scope to enhance flavor and acceptability of the seafood. The use of small shrimps or broken shrimp meat for new products is still limited. Burger patties made from minced meat are very common and are well-liked products in almost every country, especially in Europe (Llorca et al. 2003).

The culture of shrimps away from its natural rearing condition, such as in inland saline waters, leads to biological stress resulting in quality and flavor changes of shrimps. Value-added product preparation from inland saline shrimp can be done to enhance the flavor intensity and mask the quality and flavor differences. However, the study on assessment of quality of the value-added products prepared from *Litopenaeus vannamei* reared in stress condition and the shelf life of the products has not been available in the literature. Therefore, an attempt has been made in the present investigation to develop shrimp patties from inland saline water reared *vannamei* (ISRV) and compare its quality and storage stability with that from brackish water reared *vannamei* (BWRV).

Materials and methods

Shrimp and other ingredients

Inland saline water reared *L. vannamei* grown at 7–13 ppt were collected from Rohtak district of Haryana, India. Harvested shrimps were immediately iced in a polystyrene insulated container with shrimp-to-ice ratio of 1:1 (w/w) and transported by air to the laboratory within 5 h. Brackish water reared *L. vannamei* grown in 13 ppt salinity was freshly harvested from a farm in the Roha district of Maharashtra, India and brought to the laboratory within 4 h in iced condition.

Other ingredients used were purchased from local markets. All chemicals used were of analytical grade and obtained from Sigma Aldrich (Mumbai, India), Merck (Mumbai, India), Hi-Media (Mumbai India), and (Qualichem (Mumbai, India).

Shrimp patties preparation

The shrimps were peeled, deveined, and washed, and each group was separately blanched in 1% brine at 90°C for 2 min. The blanched shrimps were then comminuted using a silent cutter (Krag, Pune, Maharashtra, India). To the shrimp mince (94%), common salt (0.7%), onion (4%), corn starch (1%), and black pepper powder (0.3%) were added. It was then mixed well and made into patties using a patty maker (Mainca MH120, St. Louis, MO, USA). In the patty maker, parchment paper was placed on the bottom, and the lever was compressed to form a patty having a specification of 10 cm diameter, 8 mm thickness, and 80 g weight. It was then packed in high-density polyethylene (HDPE) trays, sealed, labelled, and stored at −18°C. Frozen storage study was carried out for up to 4 months, with the sampling interval of 1 month. The samples were subjected to biochemical, microbial, and sensory evaluation.

Proximate composition and biochemical quality parameters

The moisture, protein, fat, and ash content of shrimp patties were determined according to the AOAC method (AOAC 2005). Ten gram of sample was homogenized with 50 ml distilled water in a homogenizer (Polytron system PT 2100, Kinematica, AG, Germany) for 30 s, and pH value of homogenate was measured using a digital pH meter (Eutech tutor pH/°C meter, Eutech Instruments, Singapore) standardized earlier by buffers at pH 4.8 and 9.2. The total volatile base nitrogen (TVB-N) and trimethylamine (TMA) were determined based on an adaptation of the current official European

steam-distillation method (EU/EC 2008). The peroxide value (PV) was determined according to the AOAC (2005) method. Thiobarbituric acid reactive substances (TBARS) content was measured by the method of Tarladgis et al. (1960).

Microbial and sensory quality evaluation

The total viable bacterial count of the sample was determined by spread plate technique (BAM 2004), and total Staphylococcal count was determined according to Kilinc (2007). The sensory evaluation for overall acceptability of the product was performed by trained panel members (n = 10) using a 9-point hedonic scale, with 1 being the lowest and 9 being the highest score. The point 5 was taken as the border of acceptability. The attributes were appearance, color, odor, texture, taste, flavor, and overall acceptability. The samples were deep-fried at 170–180°C for 3 min and served to panelists for the taste attributes.

Statistical analysis

The experimental results were statistically analyzed using Statistical Package for Social Science software (SPSS VERSION 22.0, Chicago, IL, USA). Analysis of variance (ANOVA) was carried out, and the significant difference among the treatments was determined by Duncan's Multiple Range Test (DMRT). The level of significance was set at $p \leq 0.05$. The results were expressed as mean ± standard deviation for triplicates.

Results and discussion

Centesimal composition of differently reared vannamei shrimp meat

Fresh meat composition of *L. vannamei* shrimps reared in different regimes showed slight variations in centesimal composition. Moisture, protein, fat, and ash content of BWRV and ISRV samples were 77.49%, 20.83%, 0.48%, and 1.89% and 78.80%, 18.86%, 0.37%, and 1.88% respectively. Moisture content showed significantly higher ($p < .05$) values in ISRV (78.80%) as compared to BWRV (77.49%). Accordingly, crude fat content also showed significantly higher ($p < .05$) values in BWRV sample (0.48%) than ISRV (0.37%). There was no significant difference observed in protein and ash content of both the samples. Farajzadeh et al. (2016) reported the moisture, protein, fat, and ash contents of the farmed *L. vannamei* as 77%, 19.9%, 0.96%, and 1.4%, respectively, which is closely related to the proximate composition of BWRV samples in the present investigation. Javith et al. (2020) reported the moisture, protein, fat, and ash content of *L. vannamei* reared in brackish water and inland saline water as 76.04%, 20.91%, 0.82%, and 1.27% and 78.84%, 17.98%, 0.81%, and 1.28%, respectively. The minor variations between the proximate compositions of ISRV and BWRV meat samples might be due to the variations in post-harvest handling of the raw material (Javith et al. 2020).

Changes in the centesimal composition of shrimp patties during frozen storage

The patties prepared with blanched *vannamei* meat showed significantly higher ($p < .05$) moisture content in the ISRV sample (75.30%) than the BWRV sample (74.23%). No significant difference ($p > .05$) was found in the protein, ash, and carbohydrate content of both the samples. Accordingly, significantly higher ($p < .05$) fat content (0.43%) was observed in the BWRV sample than the ISRV (0.31%). The differences in moisture content results in relative differences in the other proximate components, such as protein, fat, or ash. The patties prepared with blanched meat of ISRV and BWRV had protein, ash, and carbohydrate content of 21.69%, 1.62%, and 1.08% and 22.45%, 1.52%, and 1.37%, respectively. The protein content

of the ISRV and BWRV patties (21.69% and 22.45%, respectively) is higher than ISRV and BWRV meat samples (18.86% and 20.83%, respectively). This might be due to the reduction in moisture content during blanching. Delfieh et al. (2013) studied the effect of cooking methods on proximate composition of Indian white prawn and found similar decrease in moisture content and increase in protein content after cooking.

The changes in proximate composition of shrimp patties prepared from *L. vannamei* reared in inland saline water and brackish water during frozen storage are depicted in Table 1. The moisture and protein content of shrimp patties prepared with BWRV samples and ISRV samples showed no significant difference ($p > .05$) during storage. The fat content of BWRV sample increased from 0th day (0.43%) until the 120th day (0.47%), except for the 90th day (0.37%). The fat content of the ISRV sample increased from 0th day (0.31%) to the 120th day (0.37%). No significant difference ($p > .05$) was found in the ash content of BWRV and ISRV samples during storage. The changes in moisture content resulted in relative changes in the other proximate components, such as protein, fat, or ash. Mahmoudzadeh et al. (2010) reported slight changes in moisture content of fish burger prepared from deep flounder during storage at −18°C for 5 months. Albulushi et al. (2005) reported a decrease in the protein content during storage of fish burgers at −20°C for 3 months. The addition of onion and corn starch resulted in 1–1.25% carbohydrate in the product. No significant difference ($p > .05$) was found in the carbohydrate content of BWRV and ISRV samples during storage.

Changes in biochemical parameters of shrimp patties during frozen storage

Changes in pH

The changes in biochemical parameters are given in Table 2. The pH values of BWRV samples increased in the first month (6.70) from 0th day (6.64) and decreased thereafter to the 120th day (6.61). The pH values of ISRV samples significantly decreased ($p < .05$) until the 60th day (6.64) from 6.78 and increased thereafter until the 120th day (6.76). The increase in the pH value during initial months of storage is caused by the enzymatic degradation of the fish muscle content, and constant levels of pH might be due to increasing solubility of CO_2 in the last months, effecting the aerobic microflora growth (Mahmoudzadeh et al. 2010). Mahmoudzadeh et al. (2010) reported the increase in pH values of fish burgers from 6.53 to 7.03 at the 2nd month and the decrease thereafter to 6.83 at the end of 5 months during storage at −18°C. The above result is in agreement with the present study. The shrimp pH of 7.7 or less indicates prime quality, and 7.7–7.95 indicates acceptable quality (Marshall and Wiese-Lehigh 1997). In the

Table 1. Changes in the centesimal composition (wet weight) of shrimp patties prepared from differently reared *L. vannamei* during frozen storage.

Parameter	Samples	0th day	30th day	60th day	90th day	120th day
Moisture (%)	BWRV	74.23 ± 0.65^{aA}	73.73 ± 0.01^{aA}	74.00 ± 0.47^{aA}	74.01 ± 0.56^{aA}	74.30 ± 0.25^{aA}
	ISRV	75.30 ± 0.24^{aB}	75.21 ± 0.11^{aB}	75.26 ± 0.02^{aB}	75.39 ± 0.60^{aB}	75.44 ± 0.51^{aB}
Protein (%)	BWRV	22.45 ± 0.90^{aA}	22.81 ± 0.16^{aA}	23.26 ± 0.54^{aA}	23.13 ± 0.11^{aA}	23.16 ± 0.24^{aA}
	ISRV	21.69 ± 0.35^{aA}	22.01 ± 0.34^{aB}	21.82 ± 0.31^{aB}	21.47 ± 0.54^{aB}	21.50 ± 065^{aB}
Fat (%)	BWRV	0.43 ± 0.02^{aA}	0.43 ± 0.02^{aA}	0.42 ± 0.00^{aA}	0.37 ± 0.00^{bA}	0.47 ± 0.00^{cA}
	ISRV	0.31 ± 0.02^{aB}	0.27 ± 0.04^{aB}	0.36 ± 0.00^{bB}	0.39 ± 0.00^{bB}	0.37 ± 0.00^{bB}
Ash (%)	BWRV	1.52 ± 0.03^{aA}	1.42 ± 0.03^{aA}	1.29 ± 0.29^{aA}	1.16 ± 0.48^{aA}	1.07 ± 0.49^{aA}
	ISRV	1.62 ± 0.08^{aA}	1.40 ± 0.33^{aA}	1.47 ± 0.14^{aA}	1.58 ± 0.18^{aA}	1.38 ± 0.24^{aA}
Carbohydrate (%)	BWRV	1.37 ± 0.37^{aA}	1.61 ± 0.21^{aA}	1.03 ± 0.06^{aA}	1.33 ± 0.58^{aA}	1.00 ± 0.01^{aA}
	ISRV	1.08 ± 0.10^{aA}	1.10 ± 0.09^{aB}	1.10 ± 0.17^{aA}	1.17 ± 0.15^{aA}	1.30 ± 0.00^{aB}

BWRV – Brackish water reared *vannamei*; ISRV – Inland saline reared *vannamei*.

Data expressed as the mean±SD (n = 3); the mean values in the same row with different small letter superscripts are significantly different ($p < .05$).

The mean values in the same column with different capital letter superscripts are significantly different ($p < .05$).

Table 2. Changes in biochemical parameters of shrimp patties prepared from differently reared *L. vannamei* during frozen storage.

Parameter	Samples	0th day	30th day	60th day	90th day	120th day
pH	BWRV	6.64 ± 0.00 ^{bA}	6.70 ± 0.00^{aA}	6.50 ± 0.00^{eA}	6.57 ± 0.00 ^{dA}	6.61 ± 0.00^{cA}
	ISRV	6.78 ± 0.00^{aB}	6.75 ± 0.00^{bB}	6.64 ± 0.00 ^{dB}	6.70 ± 0.00^{cB}	6.76 ± 0.00^{bB}
TVB-N	BWRV	4.30 ± 0.01^{aA}	11.13 ± 0.01 ^{bA}	15.57 ± 0.01^{cA}	18.52 ± 0.01 ^{dA}	27.38 ± 0.01^{eA}
(mg N/100 g)	ISRV	4.62 ± 0.10^{aB}	8.40 ± 0.01^{bB}	9.38 ± 0.01^{cB}	14.42 ± 0.01 ^{dB}	26.04 ± 0.01^{eB}
TMA	BWRV	0.77 ± 0.01^{aA}	4.83 ± 0.01 ^{bA}	8.12 ± 0.01^{cA}	11.15 ± 0.01 ^{dA}	14.42 ± 0.01^{eA}
(mg N/100 g)	ISRV	1.78 ± 0.25^{aB}	5.11 ± 0.01^{bB}	6.45 ± 0.01^{cB}	9.80 ± 0.10 ^{dB}	13.16 ± 0.01^{eB}
PV	BWRV	0.75 ± 0.01^{cA}	0.38 ± 0.00^{aA}	0.39 ± 0.00^{aA}	0.51 ± 0.01 ^{bA}	0.77 ± 0.01 ^{dA}
(meq O_2/kg)	ISRV	0.58 ± 0.10^{cB}	0.19 ± 0.00^{aB}	0.37 ± 0.00^{bB}	0.93 ± 0.00 ^{dB}	0.98 ± 0.00 ^{dB}
TBARS	BWRV	0.20 ± 0.00 ^{dA}	0.10 ± 0.00^{aA}	0.11 ± 0.00 ^{bA}	0.14 ± 0.01^{cA}	0.67 ± 0.01^{eA}
(MDA/kg)	ISRV	0.27 ± 0.00 ^{dB}	0.08 ± 0.00^{aB}	0.12 ± 0.00^{bB}	0.18 ± 0.00^{cB}	0.83 ± 0.00^{eB}

BWRV – Brackish water reared *vannamei*; ISRV – Inland saline reared *vannamei*.

Data expressed as mean±SD (n = 3); the mean values in the same row with different small letter superscripts are significantly different ($p < .05$).

The mean values in the same column with different capital letter superscripts are significantly different ($p < .05$).

present study, pH values of both BWRV and ISRV samples were within the acceptable limit until the end of storage.

Changes in nitrogenous compounds

The TVB-N content of both the samples significantly increased ($p < .05$) during the storage period. The TVB-N content of the BWRV sample increased from 4.30 to 27.38 mgN/100 g and 4.62 to 26.04 mgN/100 g for the ISRV sample. The increase of TVB-N value during storage is due to bacterial spoilage and activity of endogenous enzymes that results in basic nitrogen fraction (Chomnawang et al. 2007). Mahmoudzadeh et al. (2010) found an increase of TVB-N value in fish burger from 11.66 mgN/100 g to 20.97 mgN/100 g at the end of the second month and significant decrease to 14.6 mgN/100 g at the end of storage at −18°C. The increase in TVB-N values is correlated with the increase in the total viable count during storage. The level of 30–35 mgN/100 g is suggested as the upper limit of acceptable freshness for seafood (Ludorff and Meyer 1973). In this study, TVB-N contents were within the acceptable limit until the end of storage.

TMA also showed a significantly increasing ($p < .05$) trend during storage. The TMA values of BWRV sample and ISRV samples increased from initial values of 0.77 mgN/100 g and 1.78 mgN/100 g to 14.42 mgN/100 g and 13.16 mgN/100 g, respectively, at the end of storage. The increase in TMA production during storage is due to the decomposition of trimethylamine N-oxide (TMAO) by bacterial and enzymatic activity (Serdaroglu and Deniz 2001). The increase in TMA can be correlated with the increase in microbial content in the present study. It is reported that 10–15 mgN/100 g is generally regarded as the limit of acceptability for human consumption (Huss 1988). In this study, TMA contents were within the acceptable limit at the end of storage.

Changes in lipid oxidation products

The peroxide value indicates the formation of peroxide or hydroperoxide that is considered as the primary product of lipid oxidation. The peroxide value of the BWRV sample and ISRV sample was found to decrease on the 30th day (0.38 and 0.19 meq O_2/kg, respectively) from 0th day (0.75 and 0.58 meq O_2/kg, respectively) and increased thereafter until the 120th day (0.77 and 0.98 meq O_2/kg, respectively). Decrease of PV could be attributed to different rates of lipid oxidation (Arvanitoyannis et al. 2005). Increase in PV is due to lipid oxidation during storage. The results of PV could be correlated with the odor parameter from sensory analysis during frozen storage. Albulushi et al. (2005) reported that the peroxide value was detectable only after the second week of storage, and its value increased from week 4 (14 meq O_2/kg fat) to week 8 (26 meq O_2/kg fat) and then became stable to the end of storage during frozen storage of burger prepared from frozen fillets of white fleshed Arabian Sea meagre at −20°C for 12 weeks.

Mahmoudzadeh et al. (2010) reported that the PV increased at the end of the second month and then decreased at the end of the 4th month, followed by sudden increase at the end of the 5th month during storage at −18°C. The recommended value of peroxide for fresh sample is 8–10 meq O_2/kg of lipid (Okpala et al. 2014). In the present study, both the samples were within the acceptable limits until the end of storage.

The TBA value is a measure of secondary oxidation products. The TBARS value of both the BWRV sample and ISRV sample was found to decrease on the 30th day (0.10 and 0.08 MDA/kg fat, respectively) from 0th day (0.20 and 0.27 MDA/kg fat, respectively) and increased thereafter until the 120th day (0.67 and 0.83 MDA/kg fat, respectively). The initial decrease of TBA values could be due to the interaction of decomposition products of protein with malonaldehyde to give tertiary products. The increase in TBARS value is due to the decomposition of unstable hydro peroxides, which results in the production of secondary products of oxidation (Haghshenas et al. 2015). Mahmoudzadeh et al. (2010) reported that fish burgers had higher TBA value at the beginning of storage and then decreased gradually from 1.01 mg to 0.22 mg malonaldehyde/kg at the end of storage for 5 months at −18°C. For a seafood product to be acceptable for consumption, recommended TBA value is less than 2 (Gopakumar 2002). In the present study, both the samples were within the acceptable limits until the end of storage.

Changes in total viable bacterial count and Staphylococcal count

Table 3 represents the changes in the total viable bacterial count and total *Staphylococcal* count of shrimp patties prepared from *L. vannamei* reared in inland saline water and brackish water during frozen storage. The initial viable plate count of the BWRV sample and ISRV sample was 3.47 log CFU/g and 3.30 log CFU/g, respectively, and it increased thereafter to 5.52 log CFU/g and 5.19 log CFU/g, respectively, at the end of 120 days of storage. The *Staphylococcus* count also increased in both the BWRV sample and ISRV sample and reached 4.11 log CFU/g and 4.90 log CFU/g, respectively, at the end of 120 days from initial values of 2.13 log CFU/g and 2.17 log CFU/g, respectively. The increase in microbial count can be correlated with the increase in volatile compounds during storage. As *Staphylococcus* survives freezing and frozen storage (Sen 2005), the *Staphylococcus* count increased in the product during storage. In contrast to the results of present study, Mahmoudzadeh et al. (2010) reported a decrease in TPC from 5 to 3.2 log cfu/g in fish burger prepared from deep flounder during storage at −18°C for 5 months. Albulushi et al. (2005) reported 84% reduction of initial aerobic bacterial count from 3×10^4cfu/g to 4×10^3cfu/g during frozen storage of burger prepared from frozen fillets of white fleshed Arabian Sea meagre at −20°C for 12 weeks, unlike the results of present study. ICMSF (International Commission on Microbiological Specification for Foods) (1978) suggests the maximum level of total viable count for fish products as 10^7 CFU/g. In the present study, both the BWRV sample and ISRV sample were within acceptable limits until the end of storage.

Changes in sensory parameters of shrimp patties during frozen storage

Table 4 shows the changes in sensory score for all the parameters (appearance, color, odor, texture, taste, flavor, and overall acceptability) tested for shrimp patties prepared from *L. vannamei* reared in

Table 3. Changes in total viable bacterial count and *Staphylococcal* count of shrimp patties prepared from differently reared *L. vannamei* during frozen storage.

Parameter	Samples	0th day	30th day	60th day	90th day	120th day
TVC (log CFU/g)	BWRV	3.47	3.69	4.60	5.02	5.52
	ISRV	3.30	4.04	4.46	4.55	5.19
Staphylococcal count (log CFU/g)	BWRV	2.13	2.77	2.90	3.02	4.11
	ISRV	2.17	3.07	3.25	3.30	4.90

BWRV – Brackish water reared *vannamei*; ISRV – Inland saline reared *vannamei*.

Table 4. Changes in the sensory score of shrimp patties prepared from differently reared *L. vannamei* during frozen storage.

Parameters	Samples	0th day	30th day	60th day	90th day	120th day
Appearance	BWRV	7.60 ± 0.54^{aA}	7.10 ± 0.54^{abA}	7.09 ± 0.54^{abA}	6.60 ± 0.54^{bA}	6.59 ± 0.54^{bA}
	ISRV	8.10 ± 0.22^{aA}	7.60 ± 0.22^{bA}	7.50 ± 0.00^{cA}	7.00 ± 0.00^{dA}	6.60 ± 0.54^{eA}
Color	BWRV	7.90 ± 0.54^{aA}	7.40 ± 0.54^{abA}	7.10 ± 0.54^{bcA}	6.80 ± 0.44^{bcA}	6.60 ± 0.54^{cA}
	ISRV	8.50 ± 0.50^{aA}	8.00 ± 0.50^{abA}	8.50 ± 0.00^{aB}	7.40 ± 0.54^{bcA}	7.00 ± 1.00^{cA}
Odor	BWRV	8.00 ± 0.00^{aA}	7.50 ± 0.00^{bA}	7.50 ± 0.00^{bA}	7.00 ± 0.00^{cA}	6.60 ± 0.54^{dA}
	ISRV	8.00 ± 0.00^{aA}	7.50 ± 0.00^{bA}	7.50 ± 0.00^{bA}	7.00 ± 0.00^{cA}	6.60 ± 0.54^{dA}
Texture	BWRV	7.90 ± 0.54^{aA}	7.40 ± 0.54^{abA}	7.50 ± 0.00^{aA}	6.80 ± 0.44^{bcA}	6.40 ± 0.54^{cA}
	ISRV	7.70 ± 0.44^{aA}	7.20 ± 0.44^{abA}	6.90 ± 0.54^{bA}	6.60 ± 0.54^{bcA}	6.20 ± 0.44^{cA}
Taste	BWRV	8.20 ± 0.83^{aA}	7.70 ± 0.83^{aA}	7.30 ± 1.09^{abA}	7.20 ± 0.83^{abA}	6.20 ± 0.44^{bA}
	ISRV	8.00 ± 0.93^{aA}	7.50 ± 0.93^{abA}	6.50 ± 0.00^{bcA}	6.90 ± 0.89^{bcA}	6.20 ± 0.44^{cA}
Flavor	BWRV	7.90 ± 0.74^{aA}	7.50 ± 0.70^{aA}	7.30 ± 1.09^{aA}	6.90 ± 0.74^{ab}	6.20 ± 0.44^{bA}
	ISRV	7.60 ± 0.65^{aA}	7.10 ± 0.65^{abA}	6.50 ± 0.00^{bcA}	6.50 ± 0.70^{bcA}	6.00 ± 0.00^{cA}
Overall acceptability	BWRV	8.30 ± 0.83^{aA}	7.90 ± 0.89^{aA}	7.30 ± 1.09^{abA}	7.30 ± 0.83^{abA}	6.20 ± 0.44^{bA}
	ISRV	8.20 ± 0.75^{aA}	7.70 ± 0.75^{abA}	6.90 ± 0.54^{bcA}	7.00 ± 0.70^{bcA}	6.20 ± 0.44^{cA}

BWRV – Brackish water reared *vannamei*; ISRV – Inland saline reared *vannamei*.

Data expressed as mean±SD (n = 9); the mean values in the same row with different small letter superscripts are significantly different ($p < .05$).

The mean values in the same column with different capital letter superscripts are significantly different ($p < .05$).

inland saline water and brackish water during frozen storage based on 9-point hedonic scale. It was found that there were no significant differences ($p > .05$) between the sensory attributes of both the samples throughout the storage. Initially, the attributes showed excellent scoring, but as storage progressed, the scores decreased. The objectionable odor may be due to volatile compounds produced during lipid oxidation. Appearance of off-flavor may be attributed to warm-over flavor (WOF), which is usually associated with reheated meats and includes odors and flavors commonly described as stale or rancid (Brewer 2007). Off-colors during storage might have been due to interaction of ketones, aldehydes, alcohols, hydrocarbons, acids, and epoxides with proteins (Thanonkaew et al. 2006). Mahmoudzadeh et al. (2010) reported that the sensory qualities of color, texture, taste, and general acceptability parameters of fish burgers prepared from deep flounder decreased significantly during storage at −18°C for 5 months. The decrease in the values of sensory analyses is faster than chemical changes during frozen storage (Orak and Kayisoglu 2008). However, the sensory scores of BWRV and ISRV patties were within the acceptable limit during storage. The patties prepared from BWRV and ISRV remained in acceptable condition during 4 months of frozen storage. The growth of *L. vannamei* in inland saline water resulted in the variation of flavor and taste imparting free amino acid and ionic composition of the shrimp. However, after value addition of ISRV, no significant difference was observed in flavor scores when compared with BWRV patties. This might be due to the masking effect of added spices in the product. No effect of inland saline water environment was observed in the shelf life and overall quality of shrimp patties prepared from ISRV when compared with shrimp patties prepared from BWRV during frozen storage.

Conclusion

The patties prepared from ISRV have tantamount protein, ash, and carbohydrate compared to patties prepared from BWRV. The biochemical parameters of pH, TVBN, TMA, peroxide value, and TBA value were within the acceptable limits in both ISRV and BWRV samples during storage. After patty preparation, the flavor and sensory scores of ISRV patties were comparable with BWRV samples. From the present study, it is concluded that ISRV can very well be used in making value-added products, as no significant quality changes were observed as compared with BWRV. The shrimp patties prepared from BWRV and ISRV were in acceptable condition based on biochemical, microbial, and sensory analysis during 4 months of frozen storage.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

K.A. Martin Xavier http://orcid.org/0000-0001-5879-4016

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