Influence of Muscle Fats on the Quality of Intermediate Moisture Fish

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Chrysicthys nigrodigitatus with 12.95% fat having an iodine value of 74.8 and a saponification number of 198.48 and *Citharinus citherus* containing only 3.25% fat with iodine value of 67.8 and a saponification number of 145.86 were studied as examples of fatty and lean fishes respectively. The intermediate moisture (IM) products of both fish types compared with normal cooked samples, were evaluated as of acceptable colour, odour, texure and juiciness but of inferior taste due to the glycerol impact. However, during storage at 30°C the IM products became increasingly less acceptable with the deterioration being greater in the fatty fish than in the lean fish, although the fatty IM fish was superior to the IM lean fish with regard to water retention and juiciness. Overall quality differences were most apparent in colour and odour with the fatty IM fish being worse. The fatty fish had also greater evolution of TBA-reactive carbonyl breakdown products of lipid oxidation which were subsequently used up in non-enzymic browning producing the correspondingly darker fish colour and greater off odour.

A basic problem with intermediate moisture (IM) products is quality deterioration through lipid-protein interactions initiated by the intermediary products of lipid oxidation (Obanu *et al.*, 1980). These deteriorative interactions have been shown to affect the appearance, texture and flavour of intermediate moisture (IM) meats (Obanu *et al.*, 1975 b; Obanu, 1980) as well as their nutritive value (Obanu *et al.*, 1976). Only very little study has been done on IM fish (Collins *et al.*, 1972, Collins & Yu, 1975). Nevertheless, the simplicity, ease and cheapness of IM food processing and its specific suitability to tropical conditions (Obanu *et al.*, 1975a) render IM food technology attractive to meet the responsibility of handling surplus fish.

However, fish lipids are known to be much higher in their content of polyunsaturated fats, especially those of five or more double bonds (Stansby & Olcott, 1963) and should therefore be more prone to lipid oxidation than meat. Since lipid oxidation is maximal at the IM water activities (Labuza, 1975), these polyunsaturated fish fats may subject IM fish to rapid deterioration and hence curtail the product shelf-life. This study verifies this hypothesis through the storage behaviour of IM products of two fish species that differ widely in their fat content.

Materials and Methods

Sample preparation and processing

Chrysichthys nigrodigitatus (a fatty fish) and *Citharinus citherus* (a lean fish) caught by the gill-net from the lower River Niger were bought alive from fishermen. These were killed in the laboratory, gutted, washed and stored in polythene bags in a freezer at –25°C until required (the next day).

For the experiment, the fishes were thawed in tapwater and steamed for 5 min to arrest microbial growth and to facilitate filleting. The fillets from each species were cut into roughly 1 cm^3 pieces which were mixed thoroughly and one-fifth removed for use as frozen control (at –25°C). The remaining four-fifths of each species were cooked in 1.5 times their weight of an infusing solution containing 35.4% glycerol, 9.5% salt (NaCl) and 0.5% potassium sorbate as antimycotic and subsequently equilibrated in the infusing solution overnight (12 h) at room temperature (Obanu *et al.*, 1975a). The resulting intermediate moisture (IM)

products from each fish species were divided into five equal portions that were packaged separately in polythene bags. One portion per species was removed for pre-storage analysis while the rest were stored in a thermostatically controlled hot air oven at 30°C (approx. mean atmospheric temperature). One package of each fish species was removed at random every three weeks for analysis along with the frozen control cooked-for-test in 1.5 times by weight of distilled water for 15 min. At each sampling fractions of each IM fish for sensory evaluation were stored in a freezer at –25°C for pooled taste panel comparison at the termination of storage along with the frozen control cooked-for-test. Samples were evaluated for colour, odour, taste, texture and juiciness (Fig. 1) by a panel of twenty judges.

Fig. 1. *Scoring scales for sensory evaluation*

Colour	*Odour and taste*
Extremely white	–8– Extremely pleasing
Very white	–7– Very pleasing
Moderately white	–6– Moderately pleasing
Slightly white	–5– Slightly pleasing
Slightly brown	–4– Slightly offensive
Moderately brown	–3– Moderately offensive
Very brown	–2– Very offensive
Extremely brown	–1– Extremely offensive

Texture	*Juiciness*
Extremely soft	–8– Extremely juicy
Very soft	–7– Very juicy
Moderately soft	–6– Moderately juicy
Slightly soft	–5– Slightly juicy
Slightly hard	–4– Slightly dry
Moderately hard	–3– Moderately dry
Very hard	–2– Very dry
Extremely hard	–1– Extremely dry

For characterization of the muscle lipids, the raw fish pieces were dried in a hot-air oven at 80°C for 5 h, ground and extracted with ether for at least 7 h in a Soxlet apparatus (AOAC, 1970). The melting and solidifying temperatures of the oils were determined as described by Pomeranz & Meloan (1971) while the acid value, saponification number and iodine value were determined by the AOAC methods (AOAC, 1970). Moisture was determined by drying 5 g duplicates in a hot-air oven at 80°C overnight (at least 10 h) while pH was determined on a suspension of 1 g minced sample in 10 ml water. TBA value was obtained from 10 g duplicate samples by the method of Tarladgis *et al.* (1960).

Results

Characterization of the fish oils

The fatty fish, *Chrysicthys nigrodigitatus* contained 12.95% fat while the lean fish, *Citharinus citherus* had only one-quarter as much fat (3.25%). The characteristics of these fats are summarized in Table 1. The fatty fish, in addition to containing more fat, had higher acid value, saponification number and iodine value. As usual the total fat content varied inversely with muscle water content, thus the fatty fish contained less water than the lean fish (Table 1).

Moisture retention of IM fish pieces

Moisture contents after the cook-soak-equilibration processing fell from 70.37 to 48.42% for the fatty fish and from 79.53% to 51.70% for the lean fish. Thus the fatty fish continued to hold less water than the lean fish. However, this trend was reversed during storage at 30°C as the IM lean fish pieces lost moisture more rapidly than the fatty fish (Fig. 2). Thus the fatty fish showed a

Table 1. *Fat content and characteristics of the fishes studied*

Sample	Moisture content %	Fat content %	Acid value	Saponification value	Solidifying temperature °C	Melting temperature °C	Iodine value
Fatty fish	70.37	12.95	7.82	198.48	–2.5	10	74.8
Lean fish	79.54	3.25	5.70	145.86	–4.0	12	67.8

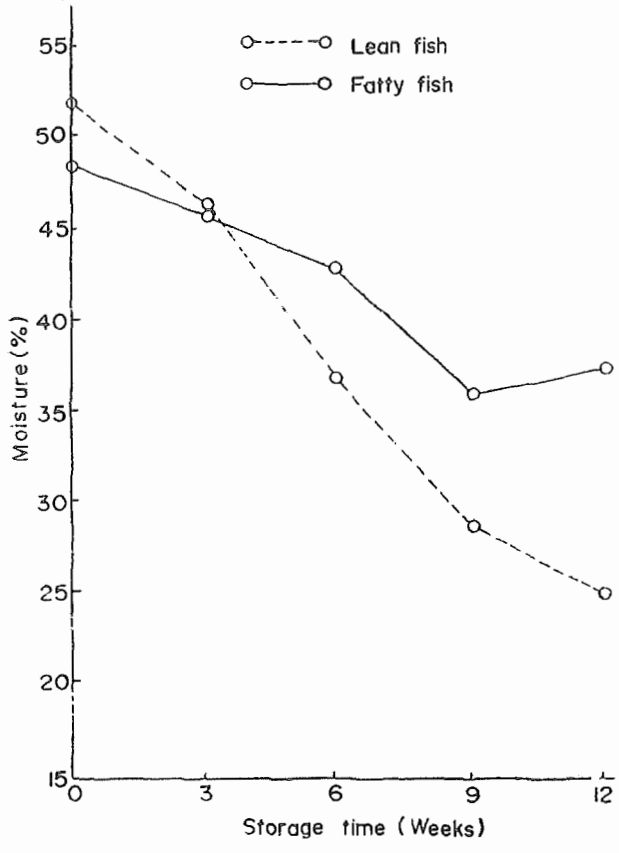

Fig. 2. Moisture content and retention of IM fish during storage at 30°C

fairly good moisture retention during storage comparable with IM meats (Obanu et al., 1975a) while the lean fish was significantly inferior ($P < 0.01$) in moisture retention declining from 51.70% water to 24.40% water within 12 weeks at 30°C.

Acidity of IM fish pieces

While the ordinarily cooked control fish had pH of 6.72 for the fatty species and 6.70 for the lean species, the IM products after the cook-soak-equilibration processing had a slightly higher uniform pH of 6.87 (Table 2). This pH uniformity was fairly well maintained during storage at 30°C ($P > 0.05$). It would therefore appear that the content and nature of the fats in the fish samples studied had no differential effect on the pH of both the cooked and IM fish products.

Thiobarbituric acid (TBA) value

Fig. 3 summarizes the optical densities at 538 nm (i.e. TBA value) of distillates from the fish samples before and during storage at 30°C. The fatty fish had higher TBA values than the lean fish soon after the cook-soak-equilibration processing and early in storage indicating greater evolution of malonaldehyde-type carbonyl compounds. The highest values were recorded at 3 weeks and 6 weeks respectively for the fatty and lean fishes; thereafter values declined as storage advanced and differences between fish types narrowed down (Fig. 3).

Colour of the IM fish pieces

The freshly processed IM fish pieces were judged to be more than "moderately white" (score 6.0) with the lean fish being whiter than the fatty fish as shown in Fig. 4. This difference was increased within the first six weeks of storage at 30°C and maintained significant ($P < 0.01$) even when both samples were becoming visibly brown. Thus while the lean fish was still judged as "slightly white" after 6 weeks storage the fatty fish at that storage time was "moderately brown" (score 3.2).

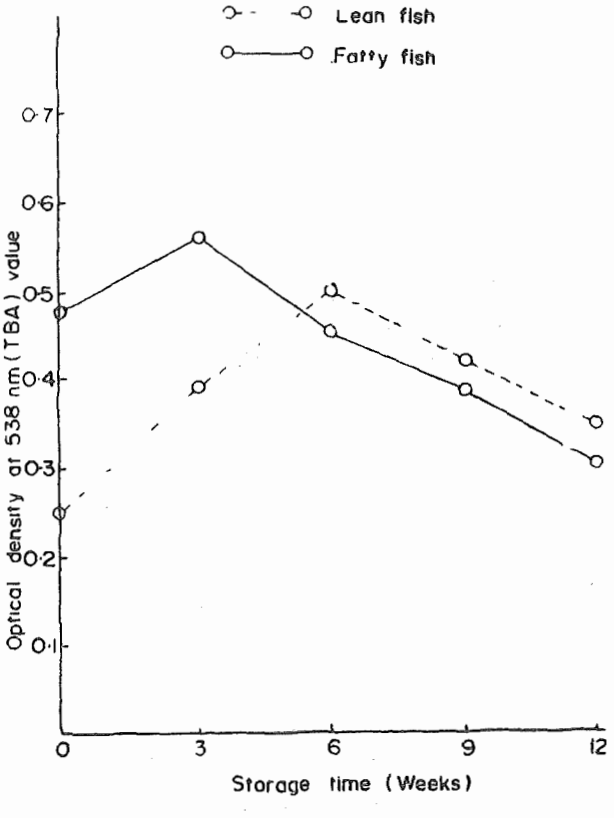

Fig. 3. TBA values of IM fish stored at 30°C

Table 2. *Influence of muscle fat on pH of cooked and IM fish*

Sample	pH of ordinarily cooked fish	pH of intermediate moisture (IM) products weeks of storage at 30°C				
		0	3	6	9	12
Fatty fish	6.72	6.87	6.75	6.77	6.82	6.87
Lean fish	6.70	6.87	6.80	6.76	6.82	6.86

Odour of the IM fish pieces

The freshly processed IM fatty and lean fish pieces had odour scores of 5.0 and 5.6 respectively; thus while the fatty fish was only "slightly pleasing" the lean fish was more than "slightly pleasing." The odour of the lean fish pieces remained fairly constant during storage at 30°C while the odour of the fatty fish pieces declined progressively with storage (Fig. 5).

Taste, juiciness and texture of the IM fish pieces

The freshly processed (IM) fatty and lean fish pieces received taste scores of 5.8 and 5.3 respectively comparable with scores of 6.0 and 5.6 given to their respective cooked counterparts. With storage, the taste of the lean fish IM product remained fairly constant at "slightly pleasing" while the taste of the fatty fish declined progressively becoming "slightly offensive" (score 4.0) at the termination of storage (Table 3). None of the panelists detected rancidity either from the taste or the odour of any of the IM fish samples.

The IM lean fish before storage was judged to be nearly as juicy as the cooked control samples–scores were 6.2 and 6.4 respectively. However, the IM fatty fish before storage was noticeably less juicy than its

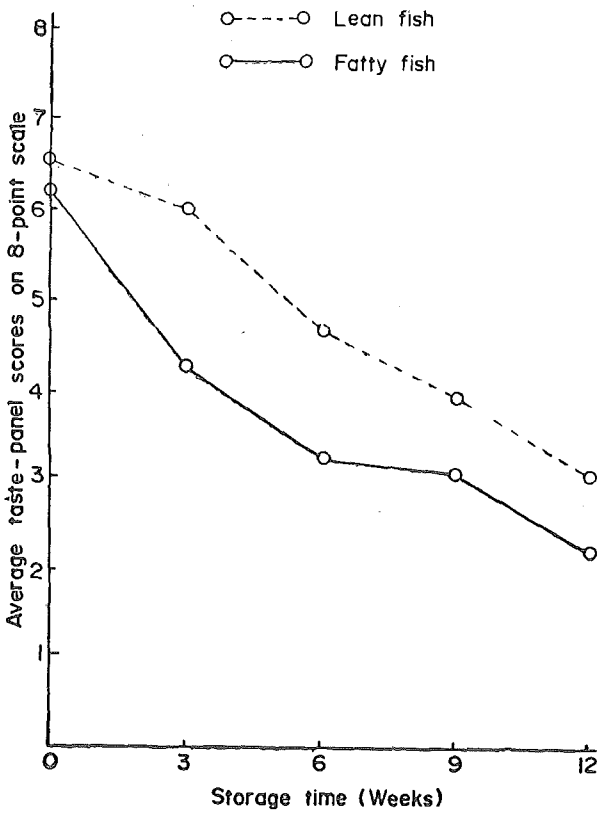

Fig. 4. Influence of storage at 30°C on colour of IM fish

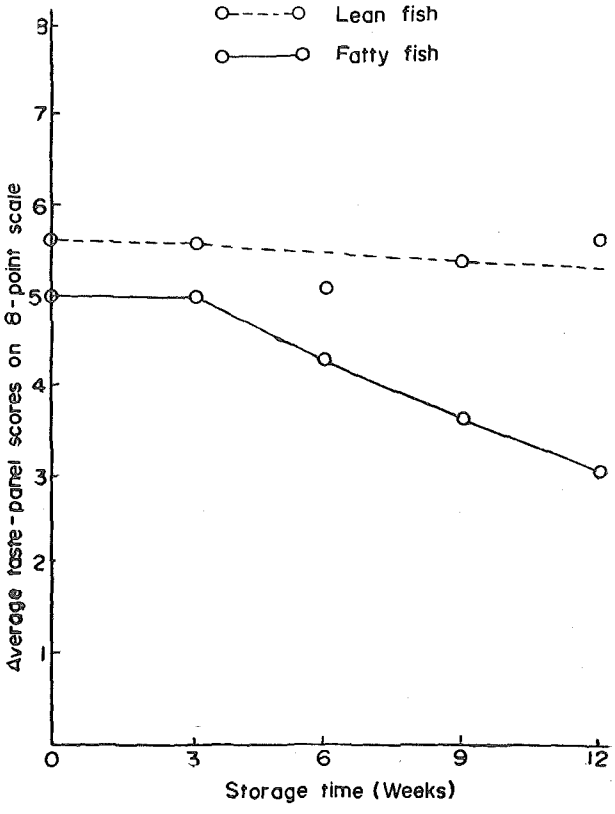

Fig. 5. Influence of storage at 30°C on odour of IM fish

cooked control sample-scores were 5.0 and 6.8 respectively. The difference in juiciness between the two IM fish types disappeared within 6 weeks storage (Table 3) when both products had become "slightly dry" (score 4.0).

As regards texture, the finger-feel of the IM lean fish was judged similar to the cooked fish with scores of 6.6 and 6.8 respectively. The IM fat fish, on the other hand, received a lower score of 5.6 compared with 6.2 for its cooked control. With storage both IM fish types became more dry and tough (Table 3) with the decline being faster for the lean fish which by 6 weeks had become more dry than the fatty fish.

Discussion

Fish fats are known to be high in long chain, polyunsaturated fatty acids (Stansby & Olcott, 1963). The higher saponification and iodine values of the *Chrysicthys nigrodigitatus* (Table 1) suggest these fatty acids may be higher in this fatty fish than in the lean *Citharinus citherus*. While these muscle fat differences do not appear to affect pH of the intermediate moisture (IM) products (Table 2) they definitely affect the moisture content and TBA value as well as the organoleptic quality of the IM fish products. The higher fat content of *Chrysicthys nigrodigitatus* induced lower moisture content prestorage (Fig. 2) and yet better taste (Table 4) and better water retention (Fig. 2) which is to be expected since water diffusion is slower in high fat fish (Jason, 1965). The intrinsic differences in the amount and unsaturation of the muscle fats of the fishes account, at least in part, for the marked differences in the levels of carbonyl compounds (measured by TBA value) during storage (Fig. 3) as well as the apparent organoleptic differences particularly in colour (Fig.4) and odour (Fig. 5). It is noteworthy that despite the evolution of TBA-reactive carbonyls early in storage, there was no detection of rancid odours or tastes. The reduction in levels of these carbonyls later in storage confirms that they are not freely accumulated to concentrations that can yield rancid flavours as would be expected with continued lipid oxidation. Rather the observed non-enzymic browning (Fig. 4) in which TBA-reactive lipid-oxidation breakdown products can take part (Sinnhuber *et al.*, 1958; Obanu *et al.*, 1980) may explain the decrease in TBA values in both fish types at advanced storage (Fig.3). Studies on freeze-dried fish have shown that carbonyl compounds can initiate browning especially in fish (Tarr & Gadd, 1965). Similar lipid-protein interactions have been observed to occur during storage of freeze-dried salmon at 37°C (Martinez & Labuza, 1968) and in IM meats stored at 38°C (Obanu *et al.*, 1975a, b; 1980). Thus it would appear that the major cause of deterioration of IM fish products is non-enzymic browning which is correspondingly more serious with increase in fat quantity and unsaturation. Hence IM products from *Chrysichthys nigrodigitatus* having more fat which is of a higher iodine value (Table 1) deteriorated generally faster than IM products from lean *Citharinus citherus* during storage at tropical temperatures around 30°C.

Table 3. *Influence of muscle lipids on the taste, juiciness and texture of intermediate moisture fish*

Weeks of fish storage at 30°C	Average taste panel scores on 8 point Hedonic scale					
	Taste		Juiciness		Texture	
	Fatty fish	Lean fish	Fatty fish	Lean fish	Fatty fish	Lean fish
0	5.8	5.3	5.0	6.2	5.6	6.6
3	4.6	4.7	4.4	5.0	5.4	5.6
6	4.8	4.0	4.4	4.4	4.0	4.4
9	3.8	5.2	3.6	3.6	4.2	3.0
12	3.8	5.2	2.6	2.4	2.4	2.2

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