Fishery Technology 59 (2022) : 106 - 113

Comparative Changes in the Quality of Pickles Prepared from Pacific White Shrimps (*Litopenaeus vannamei)* grown in Inland Saline Water and in Brackish Water during Storage

D. M. Affarin Tinku, Binaya Bhusan Nayak, K. A. Martin Xavier, V. Hari Krishna, Gopal Krishna and Amjad Khansaheb Balange*

Department of Post-Harvest Technology, ICAR-Central Institute of Fisheries Education, Versova, Mumbai - 400 061, India

Abstract

Rearing of Pacific white shrimp (*Litopenaeus vannamei*) in inland saline water, the non- natural environment and compromised or stressed condition, may affect the meat quality and flavour of the shrimp. In this study, an attempt has been made to develop shrimp pickles from inland saline water reared *vannamei* (ISRV) and compare its quality with that from brackish water reared *vannamei* (BWRV) at room temperature for 5 months. The pickles prepared from ISRV had tantamount protein (31.05% w/w), high fat (10.23% w/w) and low ash (6.79% w/w) content as compared with BWRV pickles, which had protein, fat and ash content as 29.55%, 9.32% and 7.74% respectively. No significant difference was observed in the sensory scores of the pickles. Trimethylamine, total volatile base nitrogen and total viable bacterial count were significantly increasing during storage, however, remained within the acceptable limits. The lipid oxidation and hydrolysis parameters like peroxide value and free fatty acid content increased during storage. It could be concluded that overall quality and shelf life of shrimp pickles prepared from ISRV was comparable with BWRV and there was no significant effect observed under storage conditions.

Keywords: Inland saline water, shrimp pickles, quality, proximate composition, storage, shelf life

Received 12 December 2021; Revised 16 February 2022; Accepted 05 April 2022

E-mail: amjadbalange@cife.edu.in

Introduction

Litopenaeus vannamei is the main farmed species of high market value with a global production of 49,66,200 tonnes (FAO, 2020). Shrimp inland farming in low salinity waters is now widely practised in various parts of the world (Allan et al., 2009). The Pacific white shrimp (*Litopenaeus vannamei*) has become the candidate of choice for culture in low salinity waters because of its ability to grow and survive in low salinity conditions (Roy Luke et al., 2010). Shellfish flavour comes from a combination of nitrogenous and non-nitrogenous compounds. Free amino acids, nucleotides, low molecular weight peptides and quaternary ammonium bases are examples of nitrogenous compounds. Organic acids, sugars and inorganic components such as Na^+, K^+, Cl^-, and PO_4^{3-} are examples of non-nitrogenous compounds. As free amino acids are important osmoeffectors in shrimp, they influence the strength of the flavour (Hayashi et al., 1981). Since the ions in inland saline waters differ from those in marine waters, shrimps live in a compromised environment that is distinct from their normal habitat. This has an impact on growth performance of shrimp and quality (Roy Luke et al., 2010). Javith et al. (2020) compared the meat quality and compositions of *Litopenaeus vannamei* reared in inland saline water and brackish water and found that the amino acids arginine and glutamic acid, which are responsible for the seafood-like flavour and sweet taste of crustaceans, were higher in the brackish water sample (1.66 and 3.42 g 100 g^{-1}) than in the inland saline water sample (0.98 and 2.66 g 100 g^{-1}). Consumers prefer shrimp cultured in sea water to those cultured in low salinity water, according to

studies, because of the greater quality and flavour (Liang et al., 2008).

However, value addition can improve the quality and flavour of inland saline farmed shrimp. Value addition is the upgradition of a product or service by a company before it is delivered to customers (MPEDA, 2018). Development of seafood production sector is being driven by rising interest in ready-to-eat goods, and there is room to improve the flavour and acceptance of seafood. Pickles, which are eaten as savoury foods as well as main course accompaniments have several health benefits in addition to being a flavour enhancer in everyday dishes, which is driving global market growth. Pickles are proven antioxidants that protect human body from free radical damage. They also aid digestion because they contain probiotic qualities. They're also high in natural nutrients like iron, vitamin C, calcium, potassium, and other minerals (Mutawa, 2018).

Shrimp culture in environments (inland saline waters) outside than their normal environment, causes biological stress, resulting in variations in shrimp quality and flavour. To boost the flavour intensity and disguise the quality and flavour discrepancies, value added products such as pickles from inland saline shrimp can be made. However, no research has been done on evaluating the quality and shelf life of value-added products made from *Litopenaeus vannamei* reared in inland saline water.

Materials and Methods

Brackish water reared *L. vannamei* (BWRV) grown at 3 ppt were freshly harvested from a farm in Roha district of Maharashtra, India. Harvested shrimps were immediately iced in plastic polystyrene insulated container with shrimp to ice ratio of 1:1 (w/w) and brought to the laboratory within 4 h. Inland saline water reared *L. vannamei* (ISRV) grown at 7-13 ppt were collected from Rohtak district of Haryana (India) and transported by air to laboratory within 5 h.

Upon arrival at the laboratory, the shrimps were peeled and deveined. The peeled shrimps were mixed with salt (3% of weight) and dried for 1-2 h. Then the shrimps were fried in refined sunflower oil (Fortune, Mumbai, India) and kept apart. The shrimp pickle was prepared with the ingredients that include peeled shrimp (1 kg), green chilly (50 g), ginger (150 g), garlic (200 g), oil (200 ml), vinegar (300 ml), salt (60 g) and sugar (5 g). Garlic, ginger and green chilly were fried in a pan, to which chilli powder and turmeric powder was added. Then it was removed from flame and fried shrimps were added to it. It was mixed thoroughly and allowed to cool. Then vinegar, sugar and remaining salt were added. Before preparation of shrimp pickle, standardisation of pickle was done with CIFT and CIFE recipes. The pickles were packed into stand-up laminated pouches of 200 g each in such a way that the top of contents is covered with oil and sealed. Then they were stored at room temperature (30-33C). Storage study was carried out up to 5 months with the sampling interval of one month. The samples were subjected to biochemical, microbial and sensory evaluation.

The moisture, protein, fat and ash content of shrimp pickles were determined according to the AOAC methods (AOAC, 2019). 10 g of composite 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 by a digital pH meter (Eutech tutor pH/ºC meter, Eutech Instruments, Singapore) standardized earlier by buffers at pH 4.8 and 9.2. The titrable acidity and salt content of the pickles were determined based on the procedure given by Chouksey & Basu (2004). The changes in biochemical parameters such as pH, TVB-N, TMA, PV and FFA of pickles prepared from *L. vannamei* reared in brackish water were determined. The total volatile base nitrogen (TVB-N) and trimethylamine (TMA) was determined based on an adaptation of the current official European steam-distillation method (EU-EC, 2008). The peroxide value and free fatty acid (FFA) was determined according to AOAC (2019) method. All chemicals used were of analytical grade and obtained from Sigma Aldrich (Sigma Aldrich Chemicals Pvt. Ltd., Powai, Mumbai), Merck (Merck Ltd., Mumbai), Hi-Media (Hi Media Laboratories Pvt. Ltd.) and Qualigens (Qualigens Pharma Pvt. Ltd., Umbare, Maharashtra).

The total viable bacterial count of the sample was determined by spread plate technique (BAM, 2004). The sensory evaluation for overall acceptability of the product was done by trained panel members (n=10) using 9 point hedonic scales with 1 being the lowest and 9 being the highest score. The point 5 was taken as the border of acceptability. The attributes were colour, flavour, texture, juiciness, saltiness, sourness and overall acceptability (Renitta

& Patterson, 2013). Initial sensory analysis was done after a maturation period of 15 days and afterwards it was carried out in 30 days interval.

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 were determined by Duncan s Multiple Range Test (DMRT). The level of significance was set up at $p \leq 0.05$. The results were expressed as a Mean ± standard deviation for triplicates.

Results and Discussion

From the results of the proximate composition of shrimp pickle prepared from *L. vannamei* reared in inland saline water and brackish water, no significant difference ($p>0.05$) was observed in the moisture content of BWRV sample (47.10%) and ISRV sample (49.33%). No significant difference ($p>0.05$) was observed in the protein content of both the samples. The slightly higher fat content was observed in ISRV sample (10.23%) than the BWRV sample (9.32%). The ash content of BWRV sample (7.74%) was significantly higher ($p<0.05$) than the ISRV sample (6.79%). The differences in moisture content results in relative differences in the other proximate components such as protein or fat or ash. This attributes to the higher fat and lower ash content of ISRV sample and the lower fat and higher ash content of BWRV sample. Shiriskar et al. (2010) reported the proximate composition of fish pickle immediately after preparation as 58.59%, 19.30%, 1.25% and 15.25% of moisture, protein, fat and ash, respectively. This finding varies from the present study as the standardized recipe influences the proximate composition of pickle products.

The sensory evaluation was carried out after a maturation period of 15 days from the day of preparation. From the results, it was found that the colour score of ISRV sample (8.10) was significantly higher ($p<0.05$) than the BWRV sample (7.40). No significant difference ($p>0.05$) was observed in other sensory attributes. The preferability of pickle was due to the maturation that resulted in the improvement of flavour and texture. The recipe used for pickle preparation has resulted in similar acceptance of both BWRV and ISRV samples. However, after value addition of ISRV by pickling, no difference was observed in the flavour scores when compared with BWRV sample.

Table 1 represents the changes in proximate composition of shrimp pickle prepared from *L. vannamei* reared in inland saline water and brackish water during storage. The moisture content of BWRV samples decreased till 90th day (44.76%) from initial value of 47.10% and increased thereafter to 48.68% at the end of storage. Similar decrease in moisture content was reported by Chandrashekar et al. (1978) in fish pickle from 57% to 51.66% during the storage study of 180 days. The moisture content of ISRV samples showed 0.8% increase from 49.33%

Table 1. Changes in the proximate composition (wet weight) of pickle prepared from differently reared *L. vannamei* during storage

Particulars	Samples	0th day	30th day	60th day	90th day	120th day	150th day
Moisture (%)	BWRV	47.10 ± 1.16^{abA}	45.83 ± 3.46^{abA}	46.51 ± 0.60^{abA}	44.76 ± 0.92^{aA}	47.75 ± 1.06^{abA}	48.68 ± 1.74^{bA}
	ISRV	49.33 ± 1.31^{aA}	49.62 ± 1.37^{aA}	48.51 ± 0.30^{aB}	48.44 ± 1.38^{aB}	49.62 ± 0.55^{aA}	50.10 ± 1.35^{aA}
Protein (%)	BWRV	29.55 ± 2.80^{aA}	34.99 ± 1.81^{bcA}	34.26 ± 4.52^{bcA}	37.76 ± 0.22^{cA}	31.75 ± 0.11^{abA}	32.89 ± 0.36^{abA}
	ISRV	31.05 ± 0.32^{aA}	37.19 ± 1.17^{cA}	37.88 ± 3.09^{cA}	39.10 ± 0.41^{cB}	37.56 ± 0.04^{cB}	34.37 ± 0.71^{bB}
Fat (%)	BWRV	9.32 ± 0.07^{abA}	7.41 ± 0.10^{aA}	8.97 ± 0.00^{abA}	10.32 ± 0.02^{bA}	8.49 ± 1.73^{abA}	8.43 ± 1.78^{abA}
	ISRV	10.23 ± 0.02^{aB}	6.45 ± 0.00^{bB}	6.66 ± 0.10^{bB}	9.90 ± 0.95^{aB}	5.62 ± 0.09^{cA}	5.89 ± 0.48^{cA}
Ash (%)	BWRV	7.74 ± 0.04^{aA}	7.30 ± 0.06^{abA}	6.98 ± 0.58^{bA}	7.56 ± 0.53^{aA}	7.24 ± 0.34^{aA}	7.14 ± 0.03^{aA}
	ISRV	6.79 ± 0.30^{aB}	7.14 ± 0.10^{aB}	7.37 ± 0.15^{aB}	6.50 ± 1.57^{aB}	6.94 ± 0.03^{aA}	6.94 ± 0.56^{aA}

BWRV- Brackish water reared *vannamei,* ISRV- Inland saline reared *vannamei*

Data expressed as mean±SD (n=3), the mean value in the same row with different small letters superscripts are significantly different ($p<0.05$)

The mean value in the same column with different capital letters superscripts are significantly different ($p<0.05$)

to 50.10% at the end of storage. The increase in moisture content can be possibly due to the liquefaction of protein during storage. The shrimp protein acted upon by proteolytic enzymes on storage results in liquefaction and therefore slight increase in moisture content of pickle might happen during storage (Shiriskar et al., 2010). The changes in moisture content results in relative changes in the other proximate components such as protein or fat or ash. Similar relative changes in proximate composition were reported in anchovy pickle during a storage period of 15 weeks in which moisture content slightly increased from 58.59–60.01% while protein content of anchovy pickle showed a decrease from 19.3 to 15.02% and the fat content from 1.25 to 0.8% (Shiriskar et al., 2010).

The changes in biochemical parameters of shrimp pickle are given in Table 2. The pH value has shown an increase in both BWRV sample (4.66) and ISRV sample (4.73) on the 30th day of storage from 4.28 and 4.42 and decreased thereafter to 4.23 and 4.32. The decrease in pH during storage can be due to the uptake of acid by the meat during storage through capillary forces caused by a pressure gradient created by internal meat deformation (Tanuja & Hameed, 1998; Wani & Majeed, 2014). Similar decrease in pH was reported in prawn pickle from 4.64 to 4.51 after 210 days and in squilla pickle from 4.46 to 3.72 during storage of 6 months (Kumar & Basu, 2001; Tanuja & Hameed, 1998). A pH of 4.5 is regarded as safe for pickled products (Doores, 1983). In the present study, the pH values of BWRV and ISRV samples were within the acceptable limit till the end of storage.

The TVB-N value of both BWRV sample and ISRV samples significantly increased ($p<0.05$) from 8.40 and 8.81 mgN 100 g^{-1} to 32.95 and 31.56 mgN 100 g^{-1} at the end of storage. The increase in TVB-N is due to the production of volatile bases such as TMA and ammonia by the spoilage bacteria (Joseph et al., 1998). Similar increase in the TVBN content of anchovy pickle from 5.60 to 40.73 mg% at the end of storage period of 4 months was reported by Shiriskar et al. (2010). Kumar & Basu (2001) reported the increase in TVBN value of prawn pickle from 9.15 to 23.75 mg% after 7 months of storage. Renitta & Patterson (2013) also found an increase in TVBN content of gastropod pickle from 5.2 to 24.62 mg 100 g^{-1} at the end of 8 months. The limit of acceptance for TVB-N is 40 mg% (Connell &

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

Particulars	Samples	0th day	30th day	60th day	90th day	120th day	150th day
pH	BWRV	4.28±0.01^{bA}	4.66±0.02^{aA}	4.31±0.04^{bA}	4.25±0.01^{cA}	4.30±0.01^{bA}	4.23±0.00^{cA}
	ISRV	4.42±0.09^{bcB}	4.73±0.05^{aB}	4.48±0.01^{bB}	4.38±0.01^{cdB}	4.41±0.00^{bcB}	4.32±0.01^{dB}
PV	BWRV	0.12±0.00^{aA}	1.07±0.00^{cA}	0.94±0.45^{bA}	0.91±0.17^{bA}	1.41±0.05^{dA}	2.35±0.48^{eA}
(meq O_2 kg^{-1})	ISRV	0.01±0.00^{aB}	0.37±0.04^{bB}	0.33±0.03^{bB}	1.82±0.14^{cB}	2.53±0.03^{dB}	3.28±0.03^{eB}
FFA	BWRV	0.66±0.02^{aA}	1.07±0.09^{bA}	2.33±0.02^{fA}	1.59±0.02^{eA}	1.45±0.05^{dA}	1.32±0.09^{cA}
(% oleic acid)	ISRV	0.88±0.03^{aB}	1.05±0.49^{abA}	1.92±0.24^{bcB}	2.09±0.08^{cB}	1.35±1.15^{abcA}	1.56±0.63^{bcB}
TVB-N	BWRV	8.40±0.09^{aA}	11.83±0.12^{bA}	21.60±0.58^{cA}	29.09±0.17^{dA}	31.98±0.08^{eA}	32.95±0.05^{fA}
(mg N 100 g^{-1})	ISRV	8.81±0.01^{aB}	12.13±0.12^{bB}	18.81±0.22^{cB}	26.06±0.17^{dB}	30.15±0.23^{eB}	31.56±0.43^{fB}
TMA	BWRV	1.74±0.04^{aA}	4.15±0.04^{bA}	7.00±0.30^{cA}	12.54±0.48^{dA}	15.88±0.05^{eA}	17.96±0.18^{fA}
(mg N 100 g^{-1})	ISRV	2.42±0.03^{aB}	3.19±0.04^{bB}	5.51±0.45^{cB}	11.37±0.35^{dB}	14.38±0.59^{eB}	17.13±0.30^{fB}
NaCl (%)	BWRV	7.97±0.75^{aA}	5.61±0.52^{b}	5.58±0.48^{bA}	5.48±0.28^{bA}	5.25±0.18^{bA}	5.06±0.40^{bA}
	ISRV	6.61±0.36^{aB}	5.85±0.34^{bA}	5.26±0.35^{bcA}	5.03±0.41^{cA}	4.98±0.26^{cA}	4.94±0.66^{cA}
TA	BWRV	0.36±0.13^{aA}	0.54±0.01^{bA}	0.87±0.11^{cA}	1.16±0.10^{dA}	1.18±0.02^{dA}	2.32±0.08^{eA}
(% acetic acid)	ISRV	0.54±0.10^{aA}	0.81±0.04^{bB}	0.90±0.01^{cA}	0.91±0.00^{cB}	1.04±0.03^{dB}	2.22±0.01^{eB}

BWRV- Brackish water reared *vannamei,* ISRV- Inland saline reared *vannamei*

Data expressed as mean±SD (n=3), the mean value in the same row with different small letters superscripts are significantly different ($p<0.05$)

The mean value in the same column with different capital letters superscripts are significantly different ($p<0.05$)

Shewan, 1980). In the present study, the TVB-N values of BWRV and ISRV samples were within the acceptable limit till the end of storage.

The TMA values of BWRV sample and ISRV samples increased from initial values of 1.74 mgN 100 g^{-1} and 2.42 mgN 100 g^{-1} to 17.96 mgN 100 g^{-1} and 17.13 mgN 100 g^{-1} respectively at the end of 150 days. The increase in TMA during storage is due to the degradation of TMAO by bacterial activity (Shiriskar et al., 2010). Shriskar et al. (2010) reported an increase of TMA from 0 to 15.54 mg% in anchovy pickle at the end of 15 weeks of storage. An increase of TMA-N from 2.38 to 6.78 mg% in fish pickle after 150 days of storage was reported by Chandrashekar et al. (1978). Similar results were also reported by Renitta & Patterson (2013) in the TMA-N content of gastropod meat pickles during the storage period of 180 days. The recommended level of TMA value for human consumption is 10 to 15 mg N 100 g^{-1} (Connell, 1995). In the present study, the TMA values of BWRV and ISRV samples were within the acceptable limit till 120 days.

The initial peroxide values of BWRV sample and ISRV sample was observed as 0.12 meq O_2 kg^{-1} and 0.01 meq O_2 kg^{-1}. The peroxide values of ISRV samples increased significantly ($p<0.05$) upto 3.28 meq O_2 kg^{-1} at the end of storage. The peroxide value of BWRV sample increased on 30th day (1.07 meq O_2 kg^{-1}) and reached 2.35 meq O_2 kg^{-1} at the end of storage. The increase in peroxide value is due to the oxidation of lipids in the products that results in the formation of peroxides (Kreuzer, 1971). Patil

Table 3. Changes in Total viable count of pickle prepared from differently reared *L. vannamei* during storage

Particulars	Samples	0th day	30th day	60th day	90th day	120th day	150th day
TVC (log	BWRV	3.08	2.78	2.70	2.48	2.48	2.08
CFU g^{-1})	ISRV	3.54	3.30	3.10	3.45	2.95	2.72

BWRV- Brackish water reared *vannamei,* ISRV- Inland saline reared *vannamei*

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

Parameters	Samples	Initial	30th day	60th day	90th day	120th day	150th day
Colour	BWRV	7.40 ± 0.54^{bA}	8.60 ± 0.50^{aA}	8.40 ± 0.54^{aA}	6.80 ± 0.44^{bcA}	6.60 ± 0.54^{cA}	6.60 ± 0.54^{cA}
	ISRV	8.10 ± 0.22^{bB}	9.00 ± 0.00^{aA}	9.00 ± 0.00^{aB}	6.80 ± 0.54^{cA}	6.60 ± 0.54^{cA}	6.60 ± 0.44^{cA}
Flavour	BWRV	7.60 ± 1.02^{bA}	8.90 ± 0.22^{aA}	9.00 ± 0.00^{aA}	7.40 ± 0.54^{bA}	7.40 ± 0.54^{bA}	6.20 ± 0.44^{cA}
	ISRV	7.50 ± 0.35^{aA}	8.40 ± 1.34^{aA}	7.80 ± 1.09^{aA}	6.20 ± 0.44^{bB}	6.20 ± 0.44^{bB}	6.00 ± 0.70^{bA}
Texture	BWRV	7.40 ± 1.29^{aA}	8.10 ± 0.22^{aA}	8.20 ± 0.83^{aA}	6.00 ± 0.00^{bA}	6.40 ± 0.89^{bA}	6.00 ± 0.00^{bA}
	ISRV	7.10 ± 1.14^{cdA}	8.60 ± 0.54^{abA}	8.80 ± 0.44^{aA}	7.80 ± 0.44^{bcB}	7.40 ± 0.54^{cdA}	6.60 ± 0.89^{dA}
Juiciness	BWRV	7.70 ± 0.67^{aA}	7.50 ± 0.70^{aA}	7.80 ± 1.09^{aA}	6.00 ± 0.00^{bA}	6.40 ± 0.89^{bA}	6.00 ± 0.00^{bA}
	ISRV	7.40 ± 0.54^{bcA}	8.00 ± 1.22^{bA}	9.00 ± 0.00^{aB}	7.80 ± 0.44^{bB}	7.40 ± 0.54^{bcA}	6.80 ± 0.83^{cA}
Saltiness	BWRV	7.50 ± 0.70^{bA}	8.20 ± 0.44^{aA}	8.40 ± 0.54^{aA}	7.20 ± 0.44^{bA}	6.80 ± 0.44^{bA}	6.80 ± 0.47^{bA}
	ISRV	7.40 ± 0.89^{bcA}	8.20 ± 0.83^{abA}	8.40 ± 0.54^{aA}	7.40 ± 0.89^{bcA}	6.60 ± 0.54^{cdA}	6.40 ± 0.54^{dA}
Sourness	BWRV	7.40 ± 0.54^{bA}	8.20 ± 0.44^{aA}	8.40 ± 0.54^{aA}	7.20 ± 0.44^{bcA}	6.60 ± 0.54^{cA}	6.60 ± 0.77^{cA}
	ISRV	7.30 ± 0.75^{cA}	8.20 ± 0.83^{abA}	8.40 ± 0.54^{aA}	7.40 ± 0.54^{bcA}	6.60 ± 0.54^{cdA}	6.40 ± 0.54^{dA}
Overall	BWRV	7.40 ± 1.02^{bA}	8.76 ± 0.33^{aA}	9.00 ± 0.00^{aA}	7.20 ± 0.44^{bcA}	6.60 ± 0.54^{cdA}	6.40 ± 0.54^{dA}
acceptability	ISRV	7.40 ± 0.82^{bA}	8.58 ± 0.88^{aA}	9.00 ± 0.00^{aA}	7.60 ± 0.54^{bA}	6.80 ± 0.44^{bcA}	6.40 ± 0.54^{cA}

BWRV- Brackish water reared *vannamei,* ISRV- Inland saline reared *vannamei*

Data expressed as mean±SD (n=9), the mean value in the same row with different small letters superscripts are significantly different ($p<0.05$)

The mean value in the same column with different capital letters superscripts are significantly different ($p<0.05$)

et al. (2014) reported an increasing trend of peroxide value throughout the storage study of 150 days from 0.29 to 1.16 meq kg of oil for fish pickle. Kumar & Basu (2001) found an increase in peroxide value from 1.37 to 10.25 meq kg^{-1} of oil in prawn pickle during storage period of 210 days. The recommended level of peroxide value is 10-20 meq kg^{-1} of oil (Connell, 1975). In the present study, the peroxide values of BWRV and ISRV samples were within the acceptable limit till the end of storage.

The FFA content of both BWRV sample and ISRV sample significantly increased ($p<0.05$) to 1.32 and 1.56% oleic acid at the end of storage from initial values of 0.66 and 0.88% oleic acid respectively with maximum values as 2.33% oleic acid (60^{th} day) and 2.09% oleic acid (90^{th} day). The increase in FFA is due to the hydrolysis of lipids that results in the formation of free fatty acid (Kreuzer, 1971). Renitta & Patterson (2013) reported an increase in the FFA values of gastropod pickle from 0.0042 to 0.0114 % of oleic acid at the end of storage period for 180 days. In anchovy pickle, the FFA increased from 2.99 to 9.95% of oleic acid during 15 weeks of storage period (Shriskar et al., 2010). However, in the present study, no rancidity was detected organoleptically and so FFA values may not be used for detection of spoilage of pickles. Chandrashekar et al. (1978) reported an increase in FFA from 0.30 to 5.30% of oleic acid in fish pickle during storage period of 180 days and also reported that no rancidity was detected organoleptically at the end of 180 days.

The salt content of BWRV sample and ISRV sample significantly decreased ($p<0.05$) to 5.06% and 4.94% respectively at the end of storage from initial values of 7.97% and 6.61% respectively. The decrease in the salt content might be due to the dilution of whole pickle caused by water gradually drawn out of the meat through osmosis in the acetic acid solution on storage. NaCl was found to decrease slightly in squilla pickle from 3.03-2.92% during storage of 180 days (Tanuja & Hameed, 1998). Similar decrease in salt content was reported by Shiriskar et al. (2010) in anchovy pickles during storage for 15 weeks with the values ranging between 4.58-5.40%.

The titrable acidity of BWRV sample and ISRV sample increased during storage from 0.36 and 0.54% acetic acid and reached 2.32 and 2.22% acetic acid respectively at the end of 150 days. This could be due to the meat absorbing acid during preservation (Dhanapal et al., 1994). Kumar & Basu (2001) also reported an increase in the titrable acidity from 0.36 to 0.75% of acetic acid in prawn pickle during the storage period of 210 days. Abraham et al., (1996) also observed increase in titrable acidity during 120 days storage of prawn pickle.

Table 3 represents the changes in the total viable count of shrimp pickle prepared from *L.vannamei* reared in inland saline water and brackish water during storage. The initial viable plate count of BWRV sample and ISRV sample was 3.08 log CFU g^{-1} and 3.54 log CFU g^{-1} and it decreased to 2.08 log CFU g^{-1} and 2.72 log CFU g^{-1} at the end of storage. The lower level of bacterial load might be due to the presence of spices and other ingredients and the addition of organic acids (Chellaram, 2015). Renitta & Patterson (2013) reported that the total bacterial counts in gastropod pickles were in the range of 10^2 to 10^4 g^{-1} at 240 days. Similar total counts in the range of 10^3 to 10^4 g^{-1} in clam pickles were reported by Yellappa & Chandrasekhar (1989). According to FSSAI, the microbiological requirements (aerobic plate count) for fish pickle is 103 CFU g^{-1}. In the present study, the total viable count of BWRV and ISRV samples were within the acceptable limit till 120 days.

Table 4 represents the changes in sensory score for all the attributes (colour, flavour, texture, juiciness, saltiness, sourness and overall acceptability) of shrimp pickle prepared from *L. vannamei* reared in inland saline water and brackish water during storage. The sensory evaluation was carried out on every sampling days for both the samples and was found that there were no significant difference ($p>0.05$) between the sensory attributes on the initial day of storage. The sensory scores increased and reached maximum on 60^{th} day and decreased thereafter during the storage. The maximum score on 60th day was due to aging of the pickle combined with proper mixing of the ingredients during storage (Tanuja & Hameed, 1998). The colour was reddish brown during the initial period of study and at the end of 5 months, the colour started fading. Shiriskar et al. (2010) reported initial mean score of 8 while sensory evaluation with 9-point hedonic scale and a marginal change thereafter until 6^{th} week, followed by decrease to mean score 6 at the end of 15 week in anchovy pickles. Similar results were reported by many authors (Renitta & Patterson, 2013; Tanuja & Hameed, 1998; Chandrashekar et al., 1978; Sahu et al., 2012). In the present study, both

the pickles were in acceptable condition during 5 months of storage. The growth of *L. vannamei* in inland saline water has resulted in the variation of flavour and taste imparting free amino acid and ionic composition of the shrimp. Though there was flavour difference in the ISRV, no flavour difference was observed in the ISRV pickle when compared with the BWRV pickle.

The pickles prepared from ISRV have tantamount protein, ash and fat as pickles prepared from BWRV. The biochemical parameters such as pH, TVBN, TMA and peroxide value were within the acceptable limits in both ISRV and BWRV samples during storage. After pickles preparation, the flavour and sensory scores of ISRV pickles 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 in it as compared with BWRV. The shrimp pickles prepared from BWRV and ISRV were in acceptable condition based on biochemical, microbial and sensory analysis during 5 months of storage.

Acknowledgements

The authors are grateful to the Director, ICAR- Central Institute of Fisheries Education for laboratory supports and National Agricultural Higher Education Project (NAHEP), a world bank funded project for financial support.

References

Abraham, T., Rathnakumar, K. and Jeyachandran, P. (1996) Microbiological characteristics of prawn pickle. Fish. Technol. 33: 111-115

Allan, G.L., Fielder, D.S., Fitzsimmons, K.M., Applebaum, S.L. and Raizada, S. (2009) Inland saline aquaculture. In: New Technologies in Aquaculture. pp 1119-1147, Woodhead Publishing, Cambridge, UK

AOAC (2019) Official Methods of Analysis. In: Association of Official Analytical Chemists, 21st edn., Washington DC, USA

BAM (2004) Aerobic plate count. In: Bacteriological Analytical Manual. Food and Drug Administration. pp 134-138, Washington DC, USA

Chandrashekar, T.C., Rudrasetty, T.M., Reddy, L. and Aswathnarayana, C. (1978) Utilization of trash fish for human consumption: Studies on the development of fish pickle from *Nemipterus japonicus*. Fish. Technol. 15: 125-128

Chellaram, C. (2015) Chemical composition, self-life studies and popularization on *Pleuroploca trapezium* meat pickle. J. Chem. Pharm. Res. 7: 25-30

Chouksey, M.K. and Basu, S. (2004) Determination of acetic acid and salt content in pickled fish. In: Practical Manual on Fish Processing and Quality Control. pp 68-70, Central Institute of Fisheries Education, Mumbai, India

Connell, J.J. (1995) Control of Fish Quality. Fishing News Books, Surrey, UK

Connell, J.J. and Shewan, J.M. (1980) Past, present and future of ûsh science. In: Advances in Fish Science and Technology (Connell, J.J.), pp 56–65, Fishing News Books Ltd., England

Connell, J.J. (1975) Control of fish quality (Vol. 17). Fishing News Books, Surrey, UK

Dhanapal, K., Rathnakumar, K. and Jeyachandran, P. (1994) Processing chank meat (*Xancus pyrum*) into pickles. Fish Technol. 31: 188-190

Doores, S. (1983) Organic acids. In: Antimicrobials in Foods (Branen, A.L. and Davidson, P.M.), pp 75–108, Marcel Dekker, NewYork

EU-EC (2008) Amending regulation (EC) No 2074/2005 as regards the total volatile basic nitrogen (TVB-N) limits. In: T.C.O.T.E. (ed) COMMUNITIES 1022/2008, Official Journal of the European Union, pp 18-20, Luxembourg, Europe

FAO (2020) The State of World Fisheries and Aquaculture 2020- Sustainability in action. FAO Technical publication, Rome, Italy

Hayashi, T., Yamaguchi, K. and Konosu, S. (1981) Sensory analysis of taste active components in the extract of boiled snow crab meat. J. Food Sci. 46: 479-483

Javith, M.A., Balange, A.K., Xavier, M., Hassan, M.A., Sanath Kumar, H., Nayak, B.B. and Krishna, G. (2020) Comparative Studies on the Chemical Composition of Inland Saline Reared *Litopenaeus vannamei*. J. Culin. Sci. Technol. 31: 1-4

Joseph, A.C., Gopal, T.K.S. and Nambiar, V.N. (1998) Storage studies of fried fish fillets. In: Advances and Priorities on Fisheries Technology (Balachandran KK, Iyer TSG, Madhavan P, Joseph J, Perigreen PA, Raghunath MR and Varghese MD), pp 257-260, Society of Fisheries Technologists (India), Cochin, India

Kreuzer, R. (1971) Fish Inspection and Quality Control, Fishing News Books Ltd., Farnham, U.K

Kumar, S. and Basu, S. (2001) Preparation of prawn pickle and its storage characteristics. Journal of the Indian Fisheries Association 28: 105-111

Liang, M., Wang, S., Wang, J., Chang, Q., Mai, K. (2008) Comparison of flavour components in shrimp *Litopenaeus vannamei* cultured in sea water and low salinity water. Fish. Sci. 74: 1173-1179

MPEDA (2020) MPEDA Annual Report 2019-2020. The Marine Products Export Development Agency, Ministry of Commerce and Industry, MPEDA House, Kerala, India

Mutawa, H. A. (2018) Overview of the Pickle Industry in India. UK Essays. https://www.ukessays.com/essays/business/an-overview-of-pickle-industry-in-india-business-essay.php. (Accessed 18 January 2022)

Patil, S.S., Pagarkar, A.U., Chaudhary, K.J., Desai, A.S., Shaikh, S.M. (2014) Organoleptic and biochemical quality changes in fish pickle prepared from freshwater catfish pangasius (*Pangasianodon hypothalamus*). Indian Vet. J. 91: 12-14

Renitta, R.E., Patterson, J. (2013) Quality and shelf life assessment of underutilized marine gastropod pickle. J. Food Process. 37: 589-595

Roy Luke, A., Allen Davis, D., Patrick Saoud, I., Chris Boyd, A., Harvey Pine, J., Claude Boyd, E. (2010) Shrimp culture in inland low salinity waters. Rev Aquac. 2: 191-208

Sahu, B.B., Maji, U.J., Samal, R., Sahoo, M., Mohanty, U.L., Sahu, A.K., Kumar, K., Jayasankar, P., Jahan, N., Kumar, R. (2012) Quality and storage stability of low acid Murrel (*Channa striatus*) fish pickle at room temperature. Int. Food Res. J. 19: 1629-1632

Shiriskar, D.A., Khedkar, G.D., Sudhakara, N.S. (2010) Preparation of pickled product from anchovies (*Stolephorus* sp.) and studies on quality changes during storage. J. Food Process. 34: 176-190

Tanuja, R. and Hameed, M.S. (1998) Preparation and storage studies of squilla pickle. School of Industrial Fisheries, Cochin University of Science and Technology Fine Arts Avenue, Cochin, India. 3: 24-28

Wani, S.A. and Majeed, D. (2014) Evaluation of quality attributes and storage stability of pickle prepared from chicken gizzard. Journal Meat Sci. Technol. 2: 85-89

Yellappa, N. and Chandrasekhar, T.C. (1989) Preparation of clam pickle using organic acids In: Recent Trends in Processing Low Cost Fish (Balachandran, K.K., Perigreen, P.A., Madhavan, P. and Surendran, P.K., Eds), p 238, Society of Fisheries Technologists (India), Cochin, India