BIOCHEMICAL DIFFERENCES BETWEEN THE RED AND WHITE MEAT OF TUNA AND CHANGES IN QUALITY DURING FREEZING AND STORAGE

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The differences between the white and red (dark) meat of tuna *(Katsuwonus pelamis)* in chemical, physical and organoleptic aspects and the rate and pattern of spoilage during freezing and subsequent storage are discussed in this communication. In all the indices studied distinct difference is seen between the white and red meat as well as in the head, middle and tail portions of the same fish. The characteristic colour of tuna meat is due to the presence of haemoglobin and myoglobin, the concentrations of which are about 5 times more in red meat than in white meat. The shelf-life of the frozen material varies with the type of the pack, that is, whole fish > chunks > fillets; the fillets being adversely affected during frozen storage.

INTRODUCTION

Tuna has a red (dark) fatty lateral line tissue, around the back-bone. Outside the red muscle lies a thicker layer of muscle white in colour. Unlike mackeral, sardine or seer, the percentage of red meat is more in tuna. These two types of muscle differ sharply in their chemical constitution as well as in the physiological function. The red meat is responsible for one of the characteristic behavioural traits of tuna - ceaseless swimming - and plays a key role in the muscular activity of the fish just like liver in mammals (Anon. 1966). Even though tuna meat is highly nutritious with protein, fat, essential amino acids etc., the consumer acceptability, mainly based on flavour characteristics, is less than that for seer. The red meat which comes to about 11% of the total body weight is not utilized at present. About 15% of the total catch (5990 tons) is utilized for canning by the Union Territory of Laccadives.

The present communication summarizes the biochemical difference between the white and red meat of tuna *(Katsuwonus pelamis)* and the changes brought out

TABLE I

Biochemical differences between the red and white meat of tuna.

	Whole fish		White meat		Tail	Red meat		Tail
	White meat	Red meat	Head	Middle		Head	Middle	
Moisture %	72.7	71.4	72.0	71.8	71.6	71.2	71.0	70.8
Protein %	20.8	19.7	18.9	19.5	18.8	17.8	18.1	19.1
Non-Protein Nitrogen mg. %	700.0	518.0	644.0	700.0	686.0	483.0	455.0	511.0
Salt soluble Protein %	56.6	72.9	56.6	54.3	52.6	80.6	78.3	76.0
Sarcoplasmic Protein %	35.6	28.2	—	—	—	—	—	—
Free α - NH_2 - N. mg. %	174.0	109.2	190.0	205.0	224.0	120.0	176.0	173.0
Glycogen mg. %	165.0	554.0	157.0	121.0	64.0	603.0	514.0	285.0
Lactic acid mg. %	1839.0	1573.0	1427.0	1452.0	1427.0	977.0	1034.0	1163.0
Inorganic Phosphorus mg. %	193.0	121.0	221.0	234.0	238.0	153.0	147.0	157.0
Ribose mg. %	213.0	198.0	229.0	231.0	236.0	184.0	160.0	194.0
Fat %	1.23	2.22	—	—	—	2.53	1.61	3.40
Pigments								
Myoglobin, absorbance at 410 mμ	—	—	1.46	1.48	1.44	1.60	2.0	1.50
Haemoglobin, absorbance at 410 mμ	—	—	0.48	0.90	0.50	0.50	0.70	0.80
Organoleptic characteristics								
Colour	Sl. pink	Dark red	Sl. pink	Sl. pink	Sl. pink	Sl. pink	—	—
Texture	Soft & firm	Granular	Sl. tough	Good	G. - F	—	—	—
Flavour	Good	Liver taste	G-F	Good	G. - F	—	—	—

during freezing and subsequent cold storage. The chemical indices studied are moisture, protein, solubility of protein in Dyer's solution, sarcoplasmic protein, glycogen, lactic acid, phosphorus (inorganic), ribose, fat and pigments in addition to the subjective tests.

Materials and methods

The fish *(Katsuwonus pelamis)* used was caught from the sea off Cochin. Sampling was done as follows:

(1) deskinned, beheaded, deboned and the white and red muscles separated and minced well in a waring blender,

(2) beheaded, cut into 3 pieces - portion adjascent to head, middle and tail - deskinned, deboned, and the red and white muscles removed separately and minced well in a waring blender. The fish used for freezing studies were dressed to remove gills and intestines and frozen as whole chunks and fillets and stored at -18°c.

Total protein, moisture, sarcoplasmic proteins and salt soluble proteins, non-protein nitrogen, free α-amino nitrogen, glycogen, lactic acid and phosphorus (inorganic) estimations were carried out as described earlier (Chinnamma *et al.*, 1970 and Chinnamma George, 1973); and ribose by Mejbaums (1939) method. The fat was extracted from weighed lots of the wet muscle using chloroform- methanol mixture (2:1 v/v) according to the procedure of Bligh and Dyer (1959). The pigments myoglobin and haemoglobin were estimated spectrophotometrically by the methods of Barret *et al.* (1965). The material was cooked in 2.5% brine for 10 minutes and evaluated by the taste panel members of the Institute.

Results And Discussion

The proximate composition of the red and white meat of tuna is given in Table I.

Distinct difference in chemical composition is seen between the two portions. Moisture, protein, non-protein nitrogen, sarcoplasmic proteins, free α-amino nitrogen lactic acid, phosphorus (inorganic) and ribose are more in white meat while salt soluble proteins, glycogen, fat, pigments etc. are more in red meat. This is in agreement with the earlier findings (Mannan, *et al.* 1961., and Braekkan, 1956) that protein and moisture are lower in the dark fatty tissues showing that fat replaces some protein as well as water. According to Braekkan, the higher glycogen content in red meat may be attributed to the lesser changes in it under the anaerobic conditions existing during death struggle than in the neighbouring white meat. This is also confirmed by the finding that the glycogen content is comparatively less in tail portion than in head or middle portions. Tuna flesh is known to consist mainly of myoglobin and haemoglobin and the concentrations of these in red meat are about 5 times more than that in the white meat. The red meat is about 11% of the whole weight of the fish and it is accumulated more in the middle portion (12.8%) compared to the head (10.5%) or tail (9.5%) portions.

The moisture content shows decreasing trend from head to tail and the amount of salt soluble proteins decreases from 56% to 52% in white meat and from 80% to 72% in red meat from head to tail probably due to the higher amount of connective tissues in the tail portion. The free α-amino nitrogen increases from 190 to 224 and 120 to 173 mg.% from head to tail portions in red and white meat

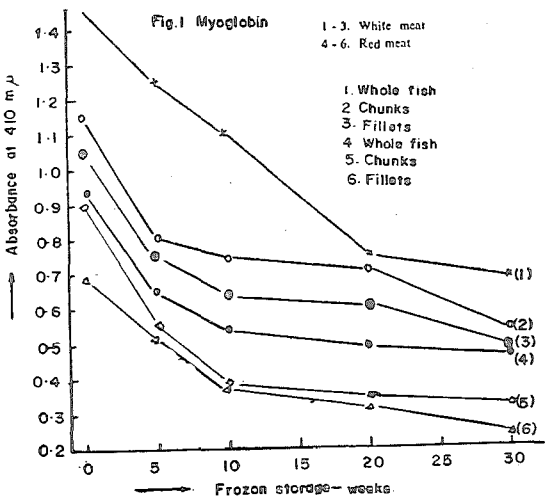

Fig. I

respectively. Ribose and phosphorus (inorganic) also show similar pattern. Pigments are accumulated more in the middle portion as is evident from table I and fat is accumulated more in the red meat and shows a decreasing trend from head to tail. Organoleptic characteristics show that the middle section is better than head or tail section.

Table II gives an account of the changes in tuna meat during frozen storage. In both white and red meats a decreasing trend is seen in the amount of salt soluble proteins, but the change is more in red meat. Earlier reports (Saito and sameshima, 1958-59) also support this finding that the rate of change in dark muscle is more than that in the white muscle irrespective of species. The formation of free α amino acids and free phosphorus as seen in the table clearly indicates the proteolytic and other changes occurring during frozen storage.

The shelf life, as shown by organoleptic characteristics, is longer for white meat than for red meat and it is in decreasing order from whole fish (30 weeks) to fillets (20 weeks) (Table II). Red meat is badly affected during frozen storage due to spoilage of fat and the change is more pronounced in fillets. The fillets are also affected by dehydration.

The colour change of the meat can be directly correlated to the loss of extractable pigments. The change in myoglobin during frozen storage is represented in figure 1. A decreasing trend is seen in the absorbance values during cold storage in both white and red meat in all forms of packs such as whole, chunks and fillets. The original characteristic colour of tuna meat is changed to dark brown during prolonged frozen storage, probably due to the formation of metmyoglobin. Sano, *et al.* (1959) had observed an increase in the amount of metmyoglobin in tuna muscle during cold storage and Bito, (1964) provided evidence that the discolouration of tuna meat during frozen storage is caused by the oxidative changes of myoglobin to metmyoglobin. Haemoglobin is much less stable than myoglobin and it is denatured to the inextractable stage by 5 weeks of storage. Barret *et al.*, (1965) had observed the same phenomenon in tuna haemoglobin.

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TABLE— II.

Biochemical and organoleptic changes in tuna meat during cold storage.

Frozen storage Period weeks	White meat			Red meat			White meat			Red meat		
	I.	II.	III	I.	II.	III.	I.	II.	III.	I.	II.	III
	Salt solubility as % of T. N.						Free α-NH_2-N. mg%					
0	53.6	50.9	50.9	66.3	65.3	65.3	260	294	294	148	176	176
5	51.9	50.7	51.2	66.1	55.1	59.8	284	283	275	154	152	182
10	50.1	48.1	49.7	60.4	54.5	55.1	305	302	305	160	160	190
20	48.5	46.2	48.9	58.5	51.5	54.5	336	353	330	179	192	202
30	46.2	44.8	47.8	55.2	51.0	51.0	323	353	358	192	198	213
	Phosphorus (inorganic) mg%						Organoleptic characteristics					
0	182	193	193	144	121	121	Good	Fair	Fair	Good	Fair	Fair
5	185	188	192	147	127	134	Good	Fair	Fair	G. F.	F.	F.
10	208	209	213	153	144	148	Fair	Fair	Fair	F.	F.P.	F.P.
20	214	218	221	175	154	168	Fair	Fair	F.P.	F.P.	F.P.	Poor
30	232	234	239	182	159	188	F.P.	F.P.	P.	P.	P.	P—off

I - whole fish II - chunks III - Fillets.

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