Production of salted and pressed anchovies (*stolephorus sp.*) and it's quality evaluation during storage

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Abstract Present study deals with the production of low cost salted and dried product from anchovy fish (*Stolephorus spp.*) using traditional technology application of different inhibitory factors to achieve a reasonable shelf life at ambient tropical temperature. Microbial safety, nutrient retention and product quality in terms of flavor and texture after rehydration have been tested. This product has been subjected to storage studies, with respect to product quality and microbial status. It can be kept well for a period of 5 weeks. The quality changes during storage are; decrease in sensory scores for the overall acceptance and also for the individual attributes. Increase in nitrogenous components such as Total Volatile Bases Nitrogen (TVB-N), Tri Methyl Amine Nitrogen (TMA-N) and Alpha Amino Nitrogen (AAN) was obtained with the advancement of the storage period. The lipid quality of the fish showed gradual increase in Peroxide Value (PV) and Free Fatty Acid (FFA) accompanied by decrease in flavor and odor scores.

Activity of microorganisms showed a marginal increase with increase in storage period.

Keywords Anchovy · Salted · Shelf life · Quality · Storage

Introduction

Anchovies (*Stolephorus spp.*) are small salt water fish having silvery with blue-green backs. They usually never grow larger than 20 cm. Anchovies prefer the warmer waters around the world, where they swim in massive schools. They are related to the herring belonging to the family Clupeidae. Anchovy production can vary widely from year to year. The fish can appear in large schools for decades and disappear the next year, and then reappear the year after that, Donald and Beamish (2009).

Anchovies are rich in omega-3 oils, calcium and iron. They can be cooked fresh but are not always easy to get hold of and are usually sold packed in salt, tinned in oil, as a paste in jars or tubes, or as a sauce. They are also popularly used as a stuffing for olives. The three important pelagic species of India are the mackerels, sardines and anchovies. Anchovies (*Stolephorus sp.*) form an important component of purse-seine fishery of Indian coast. Very small quantity is going to fish market in fresh form. The limiting factor in the effective utilization of anchovies are their small size, seasonal nature of the fishery forming gluts, sensitive to physical, time and temperature abuses, with the result that the entire quantity is either dried by spreading on beaches or salted and dried on mats and racks. This dried fish catch is mostly get utilized in the fish meal for cattle and fish feed, which fetches negligible cost. The traditional methods of salting and drying play an important role in minimizing fresh fish losses. These methods rely on

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single preservation principle such as achieving low water activity (a_w). Ideally, synergistic combinations might be useful which possess as a 'hurdle' to growth for particular type of microorganism. It is possible to inhibit spoilage with fewer and much lower hurdles than used in traditional techniques. The traditional seafood preservation methods are effective in controlling microbial activity from the point of safety, but have adverse organoleptic and textural properties. The current demand for 'natural' foods necessitates new approaches to seafood preservation. Traditional methods have evolved empirically from chance discoveries and were established by early civilizations. In India, the processing techniques have not changed much, in spite of enormous research towards improving its quality. The greatest advantages of traditional fish processing methods in India are that, they suit the food habits of the local population and are convenient to produce both in small and large scale, low cost in nature, easy to store and use. The objective of this study is to produce low cost anchovy product based on traditional technologies, which can be stored at ambient temperature. In the present investigation, an attempt has been made to produce salted and pressed product from anchovies. They are found to be nutritious and convenient to use. The methods of preparation, quality criteria and storage changes have been studied.

Materials and methods

Sample collection

Anchovies (*Stolephorus commersoni*, *Stolephorus indicus*) caught along the Mangalore coast (India) by purse-seines were used for the study. The freshly caught fish was iced at landing in the ratio of 1:1 and was immediately transported to the processing laboratory. The physical characteristics of fresh anchovies were determined by measuring total length, standard length and weight of whole fish. To get reliable representation of catch three batches of 50 fishes were selected at random in triplicate. The girth was measured using a Vernier Calliper. Total time elapsed after catch was about 5–6 h for further processing.

Biochemical analysis

The moisture, protein and total ash content was estimated by AOAC method (1990). The total lipid was estimated by the method of Bligh and Dyer (1959). The sodium chloride was estimated by Volhards method as described in FAO (1981). The Total Volatile Bases Nitrogen (TVB-N), Trimethylamine nitrogen (TMA-N) was determined by the method of Beatty and Gibbons (1937). The alpha amine nitrogen (AAN) content was estimated by the method of Pope and Stevan (1939). The free fatty acid and peroxide

value of the extracted lipid was determined by the method of Olley and Lovern (1960) and Jacobs (1958) respectively.

Microbial and sensory analysis

The microbiological analysis for Standard Plate Count (SPC) and halophiles was done using standard methods (APHA 1976). The sensory evaluation of fresh fish was conducted using the Torry's Sensory Scale (Shewan et al. 1953). Five trained panel members were evaluated the raw fish and final product. The acceptability of the products was assessed using ten point hedonic rating through panel testing. Sensory and microbial analysis was carried out at an interval of 1 week for five times to evaluate the quality changes. The results of sensory analysis were statistically compared with biochemical characteristics using correlation coefficient (Snedecor and Cochran 1962).

Drying

The whole fishes were washed, weighed and subjected to two different methods of salting. Dry salting was done for 24 h, using salt fish ratio 1:4. Brining was carried out by immersing the fish in saturated salt solution. The salted and pressed anchovies were prepared according to the procedure described by Parry (1986). The whole fish was salted overnight using crystal salt, in 1:4 salt-fish ratio. After the salting period, the fishes were drained and packed in wooden press box. The wooden box was constructed using lightwood, measuring 30×20×21 cm from inside. The boxes are detachable, with wooden cover and provision for brine to drain off and also for placing weight over the lid. A weight of 10 kg was placed above it and was rested for about 36 h. The pressed fish was shaped into cakes using a plastic box, weighing 200 g each. And then they were packed in polythene bags and stored at ambient temperature (30–35°C) for 5 weeks.

Statistical analysis

All the results presented are the means of 3 batches of experiments in which triplicate samples were taken for each parameter from each batch. Data obtained were subjected to 1 way analysis of variance and the levels were differentiated using Duncan's multiple range test (Steel and Torrie 1980). Significance was ascertained at $p < 0.01$, the correlation coefficient analysis was performed for the various methods used.

Results and discussion

The anchovies are small sized pelagic fishes measuring usually less than 10 cm. The size of fish used for present

Table 1 Quality characteristics of fresh anchovies

Characteristics	Batch		
	I	II	III
Physical characteristics			
Total length (cm)	7.9±0.17 ^{x,a}	8.5±0.60 ^{x,a}	7.6±0.58 ^{x,a}
Standard length (cm)	6.6±0.14 ^{x,a}	7.8±0.82 ^{x,a}	6.5±0.65 ^{x,a}
Total weight (g)	3.4±0.24 ^{x,a}	4.6±0.71 ^{x,a}	3.4±0.91 ^{x,a}
Girth of fish (cm)	0.61±0.05 ^{x,a}	0.65±0.06 ^{x,a}	0.59±0.08 ^{x,a}
Proximate characteristics			
Moisture (%)	75.5±0.02 ^{x,a}	74.7±0.14 ^{x,a}	74.0±0.02 ^{x,a}
Crude Protein (%)	15.2±0.00 ^{x,a}	20.6±0.50 ^{x,a}	18.5±0.03 ^{x,a}
Total lipid (%)	3.6±0.00 ^{x,a}	2.0±0.02 ^{x,a}	3.4±0.08 ^{x,a}
Ash (%)	2.4±0.53 ^{x,a}	1.5±0.03 ^{x,a}	2.0±0.06 ^{x,a}
Salt (%)	0.58±0.02 ^{x,a}	0.55±0.07 ^{x,a}	0.55±0.05 ^{x,a}
Biochemical characteristics			
TVB-N (mg %)	33.6±0.03 ^{x,a}	34.6±4.45 ^{x,a}	32.2±1.97 ^{x,a}
TMA-N (mg %)	14.0±0.00 ^{x,a}	Nil	Nil
AAN (mg %)	120.0±0.04 ^{x,a}	196.0±0.03 ^{x,a}	186.6±0.00 ^{x,a}
PV (milliequi. of O ₂ /kg of fat)	2.2±1.56 ^{x,a}	2.4±0.20 ^{x,a}	4.2±0.07 ^{x,a}
FFA (% of Oleic acid)	0.48±0.08 ^{x,a}	1.0±0.14 ^{x,a}	0.64±0.01 ^{x,a}
Microbiological characteristics			
Total plate count (log cfu/g)	3.1×10 ³ ^{x,a}	9.3×10 ² ^{x,a}	30.3×10 ² ^{x,a}
Halophilic count (log cfu/g)	Nil	Nil	Nil
Sensory characteristics			
Mean scores	7.5 ^{x,a}	8.3 ^{x,a}	8.6 ^{x,a}

The means having different superscripts (a,b,c) in a row are significantly different ($p<0.01$).

OAS overall acceptability score, TVB-N total volatile bases nitrogen, TMA-N triethylamine nitrogen, AAN alpha amino nitrogen, PV peroxide value, FFA free fatty acid.

investigation in terms of length, weight and girth are shown in Table 1. The total length ranged between 7.6 and 8.5 cm, the girth varied between 0.59 and 0.65 cm. The biochemical characteristics of fresh fish are TVB-N ranged between 32.2 and 34.6 mg %, AAN 120 to 196 mg %, PV between 2.2 and 4.3 milliequivalent of O₂/ kg of fat, free fatty acid (FFA) between 0.5 and 1% of oleic acid, between the three batches of fish. The Total Plate Count ranged between 3.3×10^2 – 3.1×10^3 log cfu/g without any halophilic microorganisms in all the 3 batches. With regard to the organoleptic quality, the overall acceptability of fish as represented on a 10 point hedonic scale (Peryam, and Pilgrim (1957) showed a value of 7.5, 8.3 and 8.6 for each of the 3 batches respectively.

The proximate composition of the whole fish (Table 1) shows that the moisture content varied narrowly ($p<0.01$) between 74 and 75.6%. But the protein content showed wide variation ($r>0.97$) ranging between 15.3 and 20.7%. The total lipid content ranged between 2 and 3.6% and the ash content between 1.6 and 2.5%. The salt content of the fish was uniform in the three batches (0.55–0.58%).

Product standardization, quality of processed product and changes during storage The proximate composition of the processed product was analyzed immediately after preparation and on the last sampling day of the storage study. The

pretreatment of fish with salt was done by dry salting. The best process and the best product as indicated by experienced panelists were prepared and the quality changes were assessed during the storage. The proximate composition of salted and pressed anchovy shows that during storage, there was increase ($r<0.01$) in the moisture content from 41.6% to 48.6% while there was decrease in the protein and fat contents with negative linear correlation ($r>0.98$) from an initial value of 22.5% and 3.6–20.5% and 2.3% respectively and ash content is relatively stable. Similar results were obtained by Shiriskar et al. 2010a, 2010b in pickled products of anchovies. The changes in the nitrogenous constituents, lipid quality and microbiological characteristics are given in the Table 2. The TVB-N, TMA-N and AAN values increased with negative correlation ($r>0.93$, $r>0.80$, $r>0.86$, $r>0.92$ and $r>0.92$ respectively) from an initial value of 3.8 mg %, 0.0 mg % and 27.6 mg % to 27.1 mg %, 15.3 mg % and 243.6 mg % respectively. The salt content increased from 4.8% to 5.8% during the storage period. In respect of lipid characteristics, PV and FFA showed an increase from initial values of 3.2 milliequivalent of O₂ / kg of fat and 1.3% of oleic acid to 24.5 milliequivalent of O₂/ kg of fat and 2.5% of oleic acid respectively at the end of the storage period. The total plate count showed a steady increase ($p<0.01$) from 2.0×10^2 log cfu/g to 4.0×10^2 log cfu/g. The halophilic count was nil for

Table 2 Changes in the quality characteristics of salted and processed products during storage period

Attributes	Storage period in weeks					
	0	1	2	3	4	5
Appearance	7.7±0.01 ^{x,a}	7.5±0.03 ^{x,b}	7.40±0.05 ^{x,c}	7.3±0.05 ^a	7.0±0.11 ^a	7.0±0.01 ^a
Color	7.4±0.09 ^{x,a}	7.5±0.08 ^{x,b}	7.3±0.06 ^{x,c}	7.3±0.05 ^a	6.8±0.07 ^{ab}	6.0±0.02 ^{ab}
Odor	7.1±0.03 ^{x,a}	7.4±0.03 ^{x,b}	7.2±0.02 ^{x,c}	7.0±0.01 ^a	6.5±0.08 ^{ab}	6.0±0.09 ^{ab}
Taste	6.5±0.01 ^{x,a}	7.2±0.7 ^{x,b}	7.0±0.06 ^{x,c}	7.0±0.04 ^a	6.0±0.10 ^b	6.0±0.11 ^a
Texture	7.0±0.11 ^{x,a}	7.1±0.03 ^{x,b}	7.0±0.09 ^{x,c}	7.0±0.03 ^a	6.5±0.04 ^{ab}	6.0±0.05 ^b
Overall acceptability	7.1±0.03 ^{x,a}	7.3±0.10 ^{x,b}	7.1±0.07 ^{x,c}	7.1±0.01 ^a	6.5±0.01 ^b	6.0±0.04 ^{ab}
TVB-N (mg%)	3.8±0.01 ^{x,a}	6.7±0.01 ^{x,b}	6.3±0.00 ^{x,c}	14.0±3.95 ^{ya,b}	24.0±0.79 ^b	27.1±1.18 ^b
TMA-N (mg%)	Nil	5.6±0.00 ^{x,b}	5.9±0.49 ^{x,c}	6.3±0.01 ^b	7.7±0.98 ^b	15.3±1.13 ^{ab}
AAN (mg%)	27.6±4.41 ^{x,a}	36.3±3.81 ^{x,b}	131.6±11.87 ^{x,c}	148.4±3.95 ^{y,ab}	184.8±23.75 ^{ab}	243.6±11.87 ^b
Salt (%)	4.8±0.00 ^{x,a}	4.8±0.01 ^{x,b}	4.5±0.00 ^{x,c}	5.7±0.00 ^{ab}	5.7±0.01 ^a	5.7(0.01) ^a
PV (milli equiv. of O ₂ /kg of fat)	3.2±0.57 ^{x,a}	5.0±0.51 ^{x,b}	7.8±0.16 ^{x,c}	9.1±0.20 ^{ab}	11.9±1.21 ^{ab}	24.5±1.82 ^{ab}
FFA(% of oleic acid)	1.3±0.02 ^{x,a}	1.5±0.17 ^{x,b}	1.7±0.00 ^{x,c}	1.6±0.01 ^a	1.9±0.03 ^a	2.5±0.02 ^{ab}
TPC (log c.f.u./g)	2.0×10 ² ±2.30 ^{x,a}	7×10 ² ±2.8 ^{x,b}	6.5×10 ² ±2.81 ^{x,c}	1.1×10 ³ ±3.0 ^{y,ab}	5.3×10 ³ ±3.75 ^{ab}	6.4×10 ³ ±3.8 ^b
Halophilies (log c.f.u./g)	Nil	Nil	Nil	Nil	1.05×10 ² ±2.02	4.15×10 ² ±2.6 ^b

The means having different superscripts (a,b,c) in a row are significantly different ($p<0.01$). The means having different superscripts (x,y) in a column differ significantly ($p<0.01$).

OAS overall acceptability score, TVB-N total volatile bases nitrogen, TMA-N triethylamine nitrogen, AAN alpha amino nitrogen, PV-peroxide value, FFA free fatty acid.

the first 3 weeks but latter on increased from 1.0×10^2 log cfu/g to 4.1×10^2 log cfu/g in the 4th and 5th week.

The sensory changes during storage of salted and pressed anchovy (Table 2) show that upto 3rd week (7.17–7.12) of storage the changes were marginal and later they were drastic shows negatively correlated ($r>0.94$). The changes in the nitrogenous constituents, lipid quality, microbiological characteristics and pH are given in Table 2.

Statistical analysis The results of the analysis for sensory and biochemical characteristics of the processed product was compared to find out the changes during the storage period and also the extent of correlation between the overall acceptance and the changes in nitrogenous substances and lipid quality (Table 3). Data obtained were subjected to 1 way analysis of variance and the levels were differentiated using Duncan's multiple range test (Steel and Torrie 1980). Significance was ascertained at $p<0.01$, the correlation coefficient analysis was performed for the various methods used.

Anchovies are generally small fish, reaching a maximum length of 10 cm. The girth of fish is an index of growth and also flesh content. It is useful in assessing the product yield rate. In the present study the mean girth of the fish is almost the same for all the three batches, though the length varied slightly, indicating their sexual and seasonal maturity. All

the three batches were caught during the glut season (November–February). In most of the fish, especially the pelagic species, the sum total of the two principle constituents (Moisture and lipid) usually accounts for about 78–80%. In the present study the lipid content is comparatively less in case of batch II (2.0%). Earlier workers, (Shiriskar et al. 2010a, 2010b) have also reported slight variation in lipid content. The variation in fat content in case of lean fish is usually not very significant (Sen and Revankar 1972). There is considerable difference in the protein content of the raw material in the three batches. In batch I it is the lowest (15.2%) and is highest in batch II (20.7%). The values for batch III was in between those of aforementioned two batches showing a protein content of 18.5%. The ash content in most of the fishes on wet weight basis averaged between 2 and 2.5%. In the present study the ash content varied between 1.5 and 2.4%. The salt content was 0.5% which is typical of marine species.

The quality of the raw material is of prime importance to get high quality finished products. Many workers have stressed that chilling immediately after catch preserves freshness of the fish. But the purse-seine anchovy catches are iced only after landing and they usually spend 3–6 h on board without ice. Organoleptically the fish were rated excellent, though the mean sensory scores of the batches slightly varied between 7.5 and 8.6. This perhaps may be due to variation in time-temperature history of the fish. Studies on freshness of anchovies

Table 3 Correlation coefficient of Anchovy product with respect to the overall sensory and biochemical characteristics

	Salted and pressed anchovies
OAS and TVB-N	-0.9350
OAS and TMA-N	-0.8084
OAS and AAN	-0.8677
OAS and PV	-0.9205
OAS and FFA	-0.9242

OAS overall acceptability score, TVB-N total volatile bases nitrogen, TMA-N triethylamine nitrogen, AAN alpha amino nitrogen, PV peroxide value, FFA free fatty acid.

used for curing purpose are scanty. However, Shiriskar et al. 2010a, 2010b have reported a mean sensory score of 8.0, 8.0 and 7.0 respectively.

The determination of TVB-N is widely used to assess the freshness of the fish and it correlates well with sensory changes during spoilage. It has the advantage of simplicity, cheapness and rapidity, but there is a high degree of variability in iced fish. This may be due to leaching of volatile amines. Connell and Shewan (1980) have fixed 40 mg % as a limit of acceptance. In the present study all the three batches were within this limit. The marine species are known to contain substantial amount of tri methyl amine oxide (TMAO) content and hence the degradation product TMA has been extensively used as specific index of the bacterial spoilage. Except elasmobranchs most species contain generally a low TMA-N content, which increases with time. Connell (1995) has fixed a limit of 15 mg % for fresh fish. In the present study, only the batch- I had a TMA-N content of 14 mg % and was absent in rest of the two batches. The content of free amino acid is used as an index of freshness, which is highly variable and species specific. In the present study the AAN content was highest in batch II (196 mg %) and lowest in batch I (120 mg %).

The lipid quality of anchovies showed a PV between 2.2 and 4.3 milliequivalent of O₂/kg of fat, which is an index of oxidative rancidity. The FFA content was in the range of 0.5–1% of oleic acid. Ackman (1980) and Hardy (1980) are of the view that irrespective of low fat content PV and FFA are good index of lipid quality, which can be compared with flavor and odor of fish. In the present study, the fish did not show any off-odor and off-flavor.

International Commission for Microbiological Standards of Foods (ICMSF 1988) recommends that raw fish products having a total bacterial count in excess of 10⁷ should be considered as unacceptable. In the present study the total plate count of the fresh raw material was under acceptable limits.

The salted fish meant for pressing were arranged in a wooden box with provision for the self-brine to drain off. The press box was closed with a wooden lid and a weight

of about 10 kg was placed over the lid. The pressing was continued for one and a half day. This duration was fixed to allow all the salt liquor to drain off from the fish. The pressed fish were shaped into cakes weighing 200 g each using a plastic mould and then packed in polyethylene bags stored at the same temperature as in case of pickled samples.

The fishes which were boiled in 10% brine for 5 min was drained in a cane basket and spread on perforated mild steel tray and dried in a agro-waste drier for about 4 h. The partially dried fish were sundried for about 7 h. The changes in weight of the fish at various stages of processing showed the yield of 70.5%, which is an intermediate moisture containing sample. The salted and pressed samples were kept for 5 weeks. During this period all the three products were analyzed for proximate composition at the beginning and end of the storage period and for various quality changes at regular time intervals.

The proximate composition of the final product shows an increase in moisture content from 41.6% to 48.6% at the end of 5th week of storage due to hygroscopic nature of the product. Correspondingly the protein content decreased from 22.5 to 20.5%, the fat content decreased from 3.6 to 2.3%, while the ash content remained constant. Information on previous work is not available on this product, as the only commercial anchovy product is the dried anchovy either with or without salt.

The changes in the sensory quality of the product during the storage period are depicted in Table 2. The sensory quality is evaluated on a 10 point hedonic scale for individual attributes and for overall acceptances, which showed that the product was acceptable during the storage period. The changes in sensory quality of salted and pressed anchovies during a period of 5 weeks decreased from good (7–8) to fair (5–6), with respect to both individual attributes and overall acceptance of the product. Information on changes in sensory quality of cured fish sample shows the same trend of reduction in sensory scores (Shiriskar et al. 2010a, 2010b).

According to Pillai and Nair (1957) TVB-N is generally considered to assess the degree of spoilage and it is also used to serve as a useful index for the assessment of proteolytic changes accompanying fish spoilage (Rao et al. 1958). The TVB-N is considered as a better index of quality than TMA-N (Velankar 1952).

In salted and pressed anchovies the TVB-N content increased from 3.8 mg % to 27.1 mg %. A limit of 100–200 mg per 100 g appears to be reasonable for salted products (Connell 1995) and the present study indicates that the product was within this limit. Joseph and Perigreen (1988) in market samples of salted fish have obtained similar increase. Information on TMA-N content of salted dried product is lacking and some authors have

observed loss of TMA-N content. This increase may be due to the increase in the microbial activity. AAN also showed a increase throughout the storage period.

The preservation of traditional cured products is mainly attributed to decrease in water content and increased salt content resulting in reduced water activity. In the present study the salt content of the products was comparatively lower and it was less than 5%. The decrease in the popularity of salt cured products is mainly due to their high salt content, which is chiefly considered as a factor leading to hypertension. This product does not have much salt content and is near to the human threshold values of 3.0% (Amerine et al. 1965). The increase in salt content during storage is marginal.

The changes in lipid quality of stored fishery products are usually assessed by estimating the PV and FFA content, which are the intermediate products during rancidity development. This anchovy product was acceptable with regard to the taste and flavor though the scores are slightly decreased. This is supported by an increase in PV and FFA. The increase in PV was from 3.2 milliequivalent of O₂/kg of fat to 24.5 milliequivalent of O₂/kg of fat and FFA of 1.36% of oleic acid to 2.52% of oleic acid during 5 weeks of storage period. The higher PV and FFA contents may be due to the salt content and exposure of the product to atmosphere throughout the storage period. Similar increase in PV and FFA was found by several research workers (Gupta and Basu 1985; Chattopadhyay et al. 1985, 1986; Shiriskar et al. 2010a, 2010b).

The spoilage in salted and dried fish during storage is mainly due to the activity of microorganisms especially the salt tolerant halophilic bacteria of *Serratia sp.* The microbiological analysis of this anchovy product clearly indicated the activity of the bacteria during the storage period, inspite of their reduced water activity. The salted and pressed anchovies had an initial count of 2×10^2 log cfu/ g, which went upto 6.4×10^3 log cfu/ g during the 5 weeks of storage. This product did not show any halophilic count upto 3rd week of storage, thereafter recorded a halophilic count of 1.0×10^2 log cfu/ g, which marginally increased to 4.1×10^2 log cfu/ g. The increase in total plate count during storage is due to the high water activity. Troller (1973) and Lupin et al. (1981) have established a relation between the water content and microbial activity. Sensory scores obtained for the overall acceptability of the product was compared with the changes in the biochemical quality during the storage period at ambient temperature. The correlation coefficient (Table 3) reveals that the assessment of quality changes by various biochemical methods are dependable and compares reasonably well with the sensory methods in salted and pressed anchovies with changes in TVB-N, PV and FFA.

Conclusion

Anchovies form a good raw material for the production of salted and pressed anchovy. The process involves simple and appropriate technologies, which suits to the developing countries. It was found that the processes used were cost effective and did not require high-energy input. The technology involved is simple and suitable for both large and small-scale production. The greatest advantage of this products are, they can be stored at ambient tropical temperatures and do not involve desalting. As this product is presently unfamiliar to the consumer and hence initial marketing efforts are needed.

References

- Ackman RG (1980) Fish lipids part II. In: Connell JJ (ed) Advances in fish science and technology. Fishing News Books Ltd. Farham, Surrey, pp 86–102
- Amerine MA, Panborn RM, Roessler EB (1965) Principals of sensory evaluation of food. Academic Press, London, New York, pp 338–339
- AOAC (1990) Official methods of analysis, 15th edn. AOAC, Arlington
- APHA (1976) Compendium of methods for the microbiological examination of foods. APHA, New York, 701
- Beatty SA, Gibbons NE (1937) The measurement of spoilage in fish. J Biol Bd Can 3:77–91
- Bligh EG, Dyer WJ (1959) Rapid method of total lipid extraction and purification. Can J Biochem Physiol 37:911–917
- Chattopadhyay AK, Bhattacharya SK, Banopadhyay JK (1985) Development of pickled products from low fresh water fishes. In: Ravindran K (ed) Harvest and Post-harvest technology of Fish. Society of fisheries Technologists, Kochin, pp 611–614
- Chattopadhyay AK, Bandopadhyay JK, Bhattacharya SK (1986) Low cost fresh water fish pickle using cheap citrus fruit (*Citrus reticulata*). Fish Technol 23(2):171–173
- Connell JJ (Ed.) (1995) Control of fish quality. Fishing News Books Ltd., Surrey, U.K., 240
- Connell JJ, Shewan JM (1980) Past present and future of fish science. In: Connell JJ (ed) Advances in Fish Science and Technology. Fishing News Books Ltd., England
- FAO (1981) Prevention of Losses in cured fish. FAO Fisheries Technical Paper, 219: 87
- Gupta SS, Basu S (1985) Pickle from blood clam (*Anadra granosa*) meat. Fish Technol 22(2):1090–1110
- Hardy R (1980) Fish lipids. Part I. In: Connell JJ (ed) Advances in fish science and technology. Fishing News Books Ltd, Farham, pp 103–111
- ICMSF (1988) Microorganisms in foods 4. Applications of the Hazard Analysis Critical Control Point (HCCP) system to ensure microbiological safety and quality. Oxford:Blackwell Scientific Publications (ISBN 0-632-2781-0)
- Jacobs MB (1958) Chemical analysis of foods and food products. Krieger publishing Co. Inc., New York, pp 393–394
- Joseph PKSurendran, Perigreen PA (1988) Studies on iced storage of cultured rohu (*Labeo rohita*). Fish Technol 25(2):105–109
- Lupin HM, Boeri RL, Moschiar SM (1981) Water activity and salt content relationship in moist salted fish products. J Food Technol 16:31–38

- Donald NJ, Beamish RJ (2009) Synchrony of marine fish catches and climate and ocean regime shifts in the North Pacific Ocean. *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science* 1:155–168
- Olley T, Lovern JA (1960) Phospholipid hydrolysis of cod flesh stored at various temperatures. *J Sci Food Agric* 11(1):664–652
- Parry RWH (1986) Brining and pressing of small pelagic fish as an alternate to traditional processing. In *Cured fish production in the tropics*. Reilly, A. and Baritte L.E, (eds) 73–78
- Pillai VK, Nair MR (1957) Determination of total volatile nitrogen in cured fishery products from the west coast of India. *Indian J Fish* 3:43–58
- Pope CG, Stevan MF (1939) Determination of amino nitrogen using a copper method. *Biochem J* 33:1070–1076
- Peryam DR, Pilgrim F (1957) Hedonic scale method of measuring food preferences. *J Food Technol* 1957(Suppl):9–14
- Rao SVS, Valson AP, Nair MR (1958) Studies on the preservation of fish by pickling. *Indian J Fish* 5:326–389
- Sen DP, Revankar P (1972) Seasonal variation in the amount of oil of oil sardine. *J Food Sci Technol* 9:93
- Shewan JM, Macintosh RG, Tucker CG, Ehrenberg ASC (1953) Development of numerical scoring system for the sensory assessment of the spoilage of wet white fish stored in ice. *J Sci Food Agric* 4:283–298
- Shiriskar DA, Khedkar GD, Sudhakara NS (2010a) Preparation of pickled products from anchovies (*Stolephorus* sp.) and studies on quality changes during storage. *J Food Process Pres* 34:176–190. doi:10.1111/j.1745-4549.2008.00332.x
- Shiriskar DA, Khedkar GD, Sudhakara NS (2010b) Preparation of boiled and dried products from anchovies (*Stolephorus* sp.) and studies on quality changes during storage. *J Food Process Pres* 34:73–86. doi:10.1111/j.1745-4549.2008.00280.x
- Snedecor GW, Cochran WG (1962) *Statistical methods*. Oxford and IBH publ. Co., Calcutta, 564
- Steel RGD, Torrie JH (1980) *Principle and procedure of statistics: a biometrical approach*, 2nd edn. Mc Graw-Hill, New York
- Troller JA (1973) The water relations of food-borne bacterial pathogens. A review. *J Milk Food Technol* 36:276
- Velankar NK (1952) Moisture, salt, TMA, volatile nitrogen content of salt cured fish. *J Sci Ind Res* 11A:359–360