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EVALUATION OF SOME NUTRITIVE VALUES AND ORGANOLEPTIC QUALITIES OF COOKED FRESH AND FROZEN MALE FORMATTED (MONO-SEX) BOLTI FISH.

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ABSTRACT

This work was aimed to study the effect of home cooking processes and frozen storage (at -20°C for 6 months) on the chemical composition, digestibility and quality of common and male formatted (mono-sex) Bolti fish flesh. The results indicated that crude protein and ether extract were higher in male formatted than the common Bolti fish flesh. Crude protein, ether extract and ash of the flesh were decreased after cooking processes. The lowest loss in protein was found in roasted fish. After frozen storage for 6 months at -20°C, the gross chemical composition of frozen fish were lower than those of fresh fish. The total indispensable amino acids (35.74%) especially theronine, methionine, valine, phenylalanine, isoleucine and tryptophan were higher in fresh male formatted Bolti fish flesh than those in fresh common fish flesh (33.51%). The total amino acids were decreased in all fish samples as result of cooking processes and frozen storage. The lowest losses in amino acids were noticed in fried samples. The results revealed that male formatted fish contained higher amounts of total unsaturated fatty acids (67.67%) than those of common fish (62.62%), especially oleic, linoleic and erucic acids. The fatty acids compositions of fresh samples were changed after cooking processes. Frying process increased oleic, linoleic and linolenic acids of both types of fish. Erucic acid was not found in fresh after frying process. Great decreases were noticed in linoleic acid content of fish after 6 months of storage at -20°C from 16.82 to 7.63% and from 20.16 to 19.46% for common and male formatted fish, respectively. Arachidic, behenic and erucic acids were disappeared after frying and wet cooking of frozen two fish types. Also, arachidic, behenic and erucic acids were not found after roasting of male formatted fish samples. The results indicated that, male formatted Bolti fish had higher digestibility values than common fish. Cooking processes and frozen storage of the two fish types reduce the digestibility values, but male formatted fish still had higher digestibility values. Cooked male formatted fishes treated had better over all acceptability values than those of common Bolti fish samples.

INTRODUCTION

Fish has long been recognized as a valuable source of high–quality protein in the human diet. (*Puwastien et al., 1999*). Fish is used as a major food in many countries including Egypt. Twenty percent from protein requirements in Egypt comes from sea, fresh water and aquaculture (farmed) fishes. Bolti fish represent about 38.20 % of total fish consumed in Egypt. The Egyptian government considers fish as major objects to cover the existing gap between production and consumption of animal protein. Also, the cost of fish production is lower than that of animal production, (*Ministry of Agriculture, 2001)*. In addition, fish proteins are more easily to be completely

digested and assimilated in the body than that of Beef protein (Tressler and Lemon, 1960).

At Kafr El-Sheikh governorate, there are different sources for fish especially Bolti fish, such as fish farms, Broullus lake, river sea, drains and canals, which produce about 21.6% of the total production of Egyptian fish, (Ministry of Agriculture, 1999). The treated fries of Bolti fish which feeded by 17 αMethyltestosterone account for about 30% from the total fingerlings used in fish farming at Kafr El-Sheikh governorate. However, the precocious maturation in tilapia was a major problem, since they reach sexual maturity after 3 to 6 months and spawn before they reach remarkable size, (Hepher and Pruginig, 1981).

Freezing is known to be one of the most suitable methods for preservation of food items in general and especially meats and fish. (Morsi, 1988).

Chemical changes that occur in food during processing are numerous, and they can be desirable, undesirable, of questionable consequence or a combination thereof, (Thomas and John, 1985).

In the course of this study, the gross chemical composition, amino acids, fatty acids, digestibility and organoleptic qualities of cooked (roasting, frying and wet cooking) fresh and frozen (at -20°C for 6 months) male formatted (mono-sex) Bolti fish were investigated and compared with those of common Bolti fish.

MATERIALS AND METHODS

Materials:

Three different size of Bolti fish were obtained from a private fish grow out farm at Damro El-Haddadi village, Kafr El-Sheikh governorate, Egypt. Nile Bolti fish (*Oreochromis niloticus*) and hormone male formatted (mono-sex) Bolti fish which, feeded with 60 mg *17 α Methyltestosetrone (MT)*/1 kg feed were under investigation during this work.

Sampling:

Three sizes of common and male formatted (mono– sex) Bolti fish large size (super), grade 1 and grade 2 were obtained from a private fish farm specialized in Bolti fish growing (the age was 180 days). The three sizes were suitable to home cooking processes: In common fish, large size (super) was in grade of 3-4 fish/Kg, grade 1 (7-8 fish/kg), and grade 2 (10-11 fish/kg), while for the male formatted fish the grades were 3-4 fish/kg for large size, 5-6 fish/kg for grade (1) and 7-8 for grade (2).

For chemical analysis, three sizes of common and male formatted Bolti fish large size (super), grade (1) and grade (2) were caught from official fish grow out farm in order to assure the same growing conditions for both common and male formatted Bolti fish. Also, three sizes of male formatted (mono-sex) Bolti fish large size (super) , grade (1) and grade (2) which were treated with male hormone (*17 α Methyltestostrone*), were obtained from the same farm.

The samples were placed in ice boxes mixed with crushed ice and transferred directly to the Food Tech. Dept., Fac. of Agric. at Kafr El-Sheikh, within 1–2 hours of fishing, during season of October and November 2002. Fish samples were taken from the ice boxes and washed by running cold water to remove the adhering sand and silt. All samples were divided into two portions. First one was used in fresh samples and second portion was packed in polyethylene bags and stored at -20°C for 6 months before using.

Methods:

Freezing:

Frozen samples were thawed at room temperature (at 25°C). Head, skin, organs and bones of all samples were removed from flesh, where it was minced using meat mincer. Chemical analysis were done on the flesh which is eatable parts of fish. All measurements were carried out in triplicates.

Cooking methods:

Three home fish cooking processes (roasting, frying and wet cooking) were carried out as described by *Central Laboratory for Aquaculture Research* (C. L. A. R, 2000), after remove up the viscera from Bolti fish to evaluate the effect of cooking method as well as the type of fish (grade 1) on organoleptic qualities and flesh chemical composition. Roasting was conducted at 300˚ - 350˚ C for 15 – 20 min. at home oven. Deep frying process were carried out using sunflower oil at 230˚- 250˚C for 10–15 min. Wet cooking was carried out by boiling fish for 15 min., in water with 2% salt, onion and some spices to be a better taste.

Proximate chemical analysis:

Moisture, total solids, ash, ether extract and protein were determined in the flesh of fresh, frozen and cooked Bolti samples according to the methods described by A.O.A.C (1990). Carbohydrate was determined by differences. The results were expressed as percentage of dry weight.

Amino acids analysis:

Determination of amino acids composition of Bolti fish flesh were carried out in the central laboratory Fac of Agric., Alex. Univ. Egypt according to the method of Moore and Stein, (1958). The amino acid analyzer was BECKMAN model 118 / 199 CL. Tryptophan content of fish muscle protein was determined colormetrically after subject to alkaline hydrolysis. The P-dimethylaminobenzaldehyde (DMAB) reagent was used as described by Miller, (1967) using a Spekol ll–Spectrophotometer and wave – length of 590 nm.

Fatty acids composition:

The total lipids were extracted from different types of Bolti fish flesh using chloroform/methanol mixture (2:1 v/v) as given by Folch, *et al.,* (1957). Then, the extracted oils were dried to remove the solvent using rotary evaporator under vacuum. Determination of fatty acids composition of Bolti fish flesh were carried out in the central laboratory Fac. of Agric., Alex. Univ.,

Egypt. The methyl esters of fatty acids were prepared following the procedure adopted by Radwam, (1978) and Patterson (1989). The fatty acids methyl esters were injected in gas liquid chromatography apparatus GC Model: Shimadzu - 4CM (PFE) equipped with PID detector and glass column 2.5 m X 3 mm

***In - vitro* digestibility of Bolti fish flesh:**

The method was used here in to determine the *in-vitro* digestibility of bolti fish flesh described by Saunder *et al*., (1973). Fish flesh samples were digested with pepsin followed by pancreatin at the end of digestion, 1.6 M of Trichloroacetic acid (T.C.A) was added to the digest (1:1 v / v). The mixture was left for 2 hours, then centrifuged (2500 xg) for 2 min. The supernatant was analyzed for T.C.A. soluble nitrogen using the micro kjeldahl method (A.O.A.C. 1990).

Organoleptic qualities of cooked fish:

The organoleptic qualities of the cooked fresh and frozen samples were tested by ten panel judges for evaluation (color, odor, texture, taste and appearance). Panel taster used a 10 point scale for grading the quality of fish samples (Dutche and Wirschaflich, 1973).

RESULTS AND DISCUSSIONS

Gross chemical composition of Bolti fish flesh:

The moisture content, total solids, crude protein content, ether extract, ash and carbohydrate content of different grades of common and male formatted Bolti fish flesh were presented in Table (1). It could be observed that with increasing of fish size, the gross chemical composition show some changes in all samples. Similar results were reported by Hafiz *et al.,* (1990). Also, total solids of common fish were higher than the male formatted Bolti fish.

Table (1): Gross chemical composition of fresh common and male formatted Bolti fish flesh.

Gross chemical Compositions % / Fish samples	Moisture	Total solids	*Crude protein	*Ether extract	*Ash content	**Carbohydrate
Large size (super)						
Common	77.51	22.49	85.98	5.76	6.23	2.03
Mono-sex	79.60	20.40	86.66	7.56	5.21	0.57
Grade 1						
Common	76.17	23.83	85.86	5.51	6.62	2.01
Mono-sex	78.32	21.68	86.41	7.46	5.52	0.61
Grade 2						
Common	74.48	25.52	84.96	5.35	6.85	2.84
Mono-sex	76.98	23.02	85.95	7.30	5.68	1.07

*** As dry weight**

*** * 100 – (crude protein + ether extract + ash content)**

On the other hand, moisture, crude protein and ether extract were higher in male formatted fishes than common fish, but ash content was lower in male formatted samples than common samples. Carbohydrate and ash contents were higher in common samples than male fish as affected by the low contents of crude protein and ether extract.

The previous results agreed well with the findings obtained by Khouraiba, (1997) and Ammar, (1999). They reported that the variation between common and mono-sex fish might be resulted from hormonal treatment when the fishes were fingerlings with 17 α Methyltestosterone.

Effect of cooking processes on gross chemical composition:

Table (2) show the effect of cooking processes on chemical composition of fresh and frozen common and male formatted Bolti fish flesh. The moisture contents of fresh flesh were decreased after roasting and frying because evaporation of moisture during cooking. Also, moisture content of fried samples show higher losses than roasted fish. After wet cooking the moisture was slightly increased, that may be due to the ability of cells to absorb the water when the fish was cooked by this way or may be due to the adsorbed water on the surface of fish during sampling after cooking.

Crude protein contents were decreased after cooking processes, this may be due to the effect of heat treatment which might have cause the loss of some nitrogenous substances with separated fluids as well as by volatilization in the form of amine and other volatile nitrogenous substances (Shian and Chai, 1985) in addition to more protein denaturation accompanied by more intense thermal treatment. The lowest loss was detected in roasted samples, while the wet cooking caused the highest loss on crude protein content. These results, may be due to dissolving the soluble protein in cooking water.

The ether extracts were decreased in all cooked samples. Wet cooking resulted in the highest losses in fat content, while frying had the lowest losses because it was carried out by using oil (sunflower oil).

Ash contents were decreased in all fish samples after cooking processes. The lowest loss occurred in fried fish, this may be due to the effect of temperature which was lower than that used in roasting. The high losses of ash content were noticed in boiled fish, which could be attributed to release of some water soluble compounds during cooking. These results are in agreement with those reported by Ammar,(1999) and Puwastien, *et al.,* (1999).

As shown in Table (2), it can be noticed that, almost similar trends occurred in moisture content; crude protein content; ether extract and ash content of roasted, fried and the wet cooked frozen common and male formatted Bolti fish flesh. Also, after 6 months of frozen storage at -20° C, the gross chemical contents were lower than those of fresh fish. This could be attributed to the effect of frozen storage on gross chemical composition of fish before cooking.

T2

Effect of cooking processes on amino acids composition:

The effect of cooking processes on amino acids composition of fresh and frozen common and male formatted Bolti fish flesh (grade 1) was represented in Table (3). Theronine, methionine, valine, phenylalanine, isoleucine and tryptophan were higher in fresh male formatted Bolti fish than those in common fish. Glutamic acid and proline were lower in male formatted fish than in common fish. However, the total indispensable amino acids were 33.51%, 35.74% and total dispensable amino acids were 53.30% and 54.49% of fresh common and male formatted Bolti fish flesh, respectively. The total amino acids of common Bolti fish (86.81%) was lower than of mono-sex Bolti fish flesh (90.23%). The indispensable amino acids that found in two types of Bolti fish were higher than those reported by FAO except methionine of common Bolti fish.

After cooking (roasting, frying and wet cooking) of fresh fishes, the total amino acids contents were decreased in all samples. Total indispensable amino acids of roasted samples were 28.65 and 30.31 of common and male formatted; Bolti fish flesh, respectively. Total dispensable amino acids of common Bolti (45.53%) was slightly lower than that of male formatted fish (44.57%) in roasted Bolti fish. It can be observed that, the cystine was absent in roasted common Bolti fish. Frying process caused decreases in total amino acids composition of the two types of fish.

The highest loss in total amino acids was noticed in wet cooked for the two types of Bolti fish, but common Bolti fish had lower total amino acids than male formatted Bolti fish. Also, cystine and tyrosine were not found after wet cooking of the common fish samples. Pieniazek *et al.,* (1975) studied the effect of heat on casein and suggested that when high temperatures are applied to proteins sulfur amino acids may be oxidized to unavailable forms.
However, it was clear that, all cooking processes reduced the percentage of amino acids which due to mechanical damage in tissues and the possible release of some inter and intro muscular protein including amino acids with the separated fluids and the lowest losses were detected after frying process because of the coagulation of protein which occurred quickly, but in wet cooking process it were occurred slowly so the high losses were noticed after wet cooking. Also, male formatted Bolti fish has higher percentage of total amino acids and the highest decrement of total amino acids were found after wet cooking process especially in common Bolti fish. After 6 months of storage at -20°C, the total amino acids contents were decreased in all fish samples (Table 3). Amino acids of male formatted (84.37%) was higher thancommon Bolti fish (80.23%). Male formatted Bolti fish also, had higher percentage of total indispensable amino acids and total dispensable amino acids than common Bolti fish.

Changes occurred in the amino acid content of frozen fishes as affected by cooking processes had the same trend of the effect of cooking methods on fresh fish. Mean while, the amounts of amino acids content were reduced in cooked fish as affected by frozen storage (at -20°C for 6 months). Also, cystine was absent in roasted and wet cooked samples. In addition, tyrosine was not found in wet cooked common fish samples.

T3

Frozen storage decreased the amino acids contents which might be due to the loss of amino acids in drip occurred during thawing the samples and could be also attributed to chemical reactions between the free amino acids and some other compounds such as the reaction between the free amino acids and lipid oxidation products, as well as formation of sulphur compounds. The results obtained here are in agreement with those reported by Salama, (1990); Abo-Zeid (1995) and Ammar, (1999).

Effect of cooking processes on fatty acids composition:

Fatty acid methyl esters were detected in fresh sample by GLC and the obtained data were presented in Table (4). Fatty acids composition of common fresh fish flesh indicated higher percentages of palmitoleic, linolenic, myristic, palmitic, stearic and behenic acids compared to fresh male formatted fresh fish which contained higher percentages of oleic, linoleic, erucic and arachidic acids. However, total saturated fatty acids (TSFA) were higher in common fish (37.38%) than those of male formatted fish (32.33%). These results may be attributed to effect of hormone on fat contents of male formatted Bolti fish.

The fatty acids composition were changed as affected by cooking processes. Behenic acid was not found in male formatted fish flesh after roasting, but still found with low percentage in common fish. Total saturated fatty acids and total unsaturated fatty acids (TUSFA) of the two fish types were not considerably different after roasting process.

Cooking in sunflower oil lead to increase in oleic, linoleic and linolenic acids in both types of fish. Erucic acid was not found in samples after frying which is very important, because erucic acid cause heart diseases in rats when fed in liberal doses of the oil, (Hudalle, 1977 and Swern, 1979), that due to the high temperature of frying which caused damage on erucic acid compared with the temperature of we t cooking. Also, total unsaturated fatty acids were increased after frying and they were higher in male formatted Bolti fish than those in common fish. Fatty acids were oxidized by forced oxidation which cause differences on fatty acids especially the unsaturated ones depending on cooking temperatures(Moghazy *et al.,* 2002).

After 6 months of storage at -20°C the fatty acids composition were changed as shown in Table (4). The great changes were occurred in linoleic acid (from 16.82 to 7.63 and from 20.16 to 19.46% of common and male formatted fish, respectively). While behenic acid was decreased from 3.37 to 0.79% in common Bolti fish.

However, fish quality decreases during frozen storage as a result of increasing time and temperature of storage (Stotelo, 1995). In addition, Sarvadeva and Srikar, (1982) suggested that the changes in fatty acids composition could be also due to hydrolysis of phospholipids by phospholipases. The remarkable decrease in total unsaturated fatty acids in muscle fats occurred during storage might be due to the oxidation and degradation of unsaturated fatty acids (Aubourg, 1999). The results in Table (4) may be attributed to the use of slow freezing process for freezing of Bolti fish.

T4

Results in Table (4), revealed that arachidic, behenic and erucic acids disappear after frying and wet cooking of two frozen fish types. Also, arachidic, behenic and erucic acids were not found after roasting male formatted fish samples. Wet cooking process decreased the amounts of fatty acids by extract in wet hot water. While, frying process increased total unsaturated fatty acids. These increases depend on the oil used in frying treatment. Roasting reduced the fatty acids contents. This reduction was more in total unsaturated acids in case of male formatted fish, while total saturated acids show more decrease in common fish samples.

It is noteworthy, that the health hazardous erucic acid disappeared after frying and wet cooking processes. In addition, arachidic and behenic acids also disappeared in the two types of Bolti fish. In the same time those acids were not found in roasted male formatted Bolti fish. Similar results were previously reported by Keshk, (2004).

Effect of cooking processes on *in – vitro* digestibility:

The effect of cooking processes on digestibility by pepsin, pincreatin and pepsin followed by pincreatin, of fresh and frozen common and male formatted Bolti fish flesh (grade 1), were presented in Table (5).

Digestibility values of cooked male formatted fish were higher than those of cooked common samples. All cooked samples had low in – vitro digestibility compared with standard (casein). While roasted fish samples had the highest values and the lowest value of digestibility was found in fried samples. Therefore, the apparent digestibility value could be affected by temperature degree which caused some changes in the peptide linkage and primary structure as reported by El-Sahn *et al.,* (1992). Besides, the heat of frying process in oil may cause more denaturation on protein contents. Thomas and John, (1985) reported that, the effect of wet heat was more complex than the effect of dry heat. Protein receiving dry heat exhibited of increasing temperature from 110°C to 155°C. The wet heat samples the solubility plot over the same temperature range showed a sigmoid curve with a minimum at 120°C. The solubility then decreased sharply after 145°C, the 155°C sample being nearly as insoluble as the dry-heated protein. The last information could explain the low digestibility of fried and wet cooked samples.

From data in Table (1), it can be noticed that the carbohydrate content of common fish were higher than that of male formatted samples due to more nonenzymatic browning (Maillard reaction) of common fish which will decrease the protein content when co-bonded with carbohydrate content due to reduction of the digestibility value of common Bolti fish (Tsen *et al.,* 1983).

Frozen samples at -20° C for 6 months showed less digestibility values as affected by frozen storage. This could be attributed to more denaturation and congregated in cross-linkage and cause histochemical changes on fish protein, (Badawy, 1996). After cooking methods the same changes were occurred as reported with fresh samples.

Generally, it can be concluded that, male formatted Bolti fish had higher digestibility values than common fish. Cooking processes and frozen storage of the two fish types reduce the digestibility values but mono-sex samples still had higher digestibility value.

Effect of cooking processes on organoleptic qualities:

The organoleptic qualities (color, odor, texture, taste and appearance) of cooked fresh and frozen of common and male formatted Bolti fish were reported in Table (6).

Cooked fresh fishes had considerably higher overall acceptability values than cooked frozen samples (at -20°C for 6 months). These results are in accordance with those reported by El-Hanafy, (1997). However, cooked mono-sex fish had better overall acceptability values than those of common fish, that may be attribute to increment of fish flesh and fat content of mono-sex Bolti fish which were higher overall acceptability value than common fishes.

The roasted fish had higher score in odor, texture and total score of organoleptic qualities as judged by panelists. Fried fish acquired an oily taste, while roasting resulted in a smoky flavor (Sherif, 1992). Also, wet cooked fish had lower scores in organoleptic evaluation than roasted and fried fishes. These results are in agreement with those reported by Ammar, (1999).

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تأثير طرق الطهي والتخزين بالتجميد على جودة اسماك البلطي المتغذي بالهرمون الذكري (وحيد الجنس)

عبد الباسط عبد العزيز سلامة، مصطفى أحمد عون ، سمير عبد المعطي القاضي ، كمال متولي النمر و أمين كمال أمين عمار
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لمواجهة مشكلة نقص البروتين الحيواني في مصر انتشر حاليا وعلى نطاق واسع استخدام الهرمونات الذكرية (هرمونات الإستروید) مثل ١٧ ألفا مثيل تستوسترون لزيادة نسبة الذكور من أسماك البلطي .

ويهدف هذا البحث إلى دراسة تأثير كل من طرق الطهي المنزلية (الشي-القلي-السلق) والحفظ بالتجميد على – ٢٠ ° م لمدة ٦ أشهر على جودة سمك البلطي العادي والمتغذي بالهرمون الذكري .

حيث أوضحت النتائج ارتفاع محتوى سمك البلطي المتغذي بالهرمون من البروتين الخام والمستخلص الايثيري بالمقارنة بسمك البلطي العادي . كما أدت طرق الطهي المنزلية والتخزين بالتجميد على – ٢٠ ° م لمدة ٦ أشهر إلى حدوث نقص في التركيب الكيماوي لهذه الأسماك وكان أعلى انخفاض بعد السلق وأقلها بعد الشي.

أشارت النتائج إلى ارتفاع نسبة الأحماض الأمينية الضرورية في سمك البلطي وحيد الجنس (٣٥,٧٤ %) مقارنة بالسمك العادي (٣٣,٥١ %) خاصة أحماض الثريونين والميثيونين والفالين والفينايل آلانين والأيزوليوسين والتربتوفان وانخفاض هذه الأحماض الأمينية نتيجة لاستخدام طرق الطهي المنزلية لهذه الأسماك الطازجة والمخزنة بالتجميد وكان أعلى انخفاض في طريقة السلق وأقلها باستخدام طريقة القلي .

وأشارت النتائج إلى ارتفاع محتوى سمك البلطي وحيد الجنس من الأحماض الدهنية الغير مشبعة (٦٧,٦٧ %) مقارنة بسمك البلطي العادي (٦٢,٦٢ %) وبخاصة أحماض الأوليك واللينوليك والإيروسيك . حيث أثرت طرق الطهي المنزلية على محتوى هذه الأسماك من الأحماض الدهنية فأدت طريقة القلي إلى زيادة الأحماض الدهنية الغير مشبعة مثل الأوليك واللينوليك واللينولينيك واختفاء حامض الايروسيك . كما أن التخزين بالتجميد على – ٢٠ ° م لمدة ٦ أشهر لهذه الأسماك أدى الى حدوث نقص واضح في حامض اللينوليك من ٢٠,١٦ إلى ١٩,٤٧ % لسمك البلطي وحيد الجنس ومن ١٦,٨٢ إلى ٧,٦٣ % لسمك البلطي العادي واختفاء أحماض الأراشيديك والبهنك والايروسيك بعد القلي والسلق .

وأشارت النتائج أيضا أن استخدام طرق الطهي المنزلية أدت إلى ارتفاع الهضمية لسمك البلطي وحيد الجنس وجودته أفضل من سمك البلطي العادي حيث كانت طريقة الشي هي أفضل الطرق لدى المحكمين وطريقة السلق أقل الطرق قبولا .

Table (2): Effect of cooking processes on gross chemical composition of fresh and frozen* common and male formatted Bolti fish flesh (Grade 1).

Cooking processes	Fish types		Gross chemical composition %							
			moisture		crude protein**		ether extract**		ash**	
			B.	A.	B.	A.	B.	A.	B.	A.
Roasting	Common	Fresh	76.17	71.62	85.86	78.51	5.51	3.91	6.62	2.72
		Frozen	74.29	67.72	81.30	73.82	4.91	4.35	5.29	4.71
	Mono-sex	Fresh	78.32	75.09	86.41	79.17	7.46	6.45	5.52	3.53
		Frozen	76.75	70.39	82.25	74.72	6.59	6.50	4.71	4.02
Frying	Common	Fresh	76.17	70.29	85.86	73.01	5.51	5.25	6.62	3.63
		Frozen	74.29	70.95	81.30	68.78	4.91	4.46	5.29	5.25
	Mono-sex	Fresh	78.32	73.31	86.41	73.55	7.46	7.26	5.52	4.22
		Frozen	76.75	72.39	82.25	72.94	6.59	6.61	4.71	4.41
Wet cooking	Common	Fresh	76.17	76.76	85.86	67.91	5.51	3.10	6.62	2.63
		Frozen	74.29	74.89	81.30	63.85	4.91	4.29	5.29	4.31
	Mono-sex	Fresh	78.32	80.21	86.41	68.61	7.46	4.01	5.52	3.25
		Frozen	76.75	76.96	82.25	64.80	6.59	5.26	4.71	3.02

*** frozen storage at -20°C for 6 months. ** = as dry weight. B. = Before cooking. A. = After cooking.**

Table (3): Effect of cooking processes on amino acids composition of fresh and frozen* common and male formatted Bolti fish flesh (Grade 1).

Cooking Processes	Uncooked fish				Roasting				Frying				Wet cooking			
	Common fish		Mono-sex fish		Common fish		Mono-sex fish		Common fish		Mono-sex fish		Common fish		Mono-sex fish	
Amino acids	Fresh	Frozen	fresh	frozen	fresh	frozen	fresh	Frozen	fresh	frozen	fresh	frozen	fresh	frozen	Fresh	frozen
Indispensable																
Lysine	8.50	7.34	7.96	7.11	7.68	6.50	6.63	5.77	8.16	6.98	7.98	7.11	5.57	4.39	6.51	5.67
Threonine	4.01	3.80	4.80	4.61	3.36	3.10	4.09	3.91	3.29	3.01	3.53	3.35	2.95	2.71	3.49	3.31
Methionine	1.93	1.71	2.05	1.91	1.67	1.40	1.42	1.29	1.78	1.55	1.66	1.54	0.92	0.72	1.28	1.18
Valine	4.72	4.49	5.01	4.80	4.28	4.01	4.45	4.26	4.60	4.36	4.62	4.40	3.81	3.51	4.15	3.96
Phenylalanine	3.98	3.58	4.09	3.73	3.34	2.92	3.84	3.49	3.72	3.30	3.53	3.19	2.75	2.35	3.51	3.15
Isoleucine	3.30	2.80	4.63	4.19	2.67	2.18	3.95	3.52	2.24	1.71	2.77	2.34	2.76	2.24	3.53	3.08
Leucine	6.43	5.89	6.47	5.96	5.18	4.60	5.24	4.75	6.31	5.76	5.42	4.90	3.65	3.03	4.78	4.29
Tryptophane**	0.64	0.48	0.73	0.58	0.47	0.30	0.69	0.55	0.48	0.31	0.60	0.46	0.65	0.48	0.66	0.50
Total in dispensable amino acids%	33.51	30.09	35.74	32.89	28.65	25.01	30.31	27.54	30.85	26.98	30.11	27.29	23.06	19.43	27.91	25.14
Dispensable																
Aspartic acid	11.46	10.88	11.51	11.06	10.50	9.90	10.00	9.56	12.26	10.91	11.36	10.95	6.97	6.38	7.83	7.39
Serine	3.36	3.10	3.39	3.15	2.69	2.42	2.90	2.68	2.86	2.58	2.94	2.71	1.94	1.65	2.27	2.05
Glutamic acid	12.85	12.47	11.81	11.40	10.56	10.01	10.20	9.75	11.27	10.80	12.08	11.41	4.84	4.48	7.71	7.29
Proline	4.95	4.66	4.41	4.09	4.65	4.35	3.92	3.59	4.40	4.10	4.90	4.49	3.91	3.63	4.01	3.68
Glycine	3.18	2.94	3.35	3.11	2.84	2.61	2.81	2.58	2.59	2.34	2.84	2.66	2.50	2.25	2.93	2.70
Alanine	5.68	5.29	6.98	6.62	5.02	4.60	6.22	5.88	5.16	4.75	5.17	4.88	4.71	4.31	5.44	5.06
Histidine	3.11	2.79	3.20	2.87	2.94	2.59	2.67	2.35	2.35	2.01	2.78	2.43	2.45	2.11	2.67	2.35
Arginine	6.81	6.45	7.01	6.68	5.75	5.37	3.50	3.15	6.16	5.79	5.71	5.40	2.96	2.59	4.02	3.66
Cystine	0.20	0.13	0.28	0.20	0.00	0.00	0.04	0.00	0.03	0.00	0.09	0.01	0.00	0.00	0.05	0.00
Tyrosine	1.70	1.43	2.55	2.30	0.58	0.32	2.31	1.30	1.83	1.45	1.09	0.85	0.00	0.00	1.35	0.99
Total dispensable amino acids%	53.30	50.14	54.49	51.48	45.53	42.17	44.57	40.84	48.91	44.73	48.96	45.79	30.28	27.40	38.28	34.18
Total amino acids%	86.81	80.23	90.23	84.37	74.18	67.18	74.88	68.39	79.76	71.71	79.07	73.08	53.34	46.83	66.19	59.32

*** frozen storage at -20°C for 6 months . ** Tryptophane was determined colorimetrically.**

Table (4): Effect of cooking processes on fatty acids composition of fresh and frozen* common and male formatted Bolti fish flesh (Grade 1).

Fatty acids %**		Uncooked fish				Roasting				Frying				Wet cooking			
		Common fish		Mono-sex fish		Common fish		Mono-sex fish		Common fish		Mono-sex fish		Common fish		Mono-sex fish	
		Fresh	Frozen	Fresh	frozen	fresh	frozen	Fresh	frozen	fresh	frozen	fresh	frozen	fresh	Frozen	fresh	frozen
Myristic	$C_{14:0}$	5.61	6.92	4.91	6.15	5.25	5.04	4.09	5.30	2.53	4.16	2.49	2.40	4.77	5.97	4.20	5.47
Palmitic	$C_{16:0}$	20.59	20.84	20.22	22.14	18.65	21.17	23.43	23.50	18.01	16.83	15.57	16.74	21.45	21.49	21.01	22.14
Stearic	$C_{18:0}$	7.11	6.87	5.83	5.18	6.67	5.03	5.30	4.17	4.35	3.21	4.36	3.90	6.60	6.28	5.60	5.33
Arachidic	$C_{20:0}$	0.70	0.88	0.91	0.99	0.38	0.47	0.68	0.00	0.33	0.00	0.29	0.00	0.97	0.00	0.00	0.00
Behenic	$C_{22:0}$	3.37	0.79	0.46	0.50	1.42	0.68	0.00	0.00	2.10	0.00	0.11	0.00	1.36	0.00	0.30	0.00
Total saturated fatty acids		37.38	36.30	32.33	34.96	32.37	32.39	33.50	32.97	27.32	24.20	22.82	23.04	35.15	33.74	31.11	32.94
Palmitoleic	$C_{16:1}$	14.16	17.97	11.21	10.25	14.14	18.26	7.54	7.16	4.00	4.11	4.27	1.12	14.69	19.40	11.76	10.84
Oleic	$C_{18:1}$	27.33	33.97	32.02	31.56	29.79	36.67	32.58	35.23	30.07	40.01	33.85	36.71	28.36	36.74	33.59	33.89
Linoleic	$C_{18:0}$	16.82	7.63	20.16	19.46	18.82	8.47	21.53	21.71	34.54	27.57	35.47	35.30	16.55	6.94	19.20	18.69
Linolenic	$C_{18:3}$	2.98	2.76	2.55	2.63	3.34	3.02	3.03	2.93	4.07	4.11	3.59	3.83	4.23	3.18	4.34	3.64
Erucic	$C_{22:1}$	1.33	1.37	1.73	1.14	1.54	1.19	1.82	---	---	---	---	---	1.02	---	---	---
Total unsaturated fatty acids		62.62	63.70	67.67	65.04	67.63	67.61	66.50	67.03	72.68	75.80	77.18	76.96	64.85	66.26	68.89	67.06

*** Frozen storage at - 20°C for 6 months.** **** Fatty acids were calculated as percentage of total fatty acids.**

Table (5): Effect of cooking processes on *in - vitro* digestibility (%) of fresh and frozen* common and male formatted Bolti fish flesh (Grade 1).

Enzymes Cooking processes	Common Bolti fish						Mono-sex Bolti fish					
	Pepsin		Pincreatin		Pepsin followed byPincreatin		Pepsin		pincreatin		Pepsin followed by Pincreatin	
	Fresh	Frozen	Fresh	frozen	fresh	frozen	fresh	frozen	fresh	frozen	fresh	frozen
Roasting	73.66	71.95	79.50	78.20	88.15	85.11	74.52	72.60	81.61	80.10	93.22	91.79
Frying	67.95	66.12	73.40	71.90	80.22	78.22	70.30	68.10	74.61	72.71	81.80	79.64
Wet cooking	71.32	69.73	78.31	75.90	88.23	84.71	72.91	71.21	80.91	79.31	90.81	89.13
Casein (control)	54.00		87.00		90.03		54.00		87.00		90.03	

*** frozen storage at - 20°C for 6 months .**

Table (6): Effect of cooking processes on organoleptic qualities of fresh and frozen* common and male formatted Bolti fish (Grade 1).

Cooking processes organoleptic qualities	Roasting				Frying				Wet cooking			
	Common fish		Mono-sex fish		Common fish		Mono-sex fish		Common fish		Mono-sex fish	
	Fresh	frozen	Fresh	frozen	fresh	frozen	fresh	frozen	Fresh	frozen	fresh	Frozen
Color	9.00	7.03	8.50	7.57	7.38	5.33	8.13	5.51	6.00	5.71	6.00	5.14
Odor	8.37	7.32	8.38	7.43	7.25	6.70	8.50	7.10	6.75	4.43	7.13	4.86
Texture	8.13	6.50	8.13	6.57	7.00	6.00	8.38	7.25	6.75	5.43	7.75	5.57
Taste	7.37	6.50	8.38	7.00	7.50	7.01	8.00	7.50	5.88	4.67	6.63	5.00
Appearance	8.50	7.59	8.25	7.57	7.13	5.99	8.50	6.25	6.00	5.00	6.88	5.43
Overall acceptability%	82.74	69.88	83.28	72.28	72.52	62.06	83.02	67.22	62.76	50.48	68.78	52.00

*** Frozen storage at -20°C for 6 months.**

Excellent : 8.50 - 10.00 Very good : 7.50 - 8.49 Good : 6.50 - 7.49

Average : 5.00 - 6.49 Bad : less than 5.00 - 4.50 Very bad : less than 4.50