Annals Agric. Sci., Ain Shams Univ., Cairo, 47(2), 723-744, 2002

QUALITY INDICES OF FARMED BOLTI FISH AS AFFECTED BY MODIFIED ATMOSPHERE PACKAGING

[46]

Nessrien[1], M. Yasin; I.M. Hassan[1]; A.A. Abou-Arab[1] and M.F. Khallaf[1]

ABSTRACT

The effects of modified atmosphere packaging (MAP) on the quality characteristics of Egyptian farmed bolti fish samples (*Oreochromis niloticus*) throughout storage at 2 °C ± 2 were studied. Extending of investigated sample's shelf – life as affected by suggested (MAP) treatments was also considered. DARTEK F-101 forming nylon film was used for packaging fish samples under 50 % CO_2 + 50 % air (CA), 50 % CO_2+50 % N_2 (CN) and 50 % CO_2+25 % N_2+25 % O_2 (CNO). Proximate chemical composition, physical, microbial and chemical quality indices as well as sensory evaluation showed that, (CN) and (CNO) treatments had the longer shelf –lives (35 and 33 days, resp.) compared with CA one (31 days) and control sample (16 days). Strong correlation was observed between sensory attributes and TVB-N as well as putrescine and cadaverine. So, such parameters could be used as quality indices for refrigerated bolti fish either packaged under modified atmosphere or not.

Key words: Bolti fish, Refrigeration, Modified atmosphere packaging, TVB-N (Total Volatil Basic Nitrogen), Biogenic amines, Sensory evaluation, TBA (Thiobarbituric acid)

INTRODUCTION

Fresh fishes are highly perishable and susceptible to spoilage. Iced or refrigerated fishery products had a short shelf-life (5-10 days) depending on species, harvest location, handling, etc... Only a small percentage of fishery products are freshly marketed at retail level. Researches on the extending shelf- life of fresh fish by refrigeration, freezing, irradiation, irradiation + refrigeration were carried out by many investigators (**Al-Kahtani *et al* 1996 and Yasin 1997**). These methods caused some changes in the quality characteristics of fish during storage. Nowadays, researches are being directed toward the use of modified atmosphere packaging (MAP) along with refrigeration to increase the shelf – life of fresh fishery products because of consumer demand and to facilitate marketing capabilities (**Reddy *et al* 1992 and Rodriguez *et al* 2001**). The use of low temperature storage that combined with (MAP) using various levels of CO_2 extends the shelf – life of fresh fishery products by reducing growth of spoilage

1- Food Science Department, Faculty of Agriculture, Ain Shams University, Shoubra El-Kheima, Cairo, Egypt.

(Received August 31, 2002)
(Accepted September 30, 2002)

bacteria. In case of packaged products, in which physical or chemical deterioration is related to its equilibrium moisture content, the barrier properties of the packages relating to water vapor will be of major importance in maintaining or extending the shelf- life. Similarly, the change in oxygen concentration in a permeable package will directly affect the oxidation rate of oxygen- sensitive nutrients such as vitamins, unsaturated fatty acids and proteins.

Thus, the aim of this investigation was carried out to shed light on the effects of different modified atmospheres packaging (MAP) on the quality characteristics of farmed bolti fish during cold storage as well as extending their shelf – lives.

MATERIAL AND METHODS

1. Fish samples

A batch (50 kg) of farmed Nile bolti fish samples (*Oreochromis niloticus*) were freshly obtained from El – Manzala fish farm, Dakahlia governorate, Egypt. The average weight of any given stored samples was about 170 g. Washing, evisceration, scaling, rewashing and draining treatments were thoroughly applied.

2. Packaging materials

High-density polyethylene (HDPE) sheets were purchased from Egyptian local market. DARTEK F-101 forming nylon film produced by DuPont Canada Inc. (Packaging, 201 South Blair St., Whitly, Ontario LIN 556) was obtained from Arabic Company for Drug Packages, Cairo, Egypt. Both of HDPE and forming nylon sheets were analyzed using GC-6000 Vega Series 2, available at Food Industries Development Center, Kaha, Kaluobia Governorate to determine water vapor transmission, oxygen permeability, elongation and tensile strength properties (Table 1).

3. Modified packaging treatments

Bolti fish samples were packed in DARTEK F-101 nylon bags. The following modification treatments of packaging atmosphere were applied using Gas Injection and Soap Flow Meter technique (Audionvas VM 301G) available at Agricultural Research Center, Giza, Egypt.

Table 1. Properties of the investigated packaging materials

Packaging materials	Water vapor Transmission (g/m^2 /24 h.)	Oxygen permeability (cc/m^2 /24 h.)	Elongation (%)	Tensile strength (kg/cm^2)
HDPE	3.55	4230	711 MD	194 MD
			312 TD	163.8 TD
DARTEK	2.95	54.3	300 MD	663 MD
			300 TD	663 TD

MD: Mechanical direction. TD: transfer direction

1- Untreated packaged sample as control (c)
2- Packaged in 50% CO_2 + 50% air (CA)
3- Packaged in 50% CO_2 + 50% N_2 (CN)
4- Packaged in 50% CO_2 + 25% N_2 + 25% O_2 (CNO)

All treatments were refrigerated and analyzed during storage at 2 °C ± 2 up to their organoleptic rejection.

4. Analytical methods

The remaining flesh after removing heads, tails and backbones was minced twice and subjected to chemical and physical analysis. Five replicates were taken (each replicate consists of two units of fish).

4.1. Chemical analysis

Moisture, protein (N x 6.25) and ash contents were carried out according to the **A.O.A.C. (1990).** The method of Bligh and Dyer (1959) was applied to determine the total lipid content. Thiobarbituric acid test (TBA) was colorimetrically measured (at 538 nm.) according **to Harold *et al* (1987).** Total Volatile Basic-Nitrogen (TVB-N) was also calculated using the method described by **Harold *et al* (1987).** Six biogenic amines were extracted and determined by the method of **Mietz and Karmas (1978).**

4.2. Physical methods

pH value was measured using the method of **Pearson *et al* (1976).** Water holding capacity (WHC) and plasticity were determined according **to Grau and Hamm (1957)** method as modified by **Voloviskaya and Kelmen (1962).**

4.3. Microbial analysis

Total aerobic count was carried out after incubation at 37°C / 48 h **(Hayes 1992).** Meanwhile, the method **of Freeman (1981)** was applied to determine the total anaerobic count. Pseudomonas count was identified after incubation at 25 °C/ 3 days **(Randell *et al* 1995).** All microbial counts are given as CFU/g.

4.4. Organoleptic evaluation

Treated samples were organoleptically evaluated by 15 panelists to evaluate appearance, color of gills, eyes lustrous, odor, texture and overall acceptability. A 9- point hedonic scale was used **(Jhaveri *et al* 1982).**

5. Statistical analysis

The Statistical Analysis System **(SAS, 1996)** was used to carry out an overall analysis of variance (ANOVA), LSD (0.01) test, Duncan's multiple range test and correlation coefficients .

RESULTS AND DISCUSSION

To study the effect of (MAP) on the quality of cold stored Nile bolti fish, the present work was classified into five items as follow:

1. Proximate chemical composition

As a general, moisture, protein and ash contents were significantly ($P<0.01$) lowered during subsequent cold storage. The lipid content was significantly ($P<0.01$) enhanced under the same conditions of different investigated stored treatments (Table 2). After 16 days

Table 2. Proximate chemical composition (on dry basis) of differently treated Nile bolti fish samples stored at 2 °C ± 2

Treatments* & Constituents	Storage time (days)							
	Zero	4	8	16	24	31	33	35
C:								
Moisture %	77.40±0.13 Aa	75.60±0.16 B	74.58±0.15 Cc	73.50±0.14 Dc Φ	----------	----------	------	--------
Protein %	84.40±0.05 Ab	81.37±0.04 B	76.82±0.11 Cd	73.57±0.21 De	----------	----------	------	--------
Fat %	10.70±0.0 Da	14.25±0.15 C	19.00±0.01 Ba	22.85±0.03 Aa	----------	----------	------	--------
Ash %	4.93±0.02 Aa	4.43±0.02 B	4.18±0.04 Cb	3.60±0.01 Db	----------	----------	------	--------
CA:								
Moisture%	77.60±0.06 Aa	----------	76.50±0.17 Ba	74.55±0.09 Cb	73.80±0.12 Da	72.14±0.17 E Φ	------	--------
Protein %	84.89±0.03 Aa	----------	77.98±0.14 Bc	75.84±0.08 Cc	74.12±0.10 Dc	73.20±0.09 E	------	--------
Fat %	10.19±0.03 Eb	---------	17.75±0.01 Db	20.51±0.02 Cc	22.80±0.00 Ba	24.59±0.03 A	------	--------
Ash %	5.02±0.02 Aa	----------	4.31±0.03 Ba	3.66±0.03 Cb	3.03±0.02 Db	2.18±0.02 E	------	--------

Table 2. Cont.

Treatments* & Constituents	Storage time (days)							
	Zero	4	8	16	24	31	33	35
CN:								
Moisture%	77.55±0.31 Aa	----------	75.96±0.08 Bb	75.18±0.09 Ca	74.23±0.14 Da	----------	-------	71.16±0.3 EΦ
Protein %	84.95±0.01 Aa	----------	81.63±0.21 Ba	79.28±0.14 Ca	77.26±0.08 Da	----------	-------	74.37±0.2 E
Fat %	10.16±0.01 Eb	---------	14.13±0.01 Dd	16.93±0.02 Ce	19.53±0.02 Bc	----------	-------	23.30±0.4 A
Ash %	4.95±0.02 Aa	----------	4.27±0.02 Ba	3.78±0.02 Ca	3.17±0.02 Da	----------	-------	2.40±0.00 E
CNO:								
Moisture%	77.46±0.27 Aa	----------	76.19±0.16 Bab	74.77±0.07 Cb	73.40±0.11 Db	----------	72.34±0.15 E Φ	-------
Protein %	84.94±0.02 Aa	----------	80.71±0.15 Bb	78.17±0.16 Cb	75.41±0.18 Db	----------	73.19±0.09 E	-------
Fat %	10.19±0.03 Eb	---------	14.43±0.04 Dc	18.20±0.00 Cd	21.68±0.03 Bb	----------	24.05±0.02 A	-------
Ash %	4.99±0.04 Aa	----------	4.27±0.01 Ba	3.56±0.01 Cb	2.88±0.04 Dc	----------	2.13±0.02 E	-------

* See Materials and Methods
Means ± Standard error
Φ: At these points samples were organoleptically rejected
Means with the same capital letters in the same line are not significantly different (P>0.01)
Means with the same small letters in the same column for the same attribute are not significantly different (P>0.01)

storage (control rejected), moisture loss percentage was 5.0, 3.9, 3.05 and 3.4 % for C, CA, CN and CNO treatments, resp. The corresponding loss percentage of protein content was 12.8, 10.66, 6.6 and 7.97%. Such loss of moisture during cold storage was due to the reduction of moisture- binding capacity, while, the protein content decrease may be due to drip loss (**Reddy *et al* 1994**). On the other hand, the presence of CO_2 could be considered as a good explanation for minimizing moisture and protein losses during cold storage (especially in CN treatment) because of its effect in reducing drip loss. (**Hong *et al* 1996**).

The lipid content that around 10 % at zero time storage was significantly ($P<0.01$) increased on dry weight basis up to the end of various storage periods (Table 2) which may be due to the progressive loss in soluble proteins as well as moisture and ash contents. All investigated samples had about 5% ash at zero time then decreased significantly ($P<0.01$) during cold storage due to the leaching out of soluble nitrogenous compounds, water soluble vitamins and water soluble minerals, etc.... in the resultant drip (**Yasin 1997**)

Statistical analysis proved that no significant differences ($P>0.01$) between (CA), (CN) and (CNO) were detected in moisture content contrary to those of protein and lipid contents which significantly ($P<0.01$) differed among all tested treatments (Table 3).

2. Physical properties

The normal curve of pH values (correction shape) could be easily noticed in stored control sample (Table 4). A slight significant ($P<0.01$) decrease in pH value of control samples after 4 days of storage may be attributed to the relationship between post mortem stage of fish and the formation of lactic acid by soluble muscle enzymes (**Bilinski and Jonas 1975**). On the other hand, the continuos significant ($P<0.01$) increase of pH values during subsequent cold storage may be attributed to the production of volatile basic compounds (**Stammen *et al* 1990**). Both (CA) and (CN) treatments almost showed the same values up to 24 days (Fig. 1), then slightly reduced at the end of their storage periods due to the dissolution of CO_2 into the fish muscles (**Reddy *et al* 1995**) and / or to the growth of lactic acid bacteria, especially under anaerobic conditions.

A significant ($P<0.01$) progressive decrease in WHC values during subsequent cold storage in all treatments was observed (Table 4 and Fig. 2). This is possibly due to protein denaturation and / or aggregation (**Gelman *et al* 1990**). However, a relative slight decrease that noticed in WHC values of (CNO) samples may be related to the corresponding slight increase in pH value from zero up to 16 days (**Hong *et al* 1996**). A proportional relationship between the WHC and cold storage was also noticed (Table 4).

On the other hand, (CN) sample showed a higher plasticity value when compared with other treatments (Table 5), which may be due to the effect of modified atmosphere in retarding the formation of lipid oxidation products that able to denature proteins and consequently reduce tenderness (**Gelman *et al* 1990 and Randell *et al* 1995**).

Table 3. Effect of different treatments on the chemical composition (on dry basis) of Nile bolti fish stored at 2 °C ± 2/16 days

Treatments*	Responded values			
	Moisture %	Protein %	Fat %	Ash %
C	75.16 B	78.27 D	17.52 A	4.24 B
CA	76.22 A	79.56 C	16.15 B	4.33 A
CN	76.23 A	81.95 A	13.74 D	4.34 A
CNO	76.14 A	81.27 B	14.27 C	4.29 B
LSD	0.26	0.19	0.05	0.06

* See materials and methods
Means with the same letter in the same column are not significantly different (P>0.01).

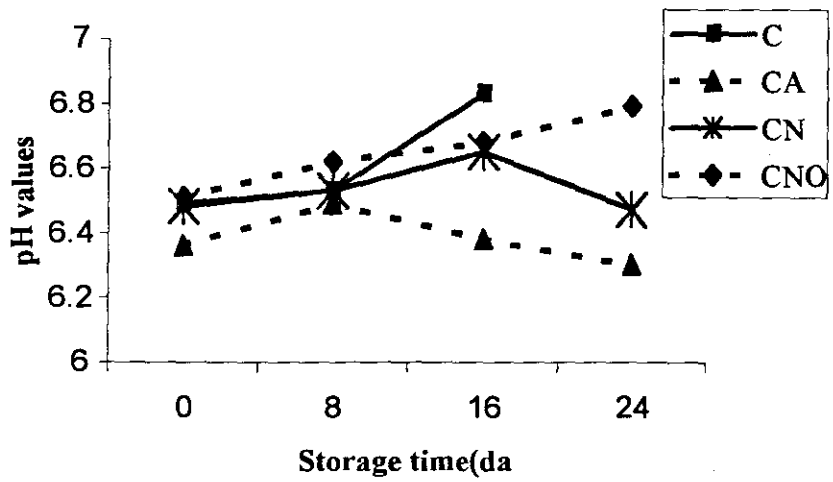

Fig 1. pH values of differently treated Nile bolti fish samples stored at 2 ° C ±2.

Table 4. Physical properties of differently treated Nile bolti fish samples stored at 2 ° C ± 2.

Treatments* & Physical Aspects	Storage time(days)							
	Zero	4	8	16	24	31	33	35
C								
pH	6.49±0.01 Cb	6.04±0.01 D	6.53±0.01 Bc	6.83±0.02 AbΦ	----------	----------	--------	--------
WHC**	9.47±0.33 Cb	11.28±0.35 B	12.45±0.3 Ab	13.26±0.38 Adc	----------	----------	--------	--------
Plasticity**	2.77±0.09 Ba	3.44±0.06 A	2.77±0.09 Bcb	2.32±0.08 Ccb	----------	----------	--------	--------
CA								
pH	6.36±0.01 BCd	----------	6.49±0.01 Ad	6.38±0.04 Bd	6.30±0.01 Cc	6.09±0.03 DΦ	--------	--------
WHC**	9.47±0.32 Db	----------	10.35±0.18 Cc	14.08±0.25 Bbc	16.44±0.36 Aa	14.29±0.21 B	--------	--------
Plasticity*	2.77±0.09 Aa	----------	2.59±0.11 Ac	2.50±0.16 Aab	2.10±0.05 Bb	2.06±0.09 A	--------	--------
CN								
pH	6.48±0.00 Cbc	----------	6.53±0.00 Bc	6.65±0.02 Ac	6.47±0.02 Cb	----------	--------	6.12±0.0 DΦ
WHC**	8.61±0.31 Db	----------	12.05±0.24 Cb	14.51±0.34 Bb	15.74±0.26 Aa	----------	--------	14.0±0.2 B
Plasticity**	2.77±0.03 Ba	----------	3.16±0.12 Aa	2.77±0.09 Ba	2.44±0.03 Ca	----------	--------	2.07±0.1 D

Table 4. Cont.

Treatments* & Physical Aspects	Storage time(days)							
	Zero	4	8	16	24	31	33	35
CNO								
pH	6.51±0.02 Ea	----------	6.62±0.00 Db	6.68±0.02 Cc	6.79±0.01 Ba	----------	7.0±0.9 AΦ	--------
WHC**	8.44±0.34 Db	----------	10.35±0.18 Cc	12.85±0.25 Bd	14.81±0.19 Ab	----------	13.1±0 B	--------
Plasticity**	2.77±0.09 Ba	----------	3.06±0.12 Aab	2.49±0.09 Bab	2.17±0.07 Cb	----------	2.1±0.8 C	--------

* See Materials and Methods

** Calculated as cm^2/0.3 g

Means ± Standard error

Φ: At these points samples were organoleptically rejected.

Means with the same capital letters in the same line are not significantly different ($p > 0.01$)

Means with the same small letters in the same column for the same attribute are not significantly different ($p > 0.01$)

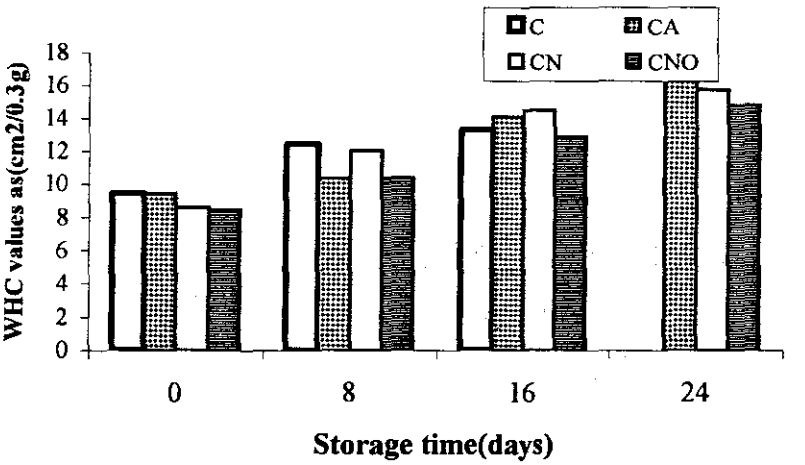

Fig 2. Mean values of WHC (as cm^2/0.3 g) of differently treated Nile bolti fish stored at 2 ° C± 2

Table 5. Effect of different treatments on physical properties of Nile bolti fish stored at 2°±2.

Treat-	Responded values		
ments*	pH	WHC	Plasticity
C	6.60A	11.73A	2.62 B
CA	6.41 C	11.30A	2.62 B
CN	6.55 B	11.73A	2.90 A
CNO	6.60 A	10.55B	2.78AB
LSD	0.03	0.47	0.16

* See Materials and Methods
Means with the same letter in the same column are not significantly different (P>0.01).

3. Microbiological properties

The general incremental trend in total plate count T.P.C. that was easily detected during cold storage of various investigated samples (Tables 6 and 7) is mainly due to the growth of psychrophilic bacteria. However, bacterial counts of (CA), (CN) and (CNO) treatments that increased with slower rate could be attributed to either the bacteriostatic effect of CO_2 or the presence of low levels of O_2. This pattern was generally agreed with the opinion of **Dalgaard *et al* (1993).**

During cold storage, the growth of total anaerobes in samples packaged either in 100% air or modified atmosphere was slightly different, a trend that may be due to the presence of CO_2 in modified atmosphere **(Reddy *et al* 1995)**. However, (MAP) samples had a lower growth of pseudomonas level up to 16 days of cold storage (Table 6 and 7). From these Tables it could be concluded that, there was significant (P<0.01) difference between control sample and other modified atmosphere packaged samples in total plate count (T.P.C.), anaerobic plate count (An.P.C.) and pseudomonase count (P.C.). On the other side, no significant effect (P>0.01) was observed between

Table 6. Total plate count (T.P.C.), total anaerobic plate count (An.P.C.), and Pseudomonas count (P.C.) of Nile bolti fish packaged in different modified atmosphere during storage at 2 ° C ± 2 .

Treatments*	Storage time (days)							
	Zero	4	8	16	24	31	33	35
C:								
T.P.C.	$13.3x10^3$	$38x10^3$	$2700x10^3$	$213000x10^3$	----------	----------	----------	----------
	$\pm3.30x10^3$	$\pm4.6X10^3$	$\pm880x10^3$	$\pm 880 x10^3$				
	Ca	C	Ba	AaΦ				
An.P.C.	$2.00x10^3$	$19X10^3$	$51 x10^3$	$390000 x10^3$	----------	----------	----------	----------
	$\pm0.3x10^3$	$\pm2X10^3$	$\pm2 x10^3$	$\pm3100 x10^3$				
	Bc	B	Bb	AaΦ				
P.C.	$3.80x10^3$	$17 X10^3$	$390 x10^3$	$560000 x10^3$	----------	---------	---------	--------
	$\pm0.1x10^3$	$\pm1.7X10^3$	$\pm0.3 x10^3$	$\pm3300x10^3$				
	Bb	B	Bb	AaΦ				
CA:								
T.P.C.	$5.60x10^3$	----------	$410 x10^3$	$2000 x10^3$	$7500 x10^3$	$8000 x10^3$	----------	----------
	$\pm2.1x10^3$		$\pm14 x10^3$	±0.00	$\pm1400x10^3$	$\pm1100x10^3$		
	Bb		Bb	Bc	Aa	AΦ		
An.P.C.	$3.70x10^3$	---------	$110 x10^3$	$3000 x10^3$	$8000 x10^3$	$8300 x10^3$	----------	---------
	$\pm0.9x10^3$		$\pm20 x10^3$	$\pm570 x10^3$	±0.00	$\pm1200x10^3$		
	Ccb		Cab	Bb	Aa	AΦ		
P.C.	$4.70x10^3$	----------	$47 x10^3$	$4000 x10^3$	$13000 x10^3$	$15000 x10^3$	----------	---------
	$\pm0.1x10^3$		$\pm12 x10^3$	$\pm0.1x10^3$	$\pm2500 x10^3$	$\pm2800x10^3$		
	Bab		Bc	Bc	Aa	AΦ		

Table 6. Cont.

Treatments*	Storage time (days)							
	Zero	4	8	16	24	31	33	35
CN:								
T.P.C.	$6.50x10^3$	----------	$10 x10^3$	$8700 x10^3$	$4500 x10^3$	----------	----------	13000000
	$\pm 2.8x10^2$		± 0.00	$\pm 6600x10^3$	$\pm 280 x10^3$			± 3300000
	Bb		Bb	ABc	ABa			AΦ
An.P.C.	$8.00x10^3$	---------	$2 x10^3$ Dc	$1500 x10^3$	$3000 x10^3$	----------	----------	9500000
	± 0.00		$\pm 0.6 x10^3$	$\pm 290x10^3$	$\pm 2 x10^3$			± 280000
	Da		Dc	Cb	Bb			AΦ
P.C.	$4.70x10^3$	----------	$1.80 x10^3$	$1270 x10^3$	$2600 x10^3$	----------	----------	90000000
	$\pm 0.3x10^3$		$\pm 0.4 x10^3$	$\pm 130x10^3$	$\pm 230 x10^3$			± 5700000
	Bab		Bd	Bd	Bb			AΦ
CNO:								
T.P.C.	$0.37x10^3$	----------	$2.17 x10^3$ Bc	$550 x10^3$	$6000 x10^3$	----------	$6500 x10^3$	--------
	± 33.0		± 88	$\pm 28x10^3$	± 0.00		$\pm 2000x10^3$	
	Bc			Bd	Aa		AΦ	
An.P.C.	$6.00x10^3$	----------	$2.3 x10^3$ Dc	$2500 x10^3$	$4000 x10^3$	----------	$6000 x10^3$	----------
	$\pm 2.0x10^3$		$\pm 0.6 x10^3$	$\pm 280x10^3$	$\pm 570 x10^3$		$\pm 0.3 x10^3$	
	Dab			Cb	Bb		AΦ	
P.C.	$2.10x10^3$	---------	$20 x10^3$ Cc	$6000 x10^3$	$11000 x10^3$	----------	$100000 x10^3$	--------
	$\pm 0.2x10^3$		± 0.00	$\pm 0.2x10^3$	$\pm 1700 x10^3$		$\pm 5700x10^3$	
	Cc			Bc	Ba		AΦ	

* See Materials and Methods
Means ± Standard error
Φ: At these points samples were organoleptically rejected.
Means with the same capital letters in the same line are not significantly different ($p<0.01$)
Means with the same small letters in the same column are not significantly different ($p<0.01$)

Table 7. Effect of different treatments on the microbial profile of Nile bolti fish stored at 2 °C± 2 / 16 days.

Treatments*	Responded values		
	T.P.C.	An. P.C.	P.C.
C	$8x10^7$ A	$13x10^7$ A	$19x10^7$ A
CA	$8x10^5$ B	$1x10^6$ B	$1.3x10^6$ B
CN	$29x10^5$ B	$5x10^5$ B	$4x10^5$ B
CNO	$1.8x10^5$ B	$8x10^5$ B	$2x10^6$ B
LSD	$116x10^5$	$497x10^5$	$746x10^5$

* See Materials and Methods
Means with the same letter in the same column are not significantly different (P>0.01).

(CA), (CN) and (CNO) treatments on the same tested microbiological parameters. These results are in agreement with the results of **Przybylski *et al* 1989.**

4. Chemical quality indices

Different rates of significant incremental patterns of TBA values were noticed during 16 days of cold storage of all treatments (Fig. 3). The lowest rate of TBA increase was found in (CN) treatment due to the lack of oxygen which prevents formation of aldhydes. However, free radicals could be produced and decomposed to other compounds (**Parkin and Brown 1983**). These incremental patterns in TBA values were continued representing maximum peaks after 24 days then dropped till the end of storage periods of different samples, reflects the instability and reactivity of oxidation products in muscle foods.

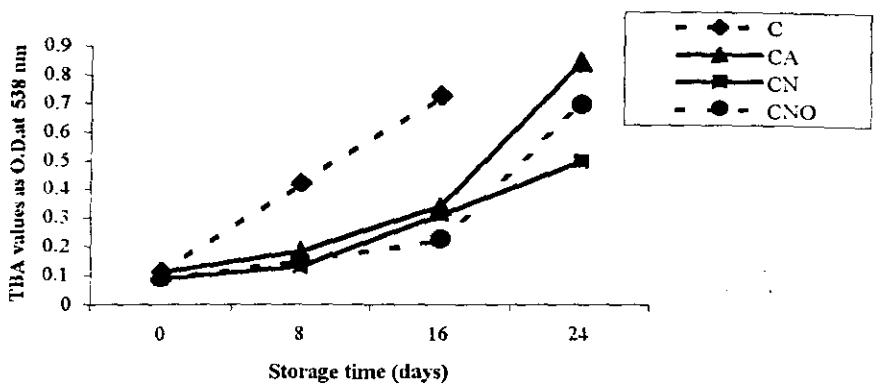

Fig 3. TBA values of differently treated Nile bolti fish stored at 2 °C ±2

For example, malonaldehyde produced as a result of lipid oxidation might react irreversibly with other components, particularly amino acids, proteins and non enzymatic browning intermediates in a Maillard-like reaction **(Yasin 1997).** Statistical analysis showed (CN) and (CNO) treatments had lower values of TBA (Table 8).

The initial values of TVB-N in different investigated treatments (Fig 4) were around 49 mg / 100g dry weight. A significant ($P<0.01$) increase was recorded in all investigated treatments with different rates depending on the nature of treatment. At the end of storage periods, a continual increase in TVB-N was taken place to be 3.96, 4.05 and 4.01folds for (CA), (CN) and (CNO) treatments, respectively. This increase might be attributed to the breakdown of nitrogenous substances as a result of microbial activity and autolytic enzymes found naturally in fish tissues **(Yasin 1997).** Changes in TVB-N concentration as affected by different suggested treatments (Table 8) showed that, (CA) and (CN) treatments had a significant ($P<0.01$) lower values than those found in other treatments.

Table 8. Effect of different treatments on TBA and TVB-N values of differently treated Nile bolti fish stored at 2 °C±2 / 16 days

Treatments*	Responded values	
	TBA (O.D.at 538 nm)	TVB-N(mg/100g dry basis)
C	0.419 A	83.79 A
CA	0.209 B	70.26 C
CN	0.175 C	69.75 C
CNO	0.152 D	75.38 B
LSD	0.006	0.85

* See Materials and Methods

Means with the same letter in the same column are not significantly different ($P>0.01$).

The changes of biogenic amine contents were also followed during cold storage of bolti fish under modified atmosphere (Table 9). Data revealed that all investigated treatments had sensible amounts of tryptamine and putrescine beside, if any, a very low concentration of cadaverine. **Abdalla *et al* (1989)** showed that, the presence of cadaverine and putrescine in sardine fish may be due to the time elapsed between catching and processing. However, a sharp drop in tryptamine content was detected in all investigated treatments during 16 days of refrigerated storage mainly due to utilization of amines as an energy source by other organisms **(Scheibner 1987)** or to the possibility of amine s reaction with proteins to form a novel amino acid **(Jones *et al* 1981).**

Table 9. Effect of modified atmosphere packaging on biogenic amines content (ppm) of differently treated Nile bolti fish stored at 2 °C ± 2.

Treatments*	Storage time (days)	
	Zero	16
C:		
Tryptamine	0.448	0.201
B-phenylethylamine	N.D.	0.015
Putrescine	0.036	7.940
Cadaverine	0.001	0.928
Histamine	N.D.	0.760
Tyramine	N.D.	0.013
CA:		
Tryptamine	0.255	0.013
B-phenylethylamine	0.005	0.055
Putrescine	0.070	6.250
Cadaverine	N.D.	0.563
Histamine	N.D.	N.D.
Tyramine	N.D.	N.D.
CN:		
Tryptamine	0.158	0.001
B-phenylethylamine	0.005	0.014
Putrescine	0.027	4.128
Cadaverine	0.061	0.367
Histamine	N.D.	N.D.
Tyramine	N.D.	0.009
CNO:		
Tryptamine	0.168	0.010
B-phenylethylamine	0.014	0.056
Putrescine	0.047	5.250
Cadaverine	0.047	0.469
Histamine	N.D.	N.D.
Tyramine	N.D.	N.D.

* See Materials and Methods.
N.D.: Not detected.

On the other hand, a sharp incremental pattern of putrescine, cadaverine and tyramine (Table 9) was noticed in various investigated samples as a result of decomposition of fish proteins and decarboxylation of the free amino acids in tissues by amino acid decarboxylase activity **(Mends 1999).** Putrescine was the sole biogenic amine with the highest concentration after 16 days of cold storage of bolti fish and reached 7.94, 6.25, 4.13 and 5.25 for (C), (CA), (CN) and (CNO) samples, respectively. Putrescine and cadaverine contents could be used as indicators for bolti fish quality stored for 16 days at 2 ° C±2 under modified atmosphere **(Ruiz-Capillas and Moral 2001).** The lowest content of biogenic amines during 16 days of refrigerated stored bolti fish was found in (CN) and (CNO) treatments. Also, histamine was appeared only in control sample at the end of its storage period (16 days).

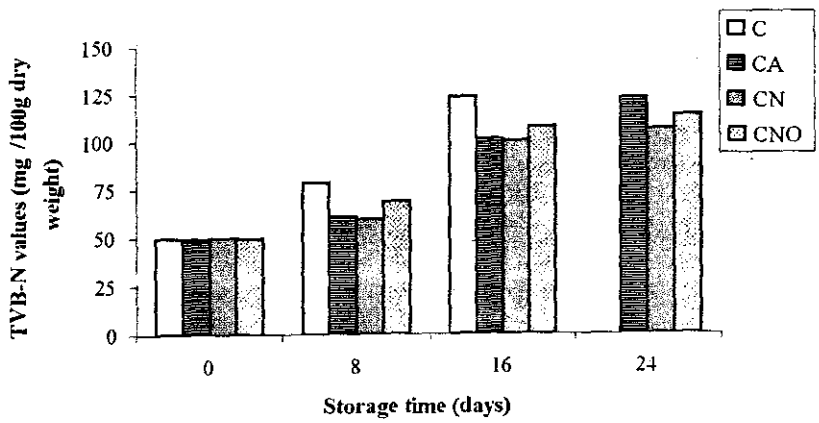

Fig. 4. Mean scores of TVB-N of differently treated Nile bolti fish stored at 2 °C ±2

Histamine which is very important in some fish species such as tuna and sardine **(Abdalla *et al* 1989 and Mendes 1999),** is not detected at all in bolti fish packaged under modified atmosphere. Such trend could be attributed to the inactivation effect of both CO_2 and N_2 on the bacterial growth as well as the inhibition of proteolytic or amine decarboxylase enzymes of both fish tissues and microorganisms **(Reddy *et al* 1999).**

5. Sensory evaluation

Sensory evaluation proved that no significant ($P>0.01$) differences were found between the four investigated treatments at zero time (Table 10).

Table 10. Mean scores of different sensory parameters of differently treated Nile bolti fish samples stored at 2 ° C ± 2

Treatments* & sensory attributes	Storage time (days)							
	Zero	4	8	16	24	31	33	35
C:								
Appearance	9.0 ±0.0 A	8.0±0.0 B	6.9 ±0.2 Ca	4.2 ±0.1 DcΦ	----------	----------	-------	-----
Eye' s lustrous	9.0 ±0.0	7.3±0.3	6.6 ±0.2	3.7 ±0.1	---------	---------	---------	-----
Color of gills	9.0±0.0A	7.4±0.2B B	6.2±0.3Ca	3.4±0.2Dc				
Odor	9.0 ±0.0	7.6±0.2	7.0 ±0.1	3.2 ±0.1	---------	---------	---------	-----
Texture	9.0±0.0A	7.6±0.2B	6.8±0.2Cab	3.9±0.1Dc				
Overall acceptability	9.0 ±0.0 A	7.6±0.2 B	6.8 ±0.2 Ca	3.9 ±0.1 Dc	----------	---------	---------	-----
CA:								
Appearance	9.0 ±0.0 A	---------	7.3 ±0.3 Ba	5.7 ±0.1 Cb	5.7 ±0.2 Cb	3.9 ±0.2 DΦ	---------	-----
Eye' s lustrous	9.0 ±0.0 A	---------	6.4 ±0.3 Ba	5.1 ±0.2 Cb	5.1 ±0.1 Cb	3.7 ±0.1 D	---------	-----
Color of gills	9.0 ±0.0 A	---------	6.4 ±0.3 Ba	5.0 ±0.1 Cb	4.9 ±0.1 Cb	3.7 ±0.1 D	---------	----
Odor	9.0 ±0.0 A	---------	6.6 ±0.2 Ba	5.5 ±0.2 Cb	5.2 ±0.1 Cb	3.0 ±0.1 D	---------	-----
Texture	9.0 ±0.0 A	---------	6.7 ±0.2 Bb	5.5 ±0.1 Cb	5.9 ±0.1 Cb	4.1 ±0.1 E	---------	----
Overall acceptability	9.0 ±0.0 A	---------	6.8 ±0.2 Ba	5.8 ±0.1 Cb	5.4 ±0.2 Cc	3.7 ±0.3 D	---------	-----

Table 10. Cont.

Treatments* & sensory attributes	Storage time (days)							
	Zero	4	8	16	24	31	33	35
CN:								
Appearance	9.0 ±0.0 A		7.3 ±0.1 Ba	6.4 ±0.2 Ca	6.5 ±0.2 Ca	--------	-------	3.5 ±0.2 DΦ
Eye' s lustrous	9.0 ±0.0 A		7.2 ±0.2 Ba	6.6 ±0.2 Ca	5.9 ±0.1 Da	--------	-------	3.5 ±0.2 E
Color of gills	9.0 ±0.0 A		6.9 ±0.2 Ba	6.1 ±0.2 Ca	5.8 ±0.2 Ca	--------	--------	2.9 ±0.2 D
Odor	9.0 ±0.0 A		7.1 ±0.2 Ba	6.4 ±0.2 Ca	6.6 ±0.2 Ca	-------	--------	3.0 ±0.2 D
Texture	9.0 ±0.0 A		7.3 ±0.3 Ba	6.5 ±0.3Ca	6.7 ±0.1 Ca	-------	-------	3.7 ±0.1 D
Overall acceptability	9.0 ±0.0 A		7.1±0.05 Ba	6.5 ±0.1 Ca	6.8 ±0.3 BCa	------	-------	3.2 ±0.1 D
CNO:								
Appearance	9.0 ±0.0 A		7.1 ±0.1 Ba	6.5 ±0.2 Ca	6.1 ±0.1 Dab	-----	3.8 ±0.4 EΦ	--------
Eye' s lustrous	9.0 ±0.0 A		6.9 ±0.2 Ba	6.3 ±0.1 Ca	5.8 ±0.1 Da	------	3.4 ±0.2 E	---------
Color of gills	9.0 ±0.0 A		6.9 ±0.2 Ba	6.4 ±0.2 Ca	5.7 ±0.2 Da	------	3.6 ±0.4 E	------
Odor	9.0 ±0.0 A		7.1 ±0.2 Ba	6.4 ±0.2 Ca	6.2 ±0.1 Ca	------	2.6 ±0.5 D	------
Texture	9.0 ±0.0 A		7.1 ±0.2 Bab	6.4 ±0.3 Ca	6.1 ±0.2 Cb	-------	3.8 ±0.1 D	--------
Overall acceptability	9.0 ±0.0 A		7.0 ±0.1 Ba	6.4 ±0.1 Ca	6.2 ±0.1 Cb	---------	3.4 ±0.0 D	-------

*See Materials and Methods Means ± Standard error

Φ: At these points samples were organoleptically rejected.

Means with the same capital letters in the same line are not significantly different (P > 0.01)

Means with the same small letters in the same column for given attributes are not significantly different (P > 0.01)

By extending the refrigerated storage time, a significant decrememtal trend ($P<0.01$) in eye' s lustrous scores was observed in all treated samples up to the corresponding point of complete deterioration. The lowest trend in both of (CN) and (CNO) treatments were due to the effect of modified atmosphere in retarding many deterioration changes. With the progression of cold storage, all treated samples realized a concomitant deterioration in gills color. Similar trend was also found in (CN) sample as explained earlier. During subsequent cold storage the (CN) sample possessed a significant higher scores of odor than those of (CA) and (CNO) ones. Undesirable odor was due to the formation of ammonia, indol and other metabolites induced by the action of spoilage bacteria during storage **(Reddy *et al* 1992).** The MAP treatments had a firm texture owing to the role of modified atmosphere **(Reddy *et al* 1995).** However, (CN) sample had the best quality compared with other samples under sensory evaluation. Statistical analysis (Table 11) showed that, (CN) and (CNO) treatments had almost similar effect on sensory attributes, while, (C) and (CA) treatments had different effect on such attributes.

Total volatile basic nitrogen (TVB-N) has been widely used as quality indice to assess the spoilage of refrigerated fish. In case of refrigerated fish packaged under modified atmosphere, the correlation between sensory attributes (overall acceptability) and TVB-N showed strong correlation (0.999 with C, 0.926 with CA, 0.957 with CN, and 0.971 with CNO).

Table 11. Effect of different treatments on sensory attributes of Nile bolti fish stored at 2°C±2 / 16 days.

Treatments*	Responded values					
	Appearance	Eye s lustrous	Color of gills	odor	texture	Overall acceptability
C	6.70 C	6.43 C	6.20 C	6.40 C	6.57 C	6.57 C
CA	7.33 B	7.00 B	6.80 B	7.03 B	7.07 B	7.20 B
CN	7.57 A	7.60 A	7.33 A	7.50 A	7.60 A	7.53 A
CNO	7.53 A	7.40 A	7.43 A	7.50 A	7.50 A	7.47 A
LSD	0.21	0.25	0.27	0.22	0.23	0.21

* See materials and methods
Means with the same letter in the same column are not significantly different ($P> 0.01$).

Also, strong correlation was observed between overall acceptability of the investigated four samples and putrescine as well as cadaverine (almost 1.0). On the other hand, the correlation between overall acceptability and total plate counts showed lower values ranging between 0.77 to 0.91. In conclusion TVB-N and biogenic amines (putrescine and cadaverine) could be used as quality indices in

refrigerated bolti fish, either packaged under modified atmosphere or not.

REFERENCES

Abdalla, M.A.; I.M. Hassan; A.R. Shalaby and N. Khayria (1989). Physiochemical and bacteriological changes occurring during storage of sardine fish. *Grasas Y Aceites; 40(6): 389-398.*

Al-Kahtani, H.A.; H.M. Abu-Tarboush; A.S. Bajaber;M. Atia; A.A. Abou-Arab and M.A. El-Mojaddidi (1996). Chemical changes after irradiation and post irradiation storage in tilapia and Spanish mackerel. *J. Food Sci. 61(4): 729-733.*

A.O.A.C. (1990). *Official Methods of Analysis.* Association of Official Analytical Chemists. 15 th (Ed.). Washington, D.C.

Bilinski, E. and R.E. Jonas (1975). Correlation between the freshness of iced salmonides and lactic acid formation in muscle extract. *Food Sci. and Tech. Abstr. 7(6): A313.*

Bligh, E.G. and W.J. Dyer (1959). A rapid method of total lipid extraction and purification. *Can. J.Biochem. Physiol. 37:911-913.*

Dalgaard, P.; L. Gram and H.H. Huss (1993). Spoilage and shelf-life of cod fillets packed in vacuum or modified atmospheres. *Int. J. Food Micro. 19:283-294.*

Freeman, W.H. (1981). *Microbes in Action. A laboratory Manual of Microbiology.* 3(Ed.), **pp. 141-142.** First published in the USA, New York.

Gelman A.; R. Pasteur and M. Rave (1990). Quality changes and storage life of common carp at various storage temperatures. *J. Sci. Food Agric. 54:231-247.*

Grau, R. and R. Hamm (1957). Zeitechrift for lebensmittel untersuchung and F. *(cited from Hassan 1980).*

Harold, E.; S.K. Ronald and S. Roland (1987). *Pearson' s Chemical Analysis of Foods. p. 386 and p. 537.* 8th Ed. Longman House, Burnt, M.; Harbow, Essex CM 202 JE, England.

Hassan, I.M. (1980). *The Effect of Irradiation Treatments Alone or Accompanied with Other Treatments on some Properties of Meat. p. 28.* Ph.D. Thesis, Fac. of Agric. Ain Shams Univ., Cairo, Egypt.

Hayes, P.R. (1992). Microbiological examination methods. In: *Food Microbiology and Hygiene.pp.184-217.* Elsevier Applied Science, London.

Hong, L.C.; E.L. Leblanc; Z.J. Hawrysh and R.T. Hardin (1996). Quality of Atlantic mackerel (*Scomber scomberus L.*) fillets during modified atmosphere storage. *J. Food Sci. 6 (3): 646-651.*

Jhaveri, S.N.; S.S. Leu and S.M. Constantinides (1982). Atlantic mackerel (*Scomber scomberus L.*): Shelf life in ice. *J. Food Sci. 47: 1808-1813.*

Jones, G.P.; D.E. Rivett and D.J. Tucker (1981). The reaction of biogenic amines with proteins. *J. Sci. Food Agric., 32: 805-812.*

Mendes, R. (1999). Changes in biogenic amines of major Portuguese bluefish species during storage at different temperatures. *J. Food Biochem. 23: 33-43.*

Mietz, J.L. and E.Karmas (1978). Polyamine and histamine content of rockfish, salmon, lobster and shrimp as an indicator of decomposition. *J. Am. Oil. Assoc. Chem. 61: 139-145.*

Parkin, K. and W. Brown (1983). Modified atmosphere storage of Dungeness crab (*Cancer magister*). ***J. Food Sci. 48: 370-374.***

Pearson, D.; M. Koozehkonani and K.L. Lee (1976). Studies of the effect of heat processing on various spoilage values of meat and fish. ***J. Association of Puplic Analysis. 14:133.***

Przybylski, L.A.; M.W. Finerty; R.M. Grodner and D.L .Gerdes (1989). Extension of shelf-life of iced fresh channel catfish fillets using modified atmospheric packaging and low dose irradiation. ***J. Food Sci. 54: 269-273.***

Randell, K.; R. Ahvenainen; K.L. Kala; E. Hurme; T.S. Mattila and M. Hyvönen (1995). Modified atmosphere packed marinated chicken breast and rainbow trout quality as affected by package leakage.***J. Food Sci. 60:667-684.***

Reddy, N.R.; D.J. Armstrong; E.J. Rhodehamel and D.A. Kautter (1992). Shelf–life extension and safety concerns about fresh fishery products packaged under modified atmospheres. A review. ***J. Food Safety 12:87-118.***

Reddy, N.R.; C.L. Schreiber; K.S. Buzard; G.E. Skinner and D.J. Armstrong (1994). Shelf - life of fresh tilapia fillets packaged in high barrier film with modified atmospheres. ***J. Food Sci. 59: 260-264.***

Reddy, N.R.; M. Villanueva and D.A. Kautter (1995). Shelf-life of modified atmosphere packaged fresh tilapia fillets stored under refrigeration and temperature-abuse conditions. ***J. Food Prot. 58: 908-914.***

Reddy, N.R.; H.M. Solomon and E.J. Rhodehamel (1999). Comparison of margin of safety between sensory spoilage and onset of *Clostridium botulinum* toxin development during storage of modified atmosphere (MA) packaged fresh marine cod fillets with MA- packaged aquacultured fish fillets. ***J. Food Safety 19:171-183.***

Rodriguez, M.N.G.; J.J. Sanz; J.A. Santos; A. Otero and M.L.G. Lopez (2001). Bacteriological quality of aquacultured freshwater fish portions in prepackaged trays stored at 3°C . ***J. Food Prot. 64:1399-1404.***

Ruiz-Capillas, C. and A. Moral (2001). Production of biogenic amines and their potential use as quality control indices for hake (*Merluccius merluccius, L.*) stored in ice. ***J. Food Sci. 66: 1030-1032.***

SAS (1996). ***Statistical Analysis System.*** SAS. User s Guide: Statistics. SAS Institute Inc. Editors, Cary, NC, USA.

Scheibner, G. (1987). Untersuchungen zur histaminverwertung durch gram-negative mikrobem. ***Mh. Vet-Med. 42:120-121.*** (cited from ***Abdalla et al 1989***).

Stammen, K.; D. Gerdes and F. Caporaso (1990). Modified atmosphere packaging of seafood ***CRC Crit. Rev. Food Sci. Nutr. 29: 301-331.***

Voloviskaya, V.P. and B.Y. Kelmen (1962). Proc. of Res., ***Meat Inst., 11: 80 (cited from Hassan 1980)*** .

Yasin, Nessrien M.N. (1997). ***Studies on the Expiration Period and Quality Attributes of Some Fish Products.*** **p. 59 and p. 103.** M.Sc. Thesis, Fac. of Agric. Ain Shams Univ., Cairo, Egypt.

مجلة حوليات العلوم الزراعية ، كلية الزراعة ، جامعة عين شمس، القاهرة ، م (٤٧)، ع(٢)، ٧٢٣-٧٤٤، ٢٠٠٢

خواص جودة أسماك البلطي المستزرعة المخزنة في جو هوائي معدل

[٤٦]

نسرين محمد يسن[١] - إبراهيم محمد حسن[١] - عاطف أنور أبو عرب[١] - محمد فرج خلاف[١]

١- قسم علوم الأغذية - كلية الزراعة- جامعة عين شمس -شبرا الخيمة- القاهرة - مصر

تم دراسة تأثير التعبئة في جو هوائي معدل علي صفات جودة أسماك البلطي المستزرعة المصرية و المخزنة علي 2± ^{o}C 2 و قد أ خذ في الإعتبار إطالة العمر التخزيني بإ ستخدام بعض المعاملات المقترحة لتعديل جو التعبئة حيث أستخدمت عبوات النايلون (DARTEK F-101) في تعبئة عينات الأسماك علي النحو التالي : (٥٠% ك أ٢ + ٥٠ % هواء) ، (٥٠%ك أ٢ + ٥٠% نيتروجين)، (٥٠% ك أ٢ + ٢٥% نيتروجين + ٢٥% أكسيجين).

وأوضحت نتائج كل من التركيب الكيماوي والخواص الطبيعية والخواص الميكروبية بالإضافة إلى دلائل الجودة الكيماوية و التقييم الحسي أن المعاملتين الثانية و الثالثة لهما أطول فترات تخزينية تحت التبريد (٣٣ ، ٣٥ يوما علي التوالي) مقارنة بالمعاملة الأولي(٣١ يوما) هذا و قد فسدت عينة المقارنة بعد 16 يوما فقط و قد لوحظ وجود ارتباط بدرجة كبيرة بين المقاييس الحسية و بين كل من القواعد النتروجينية المتطايرة الكلية و المحتوي من البيوتراسين و الكادافرين وبذلك يمكن استخدام تلك المقاييس كمقاييس جودة لأسماك البلطي المبردة سواء كانت معبأة أو غير معبأة في جو هوائي معدل.

تحكيم: ا.د محمد أمين عبد الله

ا.د حمدى عبد اللطيف المنسى