FREEZING CHARACTERISTICS OF TROPICAL FISHES
II. TILAPIA (*Tilapia mosambica*)

A. VASANTHA SHENOY AND M. ARUL JAMES
Central Institute of Fisheries Technology, Ernakulam, Cochin-11

Tilapia from fresh water and brackish water sources behaved differently during iced and frozen storage. The former showed an ice storage shelf life of about 13 days while the latter showed signs of spoilage beyond 10 days. In their respective freezing characteristics, the samples from the two sources exhibited far more significant variations. The fresh water type iced for 13 days preserved well for over 24 weeks when frozen and kept at a temperature of −18° C, while the brackish water variety held in ice for 10 days and subsequently frozen gave a shelf life of only 8 weeks under similar conditions.

INTRODUCTION

Although numerous studies have been carried out on the changes in fresh and frozen muscle from a variety of salt water species, only a few investigations have been reported on freezing studies on fresh water fish muscle. Ingalls *et al* (1950) reported that the fat of frozen white fish muscle stored for 4 months became rancid. Greig (1968) indicated a rancid off flavour in fried chub and white bass fillets previously stored for 2 to 3 months at -21°C. More recently Awad *et al* (1969) made detailed investigations to determine the extent of organoleptic and chemical changes in frozen stored muscle of fresh water white fish at-10°C. Baliga *et al* (1969) working on *Wallago attu*, followed changes in certain major protein fractions occurring during ice storage of the fish. The present paper reports the summary of work done on ice storage and frozen storage characteristics of *Tilapia mosambica*, an important species used in fish farming.

MATERIALS AND METHODS

Tilapia from both fresh and brackish water sources were used for the study. The fresh water tilapia (average weight 1.0 kg) were caught from the Malampuzha reservoir (Kerala) and the brackish water tilapia (average weight 0.25 kg) were caught from the fish farm at Narakal (Kerala). The fish were iced immediately after catching and transported in ice to the laboratory within 3 hours. On arrival the fish were eviscerated and beheaded, washed thoroughly with water and stored in crushed ice. The iced fish were taken at regular intervals, scaled, cut into chunks, washed and quick frozen. The frozen samples were stored at −18°C in polythene bags. The biochemical changes taking place in the frozen muscle samples were followed at regular intervals, after thawing for 18 hours at 4° C. Muscle samples for analysis were drawn in equal quantities from

the male and famale fish. A comparative study was also undertaken on the biochemical changes in the male and famale fish during frozen storage. Organoleptic assessment was carried out on the muscle samples after boiling for 15 mts in 3% salt solution.

Moisture (M), total nitrogen (TN), total non- protein nitrogen (TNPN), salt soluble protein nitrogen (SSN), sarcoplasmic protein nitrogen (SN), free fatty acids (FFA) and peroxide value (PV) were determined by the methods described previously (Shenoy and Pillai 1971). Water soluble nitrogen (WSN) was determined by the Kjeldahl method. Total fat was determined by extracting about 5 g of the dried muscle sample with petroleum ether (60- 80° C) for about 10-12 hours. Free amino acids were extracted with ethanol and estimated by standard microbiological assay method. The total bacterial count (SPC) was determined by the pour plate method using tryptone- glucose agar, the counts of iced samples being taken after incubation at room temperature and those of fresh samples after incubation for 48 hours at 37° C.

Results and discussion

The biochemical, organoleptic and bacteriological changes taking place in the fresh water tilapia muscle during storage in ice for 13 days are presented in Table I, while those of brackish water tilapia are presented in Table II. The free amino acid pattern of brackish water tilapia during ice storage is given in Table III. Tables IV and V summarise the biochemical changes in the fresh water and brackish water tilapia, respectively, after frozen storage periods of 4, 8, 16 and 24 weeks at -18°C. The free amino acid pattern of brackish water tilapia during frozen storage is summarised in table VI. Fig I shows the shelf life of the fresh water and brackish water tilapia in relation to prefreezing ice storage period.

Ice storage characteristics:

Analysis of tilapia muscle during ice storage showed a regular decline in the nitrogenous constituents such as TN, TN PN, SSN, SN and WSN with increasing days of ice storage, which may be attributed to leaching by the melting ice. Similar results were obtained by Shenoy and Pillai (1971) in sardine muscle stored in ice and Govindan (1962) in prawns stored in ice. FFA registered a slow increase (1% to 4%) while PV increased regularly. Development of FFA was slightly faster after 6 days of storage when the salt soluble proteins were also found to fall concomitantly. Similar results have been reported by Anderson *et al* (1969) in cod muscle held in ice. A comparison of these changes in tilapia from fresh water and brackish water sources revealed close similarity except that the inextractability of myofibrillar proteins was found to increase more rapidly in the brackish water fish.

Organoleptically the fresh water tilapia was acceptable upto 13 days of storage in ice while the storage life of the brackish water tilapia was limited to only 10 days. Slight rancid odour was detected in the former after 13 days in ice, while it was perceptible in the latter after 6 days. Yellow discolouration was observed in the brackish water fish iced for 10 days whereas the fresh water fish retained its fresh organoleptic qualities even after 13 days of storge in ice. While no appreciable change was observed in the texture of the fresh water fish muscle, marked textural changes were observed in the muscle of brackish water fish after 10 days. No significant difference in the organoleptic qualities of male and female species in brackish water tilapia was observed during ice storage although the meat of the latter was adjudged to be comparatively sweeter. An

TABLE I BIOCHEMICAL CHARACTERISTICS OF FRESH WATER TILAPIA DURING ICE STORAGE

Days in ice.	M: %	TN: %	TN PN: %	SSN: % TN	SN: %TN	PV: m moles/ 100 g fat	FFA: % oleic acid	Bacterial count/g	*Flavour score out of 10
0	76.21	3.07	0.3112	54.70	34.68	2.94	1.312	4.27×10^4	9
3	78.16	2.77	0.2663	63.33	33.57	6.42	1.409	3.0×10^4	8
6	77.09	2.83	0.2773	50.28	31.92	10.98	1.720	1.10×10^3	7
10	78.00	2.67	0.2084	48.31	28.25	12.29	2.821	4.23×10^4	7
13	78.34	2.62	0.2594	44.18	25.71	15.27	3.834	2.60×10^5	5

* Excellent-10; Good-8; Fair-6, Poor-4, Off-2.

TABLE II BIOCHEMICAL CHARACTERISTICS OF BRACKISH WATER TILAPIA DURING ICE STORAGE

Days in ice.	M: %	TN: %	TN PN: %	SSN: % TN	SN: % TN	WSN: %TN	Bacterial count /g	*Flavour score out of 10
0	77.75	2.98	0.3401	56.50	38.37	25.29	1.01×10^3	8
3	78.79	3.14	0.3486	53.22	32.29	23.92	4.05×10^4	7
6	80.06	3.06	0.2436	45.81	35.18	20.80	4.80×10^4	5
10	79.11	2.94	0.2745	58.97	30.57	20.32	2.80×10^5	4
13	80.27	2.85	0.2129	38.13	28.74	17.86	6.1×10^5	3

Excellent — 10; Good — 8; Fair — 6; Poor — 4; Off — 2.

TABLE III FREE AMINO ACIDS PATTERN OF TILAPIA DURING ICE STORAGE

Amino Acids mg % in wet muscle	Male: days of ice storage					Female: days of ice storage				
	0	3	6	10	13	0	3	6	10	13
1) Arginine	30.12	29.69	29.78	30.55	30.12	25.81	22.46	21.89	22.92	21.49
2) Glycine	24.25	21.66	21.25	22.63	22.06	41.30	39.45	28.63	25.46	27.55
3) Valine	18.01	21.23	24.53	18.52	18.25	1.875	1.868	1.88	1.86	1.89
4) Glutamic acid	15.42	13.96	14.84	15.18	15.74	11.42	10.86	11.52	10.99	11.12
5) Proline	12.66	8.01	4.02	5.45	5.55	22.54	21.26	7.57	8.16	7.15
6) Histidine	9.45	10.72	10.14	8.11	5.92	8.74	8.75	8.76	5.81	11.25
7) Leucine	1.26	0.89	0.99	1.25	1.25	1.75	2.75	2.78	2.14	2.69
8) Threonine	1.25	1.19	1.25	1.20	1.09	0.01	0.02	0.001	0.001	0.001
9) Serine	1.22	1.37	1.38	2.09	1.38	0.54	0.51	0.54	0.52	0.55
10) Lysine	0.01	0.01	0.01	0.01	0.01	8.12	7.75	6.13	3.78	2.73
11) Isoleucine	0.01	0.01	0.01	0.04	0.02	0.89	1.47	1.36	1.06	1.39

TABLE IV BIOCHEMICAL CHANGES OF FRESH WATER TILAPIA DURING FROZEN STORAGE

	Weeks of storage	M: %	TN; %	TNPN: %	SSN: %TN	FFA: %	PV: m moles/100 g fat
0 day iced sample	0	76.21	3.07	0.3112	54.70	1.312	3.94
	4	76.89	2.97	0.2576	50.35	2.027	10.64
	8	76.58	2.84	0.2241	45.59	4.074	15.58
	16	77.49	2.64	0.1988	50.07	2.451	23.02
	24	75.80	2.61	0.2045	46.98	3.636	27.33
6 day iced sample	0	78.16	2.83	0.2772	48.31	1.720	10.98
	4	76.56	2.73	0.2512	64.60	2.820	17.23
	8	77.23	2.91	0.2410	42.48	3.758	25.90
	16	75.86	2.84	0.2381	35.42	3.420	28.59
	24	75.23	2.81	0.2381	35.50	4.300	32.24
13 day iced sample	0	78.34	2.62	0.2594	44.18	3.834	15.27
	4	78.37	2.66	0.2661	37.55	3.624	27.42
	8	77.87	2.58	0.2466	38.12	4.384	33.24
	16	75.93	2.61	0.2301	31.17	6.140	38.98
	24	75.04	2.45	0.2201	30.21	6.261	45.98

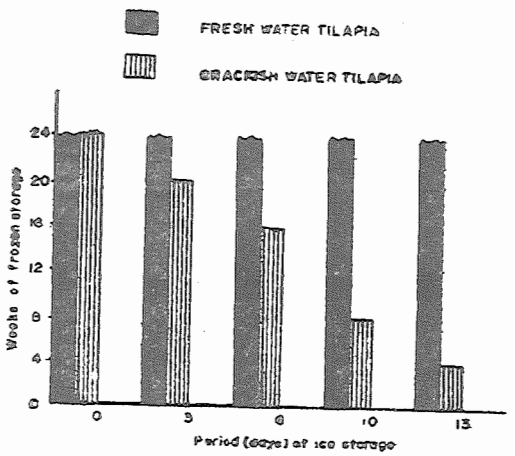

Fig: I Shelf life of fresh water and brackish water tillapia in relation to the p re-freezing ice storage period.

examination of the changes in total free amino acids in both the species has brought out certain interesting observations. A higher amount of glycine (41 mg %) was found in the female species as against 24 mg % in the male species although the total free amino acids in both remained more or less the same. The predominant amino acids in the male species were in the order arginine > glycine > valine > glutamic acid > proline, while in female species order was glycine > arginine > proline > glutamic acid with traces of valine. The quantities of valine, threonine and serine were higher in male species while those of proline, lysine and isoleucine were higher in female species as shown in Table III. The quantity of total free amino acids decreased slightly with duration of ice storage in both. The levels of glycine, lysine, and proline decreased in the female species appreciably during ice storage.

The total bacterial count of the fresh water tilapia showed gradual decrease upto

TABLE V BIOCHEMICAL CHARACTERISTICS OF BRACKISH WATER TILAPIA DURING FROZEN STORAGE

	Weeks of storage	M: %	TN: %	TNPN: %	SSN: %TN	WSN: % TN
0 day iced sample	0	77.75	2.98	0.3401	56.50	25.29
	4	78.47	2.96	0.2858	54.05	20.65
	8	78.34	2.72	0.3404	50.48	23.88
	16	77.72	3.10	0.3334	40.09	20.99
	24	77.04	2.86	0.2969	36.98	23.73
6 day iced sample	0	79.11	3.06	0.2423	45.81	20.80
	4	78.91	3.07	0.2661	32.93	21.53
	8	79.14	2.98	0.2745	42.18	21.04
	16	78.91	2.90	0.2558	35.32	20.99
	24	77.62	2.83	0.2011	30.21	20.61
13 day iced sample	0	80.27	2.85	0.2129	38.13	17.86
	4	80.06	2.93	0.2133	25.18	17.22
	8	79.54	2.81	0.2323	23.34	18.92
	16	79.43	3.04	0.1932	30.13	17.14
	24	78.34	2.71	0.1738	22.86	18.45

6 days and then significant increase on the 13th day in ice which compares well with the organoleptic observation. In the case of brackish water tilapia the total bacterial count showed gradual increase, being more significant from the 10th day onwards which again agrees well with the organoleptic observations.

Frozen storage characteristics:

It has been found that the extractability of proteins of fish muscle decreased during the 24 weeks of frozen storage at -18°C, similar to what has been shown by Awad *et al* (1969) for fresh water white fish muscle during frozen storage. The fall in salt extractable proteins was more pronounced in the brackish water tilapia than in the fresh water fish. In the case of fish held in ice for longer periods prior to freezing the salt soluble proteins decreased at a faster rate during the first few weeks of frozen storage and thereafter the change took place at a slower rate. Anderson *et al* (1969) and Shenoy and Pillai (1971) obtained similar results in cod muscle and sardine muscle respectively, during frozen storage. The amount of sarcoplasmic proteins in tilapia muscle did not change significantly during storage period upto 24 weeks at -18°C, the results being in agreement with those of Dyer *et al* (1965). No significant changes were observed in the biochemical characteristics of the male and female species of tilapia during frozen storage. The free amino acid content decreased appreciably in both male and female species during frozen storage. The major amino acids glycine,

TABLE VI FREE AMINO ACID PATTERN OF TILAPIA DURING FROZEN STORAGE

Male : Amino acids mg % in wet muscle.	No. of weeks of frozen storage 0	4	8	16	24	Female : No. of weeks of frozen storage 0	4	8	16	24
1) Arginine	30.12	15.62	22.51	11.23	10.92	25.81	15.42	19.13	21.05	14.84
2) Glycine	24.25	20.75	16.25	12.25	11.31	41.30	16.62	16.13	13.19	11.84
3) Valine	18.01	6.33	5.12	1.33	0.84	1.88	1.01	Traces	1.15	0.91
4) Glutamic acid	15.42	7.17	5.77	14.17	11.31	11.42	5.20	5.74	11.52	11.84
5) Proline	12.66	10.54	8.24	3.38	2.87	22.54	5.24	8.33	3.71	2.64
6) Histidine	9.45	7.85	2.75	3.45	2.31	8.74	3.11	2.58	3.41	2.21
7) Leucine	1.26	2.33	3.27	4.61	3.83	1.75	3.02	2.77	3.58	2.19
8) Threonine	1.25	1.19	1.15	1.45	1.04	0.01	1.14	1.19	1.19	1.03
9) Serine	1.22	0.55	0.65	1.05	0.93	0.54	0.42	Traces	1,72	0.81
10) Lysine	0.01	6.12	3.58	13.54	15.84	8.12	1.21	1.56	17.42	16.13
11) Isoleucine	0.01	1.72	0.69	1.42	1.39	0.89	1.31	1.94	1.52	1.21
12) Alanine	0.17	2.16	4.98	2.76	2.18	0.24	3.97	4.99	2.26	3.09

valine, proline, arginine and histidine decreased during frozen storage, the rate of decrease being more pronounced in the latter. Lysine, alanine and isoleucine registered an increase after a storage period of 24 weeks.

Study of changes in the lipid fraction of the fish has shown that the lipid slowly underwent hydrolysis, the FFA registering a value of 5% after 24 weeks of frozen storage. No significant difference in the rate of development of FFA, during frozen storage was observed between samples stored in ice, prior to freezing for varying periods. PV rose to 7 for the fresh fish while the increase was from 14 to 46 for the 13 days iced samples after 24 weeks of frozen storage. The rate of development of PV was slightly faster in samples held in ice for longer periods before freezing. Rancid odours were detected in the samples during frozen storage. The longer the fish was held in ice prior to freezing, the earlier the development of rancid flavours. The 6 day iced, 10 day iced and 13 day iced samples showed signs of rancid odours at the end of 24 weeks, 16 weeks and 8 weeks respectively. PV of the fat at this stage was around 30. No noticeable darkening or yellowing of the muscle was however apparent in any of the frozen samples of fresh water tilapia during 24 weeks of frozen storage. Yellow discolouration, however was observed in the brackish water tilapia after 4 weeks for the 13 day iced samples and after 24 weeks for the fresh and 3 days iced samples. The discolouration was more pronounced in the male species than in the female species. Rancid odour was detected in the samples much earlier in the brackish water fish.

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