

Quality Deterioration in Tilapia During Storage in Refrigerated Brine

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During storage of *Tilapia nilotica* in refrigerated brine at 4°C, the whole (ungutted) fish had higher levels of free fatty acid and spoiled faster than the gutted fish. The shelf-life of whole fish was 16 days and that of gutted 28 days; these values are, at least, as good as those reported for ice-storage. Flavour of the cooked fish appeared to be the quality-limiting factor reducing the shelf-life of gutted tilapia to 28 days even though the raw gutted fish was judged acceptable, after 31 days retaining 65–70% freshness.

Introduction

Chilling is a very effective way of reducing fish spoilage and it is particularly effective with tropical fish (Disney *et al.*, 1973) whose microflora is low in psychrophilic bacteria and is sensitive to cold shock. The objective in chilling is to cool the fish as quickly as possible to as low a temperature as possible without freezing them (Clucas & Sutcliffe, 1981) in order to reduce bacterial and enzymic action and maintain freshness in the fish.

So far, ice has been more widely used than any other medium for fish chilling. There are, however, circumstances in which it is difficult to practice direct icing, for example, with schooling fish, pelagic fish and other small fishes caught with driftnet in large quantities. It is now common practice to stow such catch in seawater which has been cooled to a temperature near to that of melting ice (Clucas, 1981). Besides, refrigerated seawater effects faster chilling than melting ice because of the more intimate contact between fish and the cooling medium. Taking the speed of chilling in finely crushed ice as standard, Makashev (1940) found chilling in refrigerated seawater to be 190% faster without circulation and 420% faster with circulation. However, for chilling freshwater fish 2% brine has been found preferable to seawater as 2% brine has osmotic pressure close to that of freshwater fish (Makashev, 1940), and therefore minimizes flesh damage.

In the present study the quality and shelf-life of tilapia in refrigerated 2% brine is evaluated in two storage experiments of 20 days and 32 days duration. *Tilapia* species are abundant in Nigerian rivers, lakes and ponds, and have, according to Pinegars *et al.* (1974), been introduced to many African freshwater environments where they are cultured on a large scale because of their rapid growth and fecundity.

Materials and Methods

Tilapia nilotica caught by the gill-net from Ogunpa River (at Ibadan, Western Nigeria) and lower River Niger (at Onitsha, Eastern Nigeria) were bought alive, slaughtered and transported to the laboratory in ice. All fish were around 95–150 mm long, weighing 86.0–116.5 g and were estimated to be 12–18 months of age.

In the first storage experiment using *Tilapia nilotica* from Ogunpa River (at Ibadan), the fish were divided into lots—one lot was gutted and the other left whole. The two lots of fish were washed and stored in separate tanks containing 2% brine maintained at 4°C by mechanical refrigeration. Samples were analysed at 4-day intervals for lipid content by the methanol and chloroform extraction method of Bligh & Dyer (1959) while the percent free fatty acids in the lipid extract was determined by titration against 0.1N NaOH with phenolphthalein as indicator (Bligh & Scott, 1966). The bacterial count/cm² of the skin surface was determined by swabbing 1 cm area of the skin

and culturing appropriate dilutions in nutrient agar incubated at 37°C for 48 hours. Overall acceptability of samples was determined by sensory evaluation of the raw fish.

In the second storage experiment, *Tilapia nilotica* from lower River Niger (at Onitsha) were gutted, washed and stored in a tank containing 2% brine maintained at 4°C. During the 32 days storage, samples were taken at 4 day intervals and analysed for total lipid content (Bligh & Dyer, 1959) and free fatty acid content (Bligh & Scott, 1966). The appearance, odour and texture of the raw fish were assessed based on the quality description scale of Howgate (1976) which for 'fresh' to 'spoilt' runs from 10 to 0 for odour, and 5 to 1 for appearance and texture (fingerfeel). Cooked samples were also evaluated for odour, texture and flavour on Howgate's (1976) description scale running from 10 to 1 for odour and flavour and 5 to 1 for texture. The taste-panel consisted

of staff and final-year undergraduate students of Food Science and Technology.

Results and Discussion

Lipid and microbial levels

The total lipid content of about 1% for the whole fish (Table 1) shows *Tilapia nilotica* to be a lean fish. Gutted samples contained lower total lipids confirming lipid loss with evisceration. In both whole and gutted fishes the total lipid level remained significantly unaffected ($P > 0.05$) during storage in refrigerated brine (Tables 1 & 2). However, the levels of free fatty acids (FFA) in both gutted and whole fish varied significantly ($P > 0.05$) during refrigerated brine storage. In both experiments increases in FFA with storage were recorded with peak values after 8 days in the first experiment (Table 1) and 24 days in the second remaining constant thereafter (Table 2).

Table 1. Lipid and microbial levels in tilapia stored in refrigerated brine at 4°C

Storage time Days	Lipid content % wet-weight		Free fatty acids % lipid content		Surface bacterial count per cm	
	Ungutted	Gutted	Ungutted	Gutted	Ungutted	Gutted
0	1.3	1.1	2.7	2.7	n.d.	n.d.
4	0.9	0.9	6.1	4.6	1.8×10^3	1.3×10^4
8	1.1	0.9	10.6	7.1	5.5×10^4	3.6×10^5
12	1.1	0.9	6.0	3.7	3.3×10^6	1.3×10^7
16	1.1	1.0	5.4	4.1	2.6×10^6	1.2×10^7
20	1.0	0.9	5.6	4.8	3.4×10^5	6.1×10^5

n.d. = not determined

FFA levels were higher in ungutted (whole) fish (Table 1). Surface bacterial counts were higher in gutted fish (Table 1) probably due to contamination from handling, knives and utensils during the gutting operation. Peak counts were obtained in both whole and gutted fish after 12 days in refrigerated brine (Table 1). The levels and increase in skin bacteria observed in this study (Table 1) agree with reported findings that skin bacteria of *Tilapia nilotica* increase gradually over the first 14–21 days of chill storage from an initial level of 10^3 – 10^4 bacteria/cm² to an ultimate level of 10^6 bacteria/cm² (Pinegars *et al.*, 1974) or 10^7 bacteria/cm² (for

Crrhina mrigala; Nair *et al.*, 1971, 1974). The higher FFA levels in whole rather than gutted fish in this study, despite the lower bacterial counts of the whole fish (Table 1), show the significance of gut enzymes in FFA production. The increase in FFA level with storage (Table 2) suggests that FFA could be a useful quality index.

Organoleptic quality and acceptability

Table 3 shows that whole (ungutted) tilapia stored in refrigerated brine maintained at 4°C was organoleptically acceptable up to 16 days but was rejected at the 20th

Table 2. *Lipid changes in tilapia during refrigerated brine storage at 4°C*

Days of storage	Lipid content % wet-weight	Free fatty acids % lipid content
0	0.9	1.4
4	0.6	2.3
8	0.6	2.7
12	0.6	4.7
16	0.8	4.8
20	0.8	5.4
24	0.7	5.7
28	0.7	5.7
32	0.6	5.7

Table 3. *Acceptability of tilapia stored in refrigerated brine at 4°C*

Days of Storage	Taste panel assessment	
	Ungutted	Gutted
0	+	+
4	+	+
8	+	+
12	+	+
16	+	+
20	—	+

+ = Acceptable; — = Unacceptable

day. But the gutted remained acceptable even after 32 days when acceptability is assessed using uncooked fish (Table 4). The refrigerated-brine stored fish retained 65–70% of the freshness of the raw fish as judged by the appearance, odour and texture. (Howgate, 1976). However when flavour and texture of the fish after cooking was taken as the criterion for acceptability, the chilled brine-stored fish was judged acceptable up to 28 days only (Table 5). Rejection was on the basis of the flavour which dropped sharply from 8.2 (seasoned or canned meat flavour) at 28 days to 3.3 (very bitter or rotten flavour) at 32 days. This abrupt fall in flavour at the transition between acceptable and objectionable quality agrees with the sharp fall from 7.0 (at 27 days) to 4.7 (at 36 days) for the flavour of cooked ice-stored *Cirrhina mrigala* (a freshwater carp) which earlier in storage depreciated by only 2.8 in 27 days (Nair *et al.*, 1974). Although flavour of the cooked fish is thus the acceptability determining factor, texture deterioration (softening) appeared to be the earliest discernible quality change in the cooked fish. Table 5 shows that the cooked fish lost its firmness (score=4 or 5) within 4 days being 'soft and dry' (score=3) becoming 'soft and moist' (score=2) from the 16th day of storage.

Shelf-life in refrigerated brine

Whole (ungutted) tilapia adjudged in the raw state was of acceptable quality up to

Table 4. *Organoleptic assessment of raw tilapia stored in refrigerated brine at 4°C*

Days of storage	Number of panelists	Mean taste-panel scores $\pm$ standard error		
		Appearance	Odour	Texture
0	5	5.0 $\pm$ 0.00	10.0 $\pm$ 0.00	4.7 $\pm$ 0.27
4	5	4.0 $\pm$ 0.00	9.5 $\pm$ 0.27	3.4 $\pm$ 0.27
8	16	4.3 $\pm$ 0.18	8.3 $\pm$ 0.45	4.2 $\pm$ 0.25
12	14	3.9 $\pm$ 0.19	8.5 $\pm$ 0.40	4.3 $\pm$ 0.27
16	8	3.8 $\pm$ 0.32	8.9 $\pm$ 0.39	3.8 $\pm$ 0.42
20	17	3.1 $\pm$ 0.17	7.3 $\pm$ 0.34	4.1 $\pm$ 0.27
24	17	3.4 $\pm$ 0.15	7.0 $\pm$ 0.39	3.8 $\pm$ 0.27
28	11	3.6 $\pm$ 0.27	7.1 $\pm$ 0.60	3.8 $\pm$ 0.27
32	14	3.4 $\pm$ 0.24	7.0 $\pm$ 0.67	3.3 $\pm$ 0.27

Scales run from 5 (fresh) to 1 (spoilt) for appearance and textures, and 10 (fresh) to 0 (putrid/nauseating) for odour.

Table 5. Organoleptic assessment of cooked tilapia stored in refrigerated brine at 4°C

Days of storage	Number of panelists	Mean taste-panel scores $\pm$ standard error		
		Odour	Flavour (Taste)	Texture
0	5	10.0 $\pm$ 0.00	9.0 $\pm$ 0.00	4.7 $\pm$ 0.27
4	5	9.6 $\pm$ 0.27	9.0 $\pm$ 0.54	3.2 $\pm$ 0.49
8	16	8.5 $\pm$ 0.53	8.8 $\pm$ 0.25	3.2 $\pm$ 0.33
12	14	8.1 $\pm$ 0.62	8.5 $\pm$ 0.29	2.5 $\pm$ 0.32
16	8	9.3 $\pm$ 0.42	8.4 $\pm$ 0.53	2.2 $\pm$ 0.35
20	17	8.9 $\pm$ 0.34	8.8 $\pm$ 0.27	2.2 $\pm$ 0.27
24	17	9.1 $\pm$ 0.17	7.0 $\pm$ 0.29	2.0 $\pm$ 0.15
28	11	7.3 $\pm$ 0.66	8.2 $\pm$ 0.39	2.3 $\pm$ 0.15
32	14	7.0 $\pm$ 0.59	3.3 $\pm$ 0.43	2.2 $\pm$ 0.27

Scale runs from 10 (fresh) to 1 (putrid/nauseating) for odour and flavour and 5 (fresh) to 1 (sloppy) for texture.

16 days of storage only (Table 3). Gutted samples, judged raw, retained 65–70% freshness even at 32 days (Table 4) but when cooked were acceptable up to (and not beyond) 28 days (Table 5) only. Similar maintenance of good appearance of raw fish in refrigerated brine has been reported by Longard & Regier (1974) also.

The 16-day shelf-life of whole (ungutted) tilapia stored in refrigerated brine at 4°C compares well with shelf-life of 11–16 days in ice reported for some tropical fish species (Crawford & Finch, 1968). The 28-day shelf-life of gutted tilapia stored in refrigerated brine also compares well with values of 21–28 days (Pinegars *et al.*, 1974), and 22–28 days (Clucas & Sutcliffe, 1981) for tilapia stored in ice. Thus refrigerated-brine storage of tilapia is, at least, as efficient as ice-storage. This efficiency is unlikely to be affected by species and size of fish (Nair *et al.*, 1974).

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