Proc. Indian Acad. Sci., Vol. 87 B (Animal Sciences-4), No. 12, December 1978, pp. 321–327,

Changes in the proximate chemical composition and nutritive value of the fresh water murrel, *Ophicephlaus punctatus* Bloch during storage

ISHRAQ AHMAD
Section of Ichthyology and Fisheries, Department of Zoology, Aligarh Muslim University, Aligarh 202 001

MS received 22 February 1977; revised 18 May 1978

Abstract. Changes in the proximate chemical composition and calorific value of muscle during storage of *O. punctatus* were investigated. The storage of fish was characterized by a gradual decline in the concentrations of protein and water, and a rise in the fat content. The muscle ash content was not found to follow any specific pattern of variations. The loss in calories, in terms of protein value, was relatively greater in the fishes kept at the higher temperature.

Keywords. proximate chemical composition; nutritive value; *Ophicephalus punctatus*; storage.

1. Introduction

The time lapse between the catch and consumption of fishes has focussed the need for the development of good storage and preservation techniques. Postmortem storage of fishes results in decomposition and loss of nutritive value. Therefore, enormous efforts have been made in the past to control the deterioration of fish postmortem (Birdseye 1929; Huntsman 1931; MacPherson 1932; Bate-Smith 1947). Despite considerable work (Jones 1954: Seagran 1956; Siebert 1958; Fatema *et al* 1961; Fraser *et al* 1961; Tomlinson *et al* 1961; Dyer *et al* 1962; MacCallum 1964; Nazir and Magar 1965; Jadhav and Magar 1970; Shinoy and Pillai 1971; Vasantha *et al* 1972; Venugopal *et al* 1973) information on the biochemical composition and nutritive value of fresh water fishes at different storage temperatures is rather fragmentary (Annamalay 1962; Menon 1962). The present work was undertaken to study the changes in proximate chemical composition and nutritive value that occur in the flesh of *Ophicephalus punctatus* Bloch, an economically important fresh water murrel, during storage at two different temperatures (−4°C and 32°C) up to a total period of 25 h.

2. Materials and methods

Live specimens of *Ophicephalus punctatus* in the size range 17-21 cm were obtained from local ponds in Aligarh and preserved at the aerated laboratory aquaria. During investigation, the fishes were classified into two batches and killed by

decapitation. One batch was stored at —4°C and the other at room temperature (32±2°C). The total period of storage was 25 h. After an interval of every 5 h muscle samples were obtained from the trunk region of the three individuals. Care was taken to remove bony elements from the muscle. It was then macerated in a high speed electric grinder and processed for various estimations. Methods of estimation of protein, fat, water and ash were the same as outlined by Jafri *et al* (1964).

3. Results

3.1. *Protein*

The values of protein in the muscle of *O. punctatus* during the successive periods of storage, from 5 to 25 h at —4 and 32°C, have been statistically evaluated and are presented in table 1. It can be seen that the muscle of the freshly stored fish contained 13·5% protein which declined gradually to 12% after 25 h of storage at 32°C. The quantity of protein in the fishes kept at —4°C, however showed a decline only from 13·5% to 12·90% during the storage period of 25 h (table 1). Thus, the loss in the muscle protein value, though not very marked, was found to increase with the lapse of time and was relatively more in the fishes stored at a higher temperature.

The calorific value of this species related to protein content, during a 25 hr of storage at 32°C, was found to decline from 58·05 to 51·60 calories/100 g of the fresh tissue, incurring a net loss of about 7 calories. At —4°C the decline in the calorific value for the same period of storage, was recorded to be from 58·05 to 55·47 calories/100 g of fresh tissue. The net loss incurred in this condition was only 4 calories.

Table 1. Changes in the muscle protein percentage of *O. punctatus* during storage.

Storage in hours	Mean protein %	Standard error of mean	Coefficient of variation	Variance
		Storage at —4°C		
0	13·500	0·2413	3·0962	0·1747
5	13·250	0·0642	0·8400	0·0123
10	13·200	0·0671	0·8920	0·0138
15	13·400	0·0405	0·5299	0·0050
20	13·000	0·0838	1·1169	0·0210
25	12·900	0·0808	1·0984	0·0200
		Storage at 32°C		
0	13·500	0·2413	3·0962	0·1747
5	13·300	0·0500	0·6511	0·0074
10	13·00	0·2020	2·6923	0·1225
15	12·700	0·0709	0·9669	0·0150
20	12·650	0·0534	0·7177	0·0082
25	12·000	0·1040	1·5016	0·0324

3.2. *Fat*

The value of muscle fat content during different periods of storage at —4°C and 32°C are given in table 2. The muscle of the freshly stored *O. punctatus* was found to contain about 0·6% of fat. A marked rise in the fat content was observed with lapse of time in the two lots of fishes kept at different temperatures. It is interesting to note that this increase in fat content was more rapid in the fishes stored at a higher temperature (32°C) than in those kept at a low temperature (—4°C). It may be mentioned that a peculiar unpleasant smell also developed in the early stages of those fishes stored at 32°C. No such smell is observed during the 25 h storage in the fishes at —4°C.

3.3. *Water*

It is evident from table 3 that the percentage of water in the muscle of *O. punctatus* declined with storage at the two temperatures. In freshly stored fish, the muscle was found to contain 79·92% water. This declined to 76·20% in the specimens stored at 32°C and to 77·62% in those stored at —4°C, during a period of 25 h of storage. The rate of dehydration in the muscle was, however, less rapid in fishes placed at —4°C than in those stored at 32°C.

3.4. *Ash*

The values of ash in the muscle of the fishes stored for various durations at different temperatures are given in table 4. The trend of changes recorded for the ash content was considerably different from that observed for the other constituents. The percentages of ash in fishes both at —4° and 32°C showed an initial rise upto a certain period after which a sharp decline in the ash content was evident.

Table 2. Changes in the muscle fat percentage of *O. punctatus* during storage.

Storage in hours	Mean fat %	Standard error of mean	Coefficient of variation	Variance
		Storage at —4°C		
0	0·640	0·0086	2·3437	0·00225
5	0·638	0·0064	1·7398	0·00012
10	0·640	0·0028	0·7812	0·00002
15	0·700	0·0052	1·3000	0·00008
20	0·773	0·0035	0·7891	0·00003
25	0·794	0·0049	1·0831	0·00007
		Storage at 32°C		
0	0·640	0·0086	2·3437	0·00225
5	0·642	0·0085	2·3052	0·00219
10	0·667	0·0041	1·0794	0·00005
15	0·706	0·0052	1·2889	0·00008
20	0·788	0·0026	0·5837	0·00002
25	0·856	0·0121	2·4647	0.00044

Table 3. Changes in the muscle water percentage of *O. punctatus* during storage.

Storage in hours	Mean water %	Standard error of mean	Coefficient of variation	Variance
		Storage at −4°C		
0	79·920	0·1169	0·2540	0·04100
5	79·520	0·1244	0·2711	0·04648
10	79·000	0·1802	0·3951	0·09746
15	78·460	0·1050	0·2320	0·03308
20	78·120	0·0374	0·8294	0·00419
25	77·628	0·1970	0·4405	0·11696
		Storage at 32°C		
0	79·720	0·1169	0·2540	0·04100
5	79·000	0·407	0·0892	0·00497
10	78·000	0·0562	0·1251	0·00950
15	77·980	0·0642	0·1427	0·01238
20	77·460	0·0450	0·1008	0·00609
25	76·200	0·0503	0·1144	0·00760

Table 4. Changes in the muscle ash percentage of *O. punctatus* during storage.

Storage in hours	Mean ash %	Standard error of mean	Coefficient of variation	Variance
		Storage at −4°C		
0	1·215	0·0028	4·5267	0·00002
5	1·273	0·0719	9·7957	0·01555
10	1·299	0·0960	12·8021	0·02765
20	1·220	0·6653	9·2704	0·01279
25	1·207	0·0741	10·6379	0·01648
		Storage at 32°C		
0	1·215	0·0028	4·5267	0·00002
5	1·331	0·0063	0·8264	0·00012
10	1·326	0·0038	0·4977	0·00435
15	1·342	0·0577	0·4590	1·00200
20	1·200	0·0612	8·8330	1·12360
25	1·220	0·6440	9·1475	1·24545

4. Discussion

The decline in the muscle protein content recorded during the storage of the murrel, *O. punctatus*, may be attributed mainly to the decomposition of amino acids and exudation of free drip. Tarr (1942) has pointed towards such losses in fish stored at low temperatures.

It is known that the taste, flavour and nutritive value of stored fish depend upon the amino acid make-up of its protein molecules. As discussed later, a minor change may, however, take place in the pool of the amino acids under the influence of varying temperature. The development of bad odour and flavour observed in

O. punctatus during the early stages of its storage at 32°C seems indicative of the biochemical changes in certain amino acids. At low temperatures, however, no rapid change in the amino acid composition of fish muscle has been reported. Ingalls *et al* (1950) found no appreciable difference in the essential amino acid composition of frozen meat. Freezing also did not affect the nutritive value of crab meat as determined biologically by Watson and Fellers (1935).

Drip is also reported to be an important phenomenon causing considerable loss in the muscle protein of fish during storage. This loss of protein through drip has been reported to be greater in frozen than in unfrozen fish (Moore *et al* 1970; Seagran 1956). More or less similar results were obtained during the present investigations.

The unpleasant smell in *O. punctatus* referred to earlier may be attributed to the oxidative changes occurring in the muscle (Borgstrom 1964). The differences in the degree of lipid oxidation under the two conditions of storage may be related to factors such as temperature, light and access to atmospheric oxygen. Atmospheric oxygen is believed to attack the fatty acid bonds to form a peroxide linkage, which is associated with fishy flavour (Broge 1941; Davies and Gill 1936; Obata *et al* 1949). Toyama and Matsumato (1953) have reported the presence of volatile substances of highly unsaturated fatty acids and carbonyl compounds but maintained that those may not be regarded as the chief substances responsible for the unpleasant odour peculiar to oxidized highly unsaturated fatty acids.

The rise of fat is considerable during the initial stages of autoxidation, when, peroxide begins to be formed, than during later period, during which it may be decomposed, reacting with one another or with other oxidative products. Such reactions ultimately result in the formation of various acids, carbonyl compounds and other products (Borgstrom 1961). In any case, the rise encountered in the muscle fat content of *O. punctatus* seemed due to a marked accumulation of oxidative products with different physical properties and chemical constitution.

Among the factors influencing the rate of autoxidation, temperature seems to be of prime importance, as evident from the differences arising in the time of onset of unpleasant smell in *O. punctatus* stored at the two different temperatures. Light is also known to enhance the rate of oxidation and hence the peroxide formation. Besides oxidation, the development of unpleasant odour in fish flesh, upon storage, may also be the result of hydrolysis of triglycerides, resulting in the formation of glycerol and free fatty acids. The free fatty acids may also account for the increase in the weight of the fat that has actually been observed during the present investigation on *O. punctatus*. The increase in the concentration of free fatty acids, as a part of postmortem changes in fish, has been reported by a number of workers (Banks 1937; Love 1966; Lunde 1939).

In contrast to oxidative changes, lipid hydrolysis in fish, by itself, has no obvious nutritional significance. The accumulation of free fatty acids in fish tissue as such does not seem to affect the culinary quantity of fish but the effects are likely to be due to the secondary changes, particularly increased susceptibility of fat to oxidation and development of bad odour (Lovern 1962). The hydrolysis in the fish tissue may be caused by factors such as enzymatic and bacterial activities and may be enhanced at high temperatures. In worst stages, the oxidative effects of oxidation, enzymatic and bacterial hydrolysis of fats in fish may result in extremely bad odour and off flavour responsible for reducing the consumers appeal of the fish (Ranke *et al* 1957).

The loss in the amount of water appears to be caused mainly by the dehydration from the surface, presumably due to improper wrapping of fishes (Dyer 1951). The decrease in the moisture has also been suggested by Finn (1932) who explained that due to freezing out of water, pH was lowered which would be expected to decrease the net charge of the proteins and render them hydrophobic. The drip formed in the storage tenure of fish appears to contain water in addition to salts and other constituents. The formation of drip is intracellular, as evidenced by the observations of Love (1955, 1958). It is however, difficult to single out any particular factor, since salt concentration increases due to the freezing out of water and many of the inorganic ions present in the drip combine with lactic acid, formed as a result of postmortem glycolysis, forming various compounds such as lithium lactate, calcium lactate, etc.

Acknowledgements

I wish to express thanks to Prof. S M Alam for his interest and encouragement and to Drs S Mustafa and A K Jafri for assistance rendered.

References

Annamalay S 1962 Postmortem changes in the amino acid contents of the muscle of common carp, *L. fambriatus* (Bloch): *J. Annamalai Univ.* **13** 159-167

Bank A 1937 Rancidity in fats. I. The effect of low temperatures, sodium chloride, and fish muscle on the oxidation of herring oil; *J. Soc. Chem. Ind.* (*London*) **56** 13-157

Bate-Smith E C and Bendal J R 1947 Rigor and adenosine triphosphate; *J. Physiol.* (*London*) **106** 177-185

Birdseye C 1929 Some scientific aspects of packaging and quick freezing perishable flesh products. I. More rapid freezing means better preservation; *J. Ind. Eng. Chem.* **21** 414-417

Borgstrom G 1961 *in fish as food* Vol. I (New York, London: Academic Press)

Broge J A 1941 Uber Geruch und ges Chmack von Heringsol: *Pette U. Scifen.* **48** 188-189

Davis W L and Gill E 1936 Investigations on fish flavour; *J. Soc. Chem. Ind.* (*London*) **55** 141-146

Dyer W J 1951 Protein denaturation in frozen and stored fish; *Food Res.* **16** 522

Dyer W J, Fraser I, Ellis D G, MacCallum W A and Laishley W 1962 Quality changes in refrozen cod fillet; *Bull. Int. Inst. Refrig. Annex.* 515-524

Fatema S, Shaikh mahmud and Magar N G 1961 Studies of prawn spoilage. 1. Handling and storage of prawn; *J. Univ. Bombay* **31** 16-21

Finn, D B 1932 Denaturation of proteins in muscle juice by freezing; *Proc. R. Soc.* **B111** 396-411

Fraser D I, Punjamaporam S and Dyer W J 1961 Temperature and biochemical process occurring during rigor-mortis in cod muscle; *J. Fish Res. Bd. Canada* **18** 641-644

Huntsman A G 1931 The processing and handling of frozen fish exemplified by ice fillets; *Fish Res. Bd. Canada Bull.* **20** 58

Ingalls R L *et al* 1950 Nutritive value of fish from Michigan waters; *Michigan State Coll. Agri. Exptl. Stat. Tech. Bull.* **219** 24

Jadhav M G and Magen N G 1970 Preservation of fish by freezing and glazing. III. Effects of freezing, glazing and frozen storage on B Vitamins and essential mineral present in the fish flesh; *Fish. Technol.* **7** 158-163

Jafri A K, Khawaja D K and Qasim S Z 1964 Studies on the biochemical composition of some freshwater fishes. I. Muscle; *Fish. Technol.* **1** 148-157

Jones N R 1954 Factors affecting the free amino acid composition of fresh and iced skeletal muscle North Sea codling (*Gadus Callarias*); *Biochem. J.* **58** (4) 117-118

Love R M 1955 The expressible fluid of fish fillets. I. Nucleic acid as an index of cell damage in fillets frozen from both sides; *J. Sci. Food Agric.* **6** 30-37

Love R M 1958 Studies on protein denaturation in frozen fish. III. The mechanism and site of denaturation at low temperatures; *J. Sci. Food Agric.* **9** 609

Love R M 1966 *Cryobiology* (London, New York: Academic Press)

Lovern J A 1962 The lipids of fish and changes occurring in them during processing and storage; *in Fish in Nutrition* eds. E. Heen and Krenzer (London: Fishing News)

Lunde G 1939 Recent research on vitamins in fish and fish products; *Angew. Chem.* **52** 521-524

MacCallum W A 1964 Temperature and thawdrip associated with electronic, thawing of Newfoundland cod; *J. Fish. Res. Bd. Canada* **21** 719-726

MacPherson N L 1932 Studies on the behavior of the carbohydrates and lactic acid of the muscle of haddock (*Gadus aeglefinus*) after death; *Biochem. J.* **26** 80-87

Menon G 1962 Free amino acids in spoiling mullet; *Indian J. Fish.* **B9** 118-125

Moore G S, Peters H A and Levis R E 1970 Alteration in Electrophoretic protein pattern of refrigerated fish; *J. Fish. Res. Bd. Canada* **27** 31-38

Nazir D J and Magar N G 1965 Biochemical changes in fish muscle during rigor mortis; *J. Food Sci.* **28** 1-7

Obata Y, Hoshi K and Matsumato K 1949 Chemical studies on the substances of fish smell. I. Substances concerned with fishy smell and natural coloration of fish oil. (in Japanese with English summary); *Bull. Japan. Soc. Sci. Fisheries* **15** 412-414

Ranke E, Ranke B and Bramstedt F 1957 Untersuchungen an tiefgefrorenen forellen and Lengfisch; *Arch. Fischereiwiss* **8** 53-561

Seagran H L 1956 Chemical changes in fish actomyosin during freezing and storage; *Food Res.* **21** 143-149

Siebert G 1958 Activitat Eiweiss-spaltender Enzyme in Fischen; *Experientia* **14** 65

Shinoy V A and Pillai V K 1971 Freezing characteristics of tropical fishes. I. Indian Oil Sardine; *Fish Technol.* **8** 37-41

Tarr H I A 1942 The effect of pH and NaCl on swelling and drip in fish muscle; *J. Fish Res. Bd. Canada* **5** 411-427

Tomlinson N, Arnold E S, Robert S E, and Geiger S E 1961 Observation on postmortem biochemical changes in fish muscle in relation to rigor mortis; *J. Fish. Res. Bd. Canada* **18** 321-336

Toyama Y and Matsumato I 1953 Volatile substances formed by air oxidation of methyl ester of highly unsaturated acids (in Japanese); *J. Chem. Soc. Jpn Ind. Chem. Sect.* **56** 972-973

Vasantha A, Shinoy V A and James M A 1972 Freezing characteristics of Tropical fishes II. Tilapia (T. mosambica); *Fish. Technol.* **9** 34-41

Venugopal V K A, Savagaon V S and Srinivasan A 1973 Extension of shelf-life of Indian Mackerel (*Rastralligar Kanagurta*) by irradiation; *J. Fish. Res. Bd. Canada* **30** 305-309

Watson V K and Fellers C R 1935 Nutritive value of blue crab (*Callinectes* sapidus) and sand crab (Platyonchus ocellatus Litrille); *Trans. Am. Fish. Soc.* **65** 342-349