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Postharvest quality changes in Bonga (*Ethmalosa fimbriata*) under delayed icing conditions

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ABSTRACT: Investigations on chemical, bacteriological and sensory indices of quality assessment were carried out on Bonga (*Ethmalosa fimbriata*) under delayed icing storage over a period of 24 days. The quality of whole Bonga fish stored in ice was judged on eyes, gills, texture and general appearance. Whole ungutted Bonga was in good condition for 18 days when stored in ice immediately after landing. Delayed icing for 3 hours and 6 hours reduced the shelf life to 10 days and 4 days respectively. Changes in trimethylamine (TMA), total volatile nitrogen (TVN), pH, hypoxanthine (Hx), bacterial flora, cooked odour, flavour and texture were evaluated. TheBonga exhibited a decline in organoleptic quality parameters during storage with concomitant increases in TMA, TVN, pH and bacteria counts.

Key words: Postharvest, Bonga, Tropical fish, Temperate fish, Ice storage.

Introduction

The Bonga (*Ethmatosa fimbriata*) is of great economic importance in the coast areas of Nigeria with an average annual catch of 40,000 metric tones. It is an important food fish and the main stay of the coastal artisanal fishery. Bonga is also a potential raw material for the small scale canning industry outside the traditional hot smoking process. However, Bonga obtained at most landing sites tend to deteriorate rapidly if not properly handled. The short shelf-life of this pelagic clupeid especially when not iced at the appropriate time can render then unsuitable for further processing into value added products except smoking which in most cases is used to retard deterioration.

The use of ice and application of refrigeration are gradually being introduced in the developing fisheries of Africa in response to an increasing demand for fresh fish of good quality. Many tropical fish species from warm waters have been reported to have storage life of 20 to 28 days in ice (Lima dos Santos 1981, Adebona 1981) compared with about 14 days for fish species from temperate waters (Smith *et al.*, 1980). The most widely acceptable explanation for the extended shelf-life of tropical fish species compared to temperate water species is that the relative numbers of psychrophilic and psychrotropic spoilers are lower in tropical species and accordingly confer an extended shelf-life (Shewan, 1977). Furthermore, it has been observed that certain physical and chemical characteristics including the shape, size and fat content, can all combine to influence the length of storage life in ice (Disney, Cole and Jones, 1974, Shewan, 1977). The work reports on sensory, chemical and microbiological changes in Bonga during ice storage and the effects of delayed icing on Bonga obtained from landing sites and its suitability for further processing into value added products.

Materials and Methods

Freshly caught Bonga (*Ethmalosa fimbriata*) fish samples with size range of 135 – 205g and length of 25.5 – 27.5cm were divided into three batches. The first batch was iced immediately after collection. The next two batches were kept at ambient temperature 27 ± 2°C for 3 and 6 hr before they were iced. The ratio of ice to fish weight for weight was not less than1.1 throughout the storage period of the fish, water being drained from hole at the base of the insulated box. Samples were withdrawn at periodic intervals for chemical, microbiological and sensory assessment over a period of 24 days.

Chemical analyses: Trimethylamine (TMA) and Total Volatile Nitrogen (TVN) were determined on trichloroacetic acid (TCA) extracts from 50g of fish by the Conway microdiffusion technique (Conway, 1968). Hypoxanthine (Hx) was determined on neutralized perchloric acid extracts according to the method of Burt, Murray and Stroud (1968). The pH of fish/distilled water macerates was measured using a PYE Unican pH meter.

Microbiological Analyses: Total viable aerobic counts (at incubation temperature of 20°C for 72 hr.) were estimated by plating serial dilutions of fish samples prepared by homogenizing (in Colworth Stomacher) 10g of fish muscle in 90cm^3 of sterile peptone (0.1% w/v) diluents. Surface streaking techniques were employed to obtain a total bacterial count. The hydrogen sulphide (H_2S) producers counts were carried out on peptone iron agar (Jensen and Schultz, 1980). Incubation was at 20°C for 72 hr.

Sensory assessments: The quality of whole Bonga fish stored in ice was judged on eyes, gills, texture and general appearance (Table 1). Eating quality by taste panelists experienced at evaluating fish and fishery products was assessed after steaming about 50g of fillet in a closed dish over boiling water for 35 minutes. The closed dish containing the test sample was kept in a water batch at 60°C throughout each taste panel session. Descriptions were given of odour, flavour and texture of the cooked fish flesh (Table 2). After tasting, the samples were scored using an 8-point hedonic scale. Fish scoring less than 4 for both raw and cooked samples was regarded as unacceptable.

Statistical Analysis: Linear regression analysis was used to determine correlation of parameters with storage time and t-tests used to test for significance at 5% level.

Results and Discussion

Chemical Analysis: The results of trimethylamine (TMA), total volatile nitrogen (TVN) and hydrogen ion concentration (pH) of bonga (*Ethmalosa fimbriata*) stored in ice are presented in Table 3.

TMA values during icing and delayed icing ranged from 0.4 to 1.96mg-N/100g of flesh initially and2.20 to 5.6mg-N/100g of flesh at the end of the storage period. TVN ranged from initial values of 7.6mg-N/100g to 22.7mg-N/100g flesh with values increasing significantly ($P<0.05$) with storage time to between 47.7 and 89.0mg – N/100g flesh at the end of the storage period. The pH ranged from 6.8 to 7.2. Increases in pH values during iced and delayed iced storage treatments were small. At 0hr ice storage, it increased from 6.8 to 7.1 and at 3hr and 6hr delay icing, the increases were from 6.9 to 7.3 and 7.0 to 7.6 respectively.

Table 1: Score card of iced raw whole Bonga (*E. fimbriata*) samples.

Score	Eyes	Gills	Texture	General appearance
Excellent 8	Eyes clear, pink	Gills purple red, some mucus fresh odour	Firm flesh and elastic to touch	Bright opalescent sheen, no bleaching scales and belly intact.
Very Good 7	Eyes clear and slightly pinkish	Gills purple red, some mucus, fresh odour	Firm flesh and elastic	Bright opalescent scales intact, no bleaching
Good 6	Eyesslightly sunken	Gills purple, some mucus	Flesh firm to slightly hard	Loss of bright opalescence, scales slightly intact, no bleaching.
Fairly Good 5	Eyes opaque, sunken	Gills dirty brown, some mucus	Firm flesh and hard	Loss of bright opalescence, slightly loose scales and some bleaching.
Fair 4	Eyes opaque, sunken	Gills dirty brown, much mucus stale odour	Slightly firm flesh, not elastic	Dull skin with loose scales.
Poor 3	Eyes opaque, sunken	Gills dirty brown, much mucus stale odour	Slightly firm flesh, not elastic	Dull skin with loose scales.
Very Poor 2	Eyes very opaque and sunken	Gills very dirty brown, considerable mucus, slightly off-odour	Softer flesh, not elastic	Bacterial discoloration loose scales and dull skin.
Extremely Poor 1	Eyes completely sunken and very opaque	Gills very dirty brown, considerable mucus, off-odour	Very soft flabby and retains finger indentations	Marked bleaching and shrinkage of skin, very loose scales and belly burst.

Table 2: Descriptive terms for organoleptic scoring of cooked bonga (*E. fimbriata*) flesh.

Score	Cooked flavour	Cooked odour	Cooked texture
Excellent 8	Fresh, very sweet flavours characteristics of the species	Strong, fresh pleasant odour	Firm, chewy and succulent
Very Good 7	Very sweet meaty flavour	Fresh pleasant odour	Firm, Chewy and slightly dry slightly firm, dry and chewy
Good 6	Sweet meaty flavour	Lack of odour, neutral bit pleasant	Slightly firm, dry and chewy
Fairly Good 5	Slight sweetness and little flavour but still characteristic of the species.	Neutral but pleasant odour	Slightly soft texture.
Fair 4	Neutral but no off-flavour	Odour neutral	Soft texture and breaks easily
Poor 3	Not bitter but trace of off-flavour	Faint to slightly rancid odours	Very soft and sticky
Very Poor 2	Rancid, sour, off-flavour with bitterness	Rancid, sour lactic acid odours	Very soft and sticky
Extremely Poor1	Strong bitterflavour but not nauseating	Strong acid ammonia odour	Very soft and sloppy texture.

The TMA and TVN values of bonga increased with storage in ice with slight fluctuations. Subsequent delay before storage in ice showed fluctuated values with highest values obtained as delays in icing were extended. However, regression analysis showed significant ($P < 0.05$) correlation between TMA and TVN measurements and storage time for fish immediately iced after landing. The same trend was observed for bonga fish delayed for 3 and 6hr. before icing with their TMA and TVN production against storage time also showing significant ($P < 0.5$) correlation. The changes in TVN content during immediate and delayed ice storage showed similarity to those of TMA in bonga, except that the initial values of TVN were usually much higher. It has been suggested that for marine fish species, TVN values of 30-40mgM/100g of flesh may be taken as an indication that the fish stored in ice immediately after landing reached this level on the 18d of storage (38.63mg N/100g) in ice. Bonga fish delayed for 3 and 6 hr. before icing were above the suggested limit of acceptability 55.9mg N/100g and 50.25mg N/100g on the 10d and 4d respectively.

The suggested limit of acceptability of 5mg N/100g of flesh of TMA (Montgomery, Sidhu and Vale, 1970) was never reached with fish stored immediately after landing. However, fish delayed for 3 and 6hr before ice storage reached the suggested level of acceptability after 10th and 7th days respectively. Despite the trend of increase with storage time, the high within sample variations in TMA and TVN especially in the 3 and 6hr delayed iced fish could be due to the washing effect of ice during storage (Reilly *et al*., 1985). This notwithstanding, this study have shown that the TMA and TVN are suitable chemical quality indices of assessing spoilage of bonga stored in ice.

Hydrogen ion concentration (pH) of most species of fish is between 6.6 and 6.8 immediately after death. The pH of bonga at 0hr., 3hr., and 6hr delayed icing were 6.8, 6.9 and 6.9 respectively. pH values provide an index of bacteria spoilage. As spoilage progresses, basic end products produced as a result of bacteria action on trimethylamine oxide (TMAO) and other amines, particularly ammonia, accumulate, causing the pH of the flesh to rise. The highest hydrogen ion concentration (pH) values recorded at point of rejection in this study were 7.2, 7.3 and 7.4 for 0, 3 and 6hr delay in ice respectively. It has been observed that in stale or putrid fish, the pH attains a value of 7.5 or 8.0 in extreme spoilage (Connell, 1995).

Table 3: Trimethylamine (TMA), total volatile nitrogen (TVN)and hydrogen ion concentration (pH) content of Bonga (*Ethmalosa fimbriata*) stored in ice after 0, 3 and 6hr delay at ambient temperature.

Storage days in ice	TMA/TVN (mg-N/100g)								
	0hr.			3hr.			6hr.		
	TMA	TVN	pH	TMA	TVN	pH	TMA	TVN	pH
0	0.41±0.03	7.60±0.29	6.8	1.52±0.03	9.8±0.37	6.9	1.96±0.15	22.67±1.83	6.9
4	0.98±0.01	14.63±0.45	6.7	1.49±0.03	28.03±1.03	7.0	1.89±0.06	50.25±0.58	7.1
7	0.94±0.05	15.30±0.46	6.8	2.10±0.14	21.03±0.95	6.9	5.95±0.22	48.26±0.85	7.2
10	1.21±0.04	21.08±1.44	6.8	4.93±0.13	55.90±0.22	7.1	5.56±0.26	88.98±1.18	7.4
13	1.03±0.09	20.59±1.07	6.9	5.89±0.23	42.14±0.47	7.1			
15	2.03±0.13	20.97±1.14	7.0	3.90±0.25	85.50±1.43	7.3			
18	1.96±0.10	38.63±1.04	7.1						
21	2.11±0.10	49.29±1.30	7.2						
24	2.20±0.15	47.74±0.47	7.2						
Mean	1.43±0.22	26.20±5.05	6.94	3.31±0.77	40.40±11.17	7.05	3.84±1.11	52.54±13.68	7.15
Correlation coefficient "r"	0.93	0.93	0.93	0.81	0.87	0.85	0.85	0.93	0.99

Each result is mean ± standard deviation of triplicate determinations.

Table 4: Standard plate count (SPC) and H_2S producers count of Bonga (*E. fimbriata*) with 0, 3 and 6hr delayin ice andsubsequent storage.

Days in ice	0hr.				3hr.				6hr.			
	SPC	Log No.	H_2S producers	Log No.	SPC	Log No.	H_2S producers	Log No.	SPC.	Log No.	H_2S producers	Log No.
0	$2.1x10^3$	3.32	$2.0x10^1$	1.3	$2.5x10^4$	4.4	$3.4x10^2$	2.53	$5.5x10^5$	5.74	$5.6x10^4$	4.75
4	$2.5x10^3$	3.40	$2.1x10^2$	2.32	$1.8x10^5$	5.26	$3.2x10^3$	3.51	$7.2x10^7$	7.86	$3.1x10^6$	6.49
7	$5.9x10^4$	4.77	$3.8x10^3$	3.58	$2.7x10^6$	6.43	$7.8x10^4$	4.89	$9.1x10^8$	8.96	$3.8x10^7$	7.58
10	$7.9x10^5$	5.90	$4.2x10^4$	4.62	$3.1x10^7$	7.49	$6.2x10^5$	5.79	$7.8x10^9$	9.89	$2.6x10^8$	8.42
13	$2.8x10^6$	6.45	$7.5x10^4$	4.88	$4.2x10^8$	8.62	$1.8x10^6$	6.26				
15	$7.6x10^6$	6.90	$7.5x10^5$	5.88	$7.2x10^9$	9.86	$4.5x10^7$	7.65				
18	$2.8x10^7$	7.45	$3.4x10^6$	6.53								
21	$6.7x10^8$	8.83	$7.9x10^6$	6.90								
24	$2.1x10^9$	9.32	$2.1x10^7$	7.32								

Table 4:

This study has shown a very strong correlation between pH and storage time as well as relating pH with general appearance sensory of raw Bonga.

Microbiological changes: Changes in standard plate count (SPC), Hydrogen Sulphide (H_2S) producers and log numbers are presented in Table 4. The initial values for SPC were 10^3, 10^4 and 10^{5CFU}/g for 0, 3 and 6hr delay in ice respectively. On rejection, SPC's were 10^9/g for fish immediately iced and fish delayed for 3hr and 10^8/g for fish delayed for 6hr before icing. The values for H_2S producers were 10^1, 10^2 and 10^4/g for 0, 3 and 6hr delay respectively. On rejection, H_2S – producers of 10^7/g were recorded for fish delayed for 0 and 3hr and 10^8/g for fish delayed for 6hr.

The log numbers showed initial values of 3.32, 4.40 and 5.74 for 0, 3 and 6hr delay in ice respectively with significant ($P < 0.05$) changes during storage to values of 9.32, 9.86 and 9.89 for the 0. 3 and 6hr delay in icing respectively. The log bacteria counts of H_2S – producers showed initial values of 1.3, 2.53 and4.75 for 0, 3 and 6hr respectively. There were significant ($P < 0.5$) changes during delay in ice storage to values of 7.32, 7.65 and 8.42 respectively.

The standard plate count (SPC) and Hydrogen Sulphide (H_2S) producers of bonga iced immediately after landing revealed an initial lag phase lasting 4 days followed by a significant increase over the storage period in ice from 10^3 – 10^9 and 10^2 – 10^7 for SPC and H_2S – producers respectively. Bonga fish delayed for 3 and 6hr at ambient temperature before icing showed no lag phase. The lag phase exhibited in bonga fish iced immediately was due to suppression of mesophilic organisms at the initial stage compared to the bonga samples left at ambient temperature, which will help, in their faster growth. Based on the limits of 10^7 cfu/g specified for quality grading of seafood by the International Commission of Microbiological Specifications for Foods (ICMSF, 1978), the 0. 3 and 6hr delay in ice fish samples were acceptable at 18, 10 and 4 days respectively. This study have shown that bonga have a storage life in ice of 18 days. The results for fish iced immediately after landing and those delayed for 3hr and 6hr before ising agreed with the observations of Liston (1982), in that H_2S producers count exceeded 10^6 cfu/g on rejection.

Sensory assessments: The mean sensory scores of six panelists experienced at evaluating fish and fishery products for whole fresh Bonga stored in ice are presented in Table 5. Fish iced at zero days displayed all the characteristics of a freshly caught fish with a score of 7.0 from a maximum of 8.0. The eyes were clear and bulging, gills purple-red with some mucus and the flesh was firm and elastic. The general appearance showed a bright opalescent fish with scales intact and no trace of bleaching. An average score of 4.0 was recorded on the 18th day, a score regarded as the last limit of acceptability. After the 18th day, changes in the various attributes were much more pronounced. The eyes were sunken, the gills dirty brown with much mucus and stale odour. The flesh was slightly firm without any elasticity and the skin was dull with loose scales. By the 24th day in ice, the mean panelists score had declined from 7.0 to 3.0.

All the sensory attributes of the raw Bonga gave significant ($P < 0.05$) correlation with days of storage in ice Rejection of raw Bonga using the hedonic scale of 4 and below as level of unacceptability by the panelists was mainly characterized by sunken eyes, very soft flesh which retained finger indentation, dirty brown gills with "off-flavour" and a general appearance marked with bleaching, shrinkage of the skin and loose scales. Using the hedonic scale of 4.0 and below as the limit of unacceptability, the shelf-life of Bonga in ice was 18 days. The shelf-life of fish in ice is a function of so many factors including method of capture, the location of the fishing ground, the season of the year, size of the fish and conditions under which the experiment was carried out (Clucas and Ward, 1996).

The long shelf-life of tropical fish has considerable practical and commercial implications. Fish caught close to population centres where only a few days storage life is necessary before marketing need not necessarily be maintained at 0°C. However, whereas up to three to fours weeks are needed for transport and distribution of the fish, chilled storage may be preferably to frozen storage to ensure retention of quality.

The cooked flavour, odour and texture scores of Bonga samples stored in ice at 0hr, 3hr and 6hr, delay in ice as well as the correlation coefficients "r" are presented in Table 6 (section A, B and C). The results show that Bonga stored in ice at zero hr has a flavour characteristic of the species and a very strong meaty flavour was still adjudged to be fairly good with a score of 4.4 on the 18th day and an accompanying slight sweetness and little flavour still characteristic of the species. Delay at ambient temperature for 3 hr before icing make the cooked flavour of Bonga before icing showed no rancid and bitter taste but some traces of off-flavour were noticeable after the 7th day with a score 4.3.

Table 5: Panelists mean sensory scores for whole fresh Bonga (*E. fimbriata*) stored in ice.

Storage time in ice (Days)	Eyes	Gills	Texture	General appearance
0	7.0±0.50	6.9±0.67	6.8±0.63	7.5±0.58
4	7.0±0.67	6.8±0.69	6.6±1.02	7.0±0.76
7	6.9±0.67	6.6±0.84	6.3±0.63	6.8±0.48
10	6.5±0.50	6.0±1.29	5.8±0.95	6.6±0.67
13	5.8±0.63	5.4±0.98	5.6±0.89	5.9±1.06
15	4.8±0.85	4.6±1.06	5.2±0.94	4.7±1.11
18	4.7±0.69	4.0±1.26	4.2±0.85	4.3±0.96
21	4.3±1.40	4.1±0.99	4.1±1.27	4.0±1.26
24	3.5±1.29	3.0±1.08	3.4±1.40	3.0±1.04

The cooked odour scores of Bonga showed a fresh, pleasant odour at 0hr in ice with a score of 7.0 indicating a very good product. There was a gradual decline from these characteristics up to the 13th day (score 5.0). Delaying the fish for 3hr before icing showed similar trend to that of cooked flavour, from a score of 6.8 to a gradual decrease to 4.4 on the 13th day. At this point, the odour was neutral. When Bonga was delayed for 6hr before icing, the cooked odour scores were between 5.7 and 4.2, which indicate lack of odour to a neutral odour respectively. Cooked odour after 0, 3 and 6hr delayed icing were acceptable for 12, 15 and 10 days respectively.

The cooked texture score at 0hr icing was 7.5, with firm chewy and succulent attributes. Slightly soft texture was noticeable after 15th day storage in ice. Delay in ice for 3hr gave slightly firm, dry and chewy texture at zero days with a score of 6.1 and soft sticky texture on the 13th day (score 4.6). When bonga was delayed for 6hr before icing, the limit of acceptability (score 4.0 was reached on the 10th day, with soft texture and the flesh breaking easily.

Sensory attributed of cooked samples of bonga, which include flavour, odour and texture, gave significant ($P < 0.05$) correlation with storage time. The cooked flavour for Bonga iced immediately after landing, was acceptable up to the 15 days. When icing was delayed for 3 and 6hr before icing the cooked flavour was only acceptable up to and inclusive of 13th day and 7th day respectively.

The cooked odour was acceptable up to the 18th, 13th and 10th days at 0, 3 and 6hr delay in ice respectively. The cooked texture was acceptable up to the 15th dat at 0hr delay icing and 10d at 3 and 6hr delay icing. Similar findings were reported for Tilapia (*Oreochromis niloticus*), Mackerel (*Rastrelliger fanghni*) and Silver belly (*Leiognathus spp.*) (Saluan-Abdulhasan, 1989; Barile *et al*., 1985; Jayaweera, 1980). These authors similarly observed that spoilage of the fish began after 6-8hr at ambient temperature of between 28-30°C. The strong correlation of cooked flavour, odour and texture scores against storage time is an indication of the suitability of visual and organoleptic changes as quality indices in Bonga. The deficiencies of olfactory and organoleptic assessment are the reliance upon a subjective judgement and the range of individual preference.

The correlation between cooked flavour, cooked odour and cooked texture scores and storage time were analysed and the correlation coefficient "r" for the three parameters at 0, 3 and 6hr delay icing were very strong and significant at $P < 0.05$.

Table 6:

Table 6: Panelists mean sensory scores for cooked Bonga (*E. fimbriata*) and storage time with delays in icing.

SECTION	A			B			C		
	Cooked flavour			Cooked Odour			Cooked Texture		
Storage days in ice	**0hr.**	**3hr.**	**6hr.**	**0hr.**	**3hr.**	**6hr.**	**0hr.**	**3hr.**	**6hr.**
0	7.6±0.54	6.1±0.89	5.5±1.26	7.0±0.65	6.8±0.62	5.7±1.11	7.5±0.41	6.1±0.98	5.6±1.30
4	6.5±0.87	5.7±0.85	4.6±1.21	6.9±0.84	6.4±0.70	4.7±1.31	6.9±0.67	5.6±1.02	4.7±1.70
7	6.5±1.04	5.5±1.04	4.3±1.11	6.6±0.98	6.0±0.87	4.4±0.79	6.5±0.50	5.7±0.99	4.6±0.98
10	5.5±1.26	4.9±1.17	4.0±0.82	5.5±1.00	5.7±0.75	4.2±0.94	6.3±0.85	5.0±0.58	4.0±0.58
13	5.1±1.01	4.5±1.10	3.5±0.76	5.0±1.00	4.4±0.98	3.2±1.11	5.4±1.00	4.6±0.89	3.8±1.18
15	4.6±1.15	4.2±0.69		4.5±0.71	4.3±1.18		4.8±0.62	4.4±0:67	
18	4.4±0.67	3.6±0.89		4.2±0.90	3.0±1.16		4.1±1.13	3.4±0.67	
21	4.0±0.96			4.2±0.94			4.2±0.55		
24	2.5±0.58			2.9±0.84			2.5±0.41		
Cor. Coef. “r”	-0.99	-0.96	-0.99	-0.98	-0.95	-0.99	-0.99	-0.96	-0.95

Each result is Mean ± standard deviation of six panelist response on a scale where 8 = excellent; 7 = very good; 6 = good; 5 = fairly good; 4 = fair; 3 = poor; 2 = very poor and 1 = extremely poor.

Conclusion

This study has shown that bonga can have a shelf-life of 18 days if stored in ice immediately after landing. This long shelf-life has several important commercial implications for the bonga fisheries which is the mainstay of the small scale fishery. The use of ice would permit the distribution of this fish over long distances for further processing into value added products outside the traditional smoked fish products. The use of these chemical indices in the measurement of quality in this particular study was found to be suitable for bonga especially for those stored in ice throughout the study period but may prove to be not so much sensitive when there was delay before ice storage.

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