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Quality of Surimi produced from aquacultured grass carp "Ctenopharyngodon idellus" during frozen storage

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SUMMARY

This study was performed to explore the quality of surimi produced from cultured grass carp fish and its frozen storage characteristics. Surimi was produced from fresh cultured grass carp by traditional method through successive washing with chilled water, followed by addition of cryoprotectant agents. Surimi was packaged, frozen at -35°C and then stored in-18°C for three months. Produced Surimi was investigated at zero time for yield percent, chemical composition, and fatty acid profile. pH, folding test, TBA-value, instrumental colour, total bacterial count (TBC) and Staphylococcus aureus (S.aureus) count were performed at zero time then monthly during storage period. Grass carp surimi presented high yield% (52.7) and protein content (17.25%) with low fat 2.19%. Fatty acid profile showed high % of polyunsaturated fatty acid (26.74) with low content of omega three and omega six fatty acids. TBA-value was increased as the storage time increased, however, all values were far from oxidative rancidity limit. Significant reduction of TBC with increase storage time was observed. Grass carp surimi gel exhibited excellent whiteness and good strength properties, but surimi gel started to loss its strength by the second month of frozen storage.

INTRODUCTION

Carp production in Egypt is increased steadily throughout the decades. Total production of aquaculture carp species in 2006 was 91.618 tones, which approximately constitute 15% of the total harvest (Nassr-Alla, 2008). Common carp was introduced to Egypt since 1930 for governmental experimental aquaculture, while grass and silver carps were

introduced from Hungary in the late 1980s for the same purpose. It is worth to mention that grass carp can be raised on aquatic weeds and therefore it is used in nationwide programme for biological weed control in the irrigation and drainage systems in Egypt. The production of grass carp from weed control programme is 18 060 tonnes rather than that of aquacultured production ((FAO, 2005). However, grass carp is low price and not popular commodity that is affordable to middle and low income classes in Egypt and other countries, therefore many fish sellers use unauthenticated ways to sale it with high price. Production of surimi from grass carp fish with further processing into fish products could maximize the benefits and utilization of grass carp (Yangkang et al., 2006; Wu and Mao, 2009 and Xiong et al., 2009).

Surimi is a Japanese word literally means minced meat, where fish muscle has been separated from the bones and then comminuted. Minced meat becomes raw or unfrozen surimi after it has been washed to remove fat and water-soluble constituents (Flick et al., 1990; Okada, 1992 and Mahawanich, 2008). The water-soluble matter in minced fish meat includes sarcoplasmic proteins, digestive enzymes, inorganic salts and low-molecular organic substances, which are known to accelerate the denaturation of muscle proteins during frozen storage. Therefore, the removal of such substances increases the concentration of myofibril proteins, which is primarily responsible for gel formation. Surimi is served as a potential raw material for a variety of products, which become more increasingly popular due to their unique textural properties as well as high nutritional value (Park & Morrissey, 2000; Xichang et al., 2005 and Shaviklo and Johannsson, 2006). Fresh or ice-stored fish are commonly used for surimi production worldwide, where fish freshness considers as the crucial factor determining the surimi quality (MacDonald et al., 1990 and Benjakul et al., 2002).

Sucrose, sorbitol and phosphates are the most anti-denaturant additives commonly mixed with surimi to improve the gel-forming ability, increase protein solubility and decrease cooking loss. Also cryoprotactants give surimi the ability to resist freeze denaturation during frozen storage, which is an irreversible change in the protein resulting in a reduction in gel strength. Furthermore, myofibril proteins in the frozen surimi will retain their functional properties for many months if properly stored (Flick et al., 1990 and Okada, 1992). Lean white fish are considered to be better than fatty fish (probably because of poor color and the problem of lipid removal), but any species with actomyosin gel-forming capability

should be acceptable (Nowsad et al., 2000).

This study aims to investigate surimi production from aquacultured grass carp "Ctenopharyngodon idellus" and its quality and stability during frozen storage.

MATERIALS AND METHODS

Fresh cultured grass carp of 1300-1500 gm and 50 cm were purchased from a fish market in Giza, Egypt. They were immediately transported to Food Hygiene and Control Department laboratory-Faculty of Veterinary Medicine - Cairo University within 30 minutes in an ice box. Immediately after arrival fish were thoroughly washed and dressed to remove scales, head, and viscera. They were washed once again in chilled water and manually deboned and filleted. The fillets were strained in a sieve for 20 min. Preparation of surimi was based on the method reported by Hall and Ahmad (1992). The strained fillets were minced with 4 mm diameter electrical meat grinder (Fama Fabbrica Atter zzature Machine Alimentrac, Rimini-Italy). The minced fish was washed with cold water in tanks using a ratio of mince/water 1/3 (w/v) for 15 min with 5 min mixing. The minced fish flesh was washed three times with 0.3% salt added in the last washing water. After each wash, the mince was strained through a plastic screen for 15 min. After the last wash, the mince was strained, and then pressed for 45 min by board press in cheese cloth. Dehydrated surimi was mixed manually with 4% sorbitol, 4% sucrose and 0.3% Na-tripolyphosphate as a cryoprotectant. Surimi was packaged in polyethylene bags (400 gm), frozen within 1 hour at -25°C, and then stored in a deep freezer at -20°C for a period of 3 months. Produced surimi was investigated at zero time for yield percent, chemical composition, and fatty acid profile. While investigation for pH, folding test, TBA-value, instrumental colour, aerobic plate count and S.aureus count were performed at zero time and periodically for three months of frozen storage at monthly interval.

Grass carp Surimi Gel Preparation

Surimi gel was prepared as recommended by Turan and Sönmez (2008) by addition with 2.5% salt and the moisture content was adjusted to 80% with cold water. The mixture was chopped for 5 min at 4°C to obtain the homogenous solution. The solution was then stuffed into polyvinylidine casing with a diameter of 3.5 cm and both ends of casing were sealed tightly. Two-step heated gels were prepared by setting the sol at 40°C for 30 minutes, followed by heating at 90 °C for 20 minutes. The gels were then cooled in iced water and stored for 24 hours at 4 °C prior to analysis.

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Yield percent: Yield was calculated (after Jin et al., 2007) from the difference between the weight of whole muscle and ending mass of surimi.

Yield % = (whole muscle weight –surimi weight)/(whole muscle weight) × 100.

Chemical composition: Percentages of moisture, fat, protein, and ash were determined by the AOAC method (1990). Where moisture content was determined using the direct water distillation method, the fat content was determined with the Soxhlet method, and the protein content with the Kjeldahl method. The total ash content was determined by igniting the charred sample in a muffle furnace at 525°C until a constant weight was reached (LFRA, 1978).

Fatty Acid Profile: Lipid was extracted following the Bligh and Dyer (1959) method and was saponified with 20% of potassium hydroxide in methanol, and the unsaponifiables was extracted with diethyl ether (peroxide free). Fatty acid standard and samples were converted to methyl ester following the Vogel, (1975) method, where fatty acid methyl esters of samples' lipid were separated and quantified by GC (GVC Pye Unican series304 gas chromatography). Peaks were identified by comparison with retention times of known standards. The content of individual fatty acids was expressed as a percentage of the total fatty acid content.

pH determination: Twenty grams of thawed surimi were homogenized with 20 ml of distilled water. A standard pH -meter (ORION/KNI pHE EU TECH England) equipped with a glass electrode was used according to the technique described by Pastoriza and Sampedro (1994).

Folding test According to Min et al. (1989): A folding test was carried out by folding a 4-mm thickness slice of the prepared gel into halves and quarters. The scales for the folding test were 5: no crack showing folding twice; 4: no crack showing after folding once but cracks when folding twice; 3: cracks gradually when folded in half; 2: cracks immediately when folded in half; and 1: breaks by finger pressure.

Thiobarbituric (TBA) acid – value: Oxidative rancidity of surimi during frozen storage was quantified using TBA-values. The spectrophotometrically determined of TBA-value was applied as recommended by Johns et al., (1989) and Faustman and naderu al. (1992). TBA- value was expressed as mg malonaldehyde/kg sample.

TBA - value= 7. 8 D where D = .Absorbance of sample at 532nm.

Instrumental Color determination: The L*, a* and b* (L*= lightness/darkness a*= redness/green, and, b* = yellowness/blue) of the prepared gel samples were measured

by a Hunter Lab Colour Meter (D25-INC4750- Hunter associates lab, Reston, Virginia) with an optical sensor which was standardized with a white colour standard at the beginning of each measurement session. Five readings were made from the surface of samples. The color of surimi was determined by calculating whiteness (W) (Park, 1994 and Luo et al., 2004) as:

Whiteness = (L*–3 b*).

Bacteriological examination: It included the determination of total bacterial counts and S.aureus count. Surimi homogenate was prepared by homogenization of 10 g of surimi with 90 mL of 0.1% sterile peptone water by using stomacher (Steward Stomacher 400 Lab Blender, London, UK). Serial decimal dilutions up to 10^6 were prepared from the surimi homogenate. The microbiological procedures recommended by APHA (1992) were applied. Standard plate count agar and Parid Parker agar were used to enumerate aerobic plate counts at 32°C for 24-48hours and S.aureus count at 37°C for 48 hours respectively.

Statistical analysis:

Results were reported as mean values of each determinations ± standard error (SE). Analysis of variance was performed by ANOVA procedures (SPSS 17.0 for Windows, SPSS Inc, Chicago, IL, USA). Differences among the mean values of the various analysis were determined by the least significant difference (LSD) test, and the significance was defined at $P < 0.05$ (Wu and Mao, 2008).

RESULTS AND DISCUSSION

Yield and Chemical composition

Grass carp flesh yield obtained after filleting and mince washing steps are presented in table (1). Considerable high yield percentage of Surimi from grass carp fillet (52.7%) was observed, which could be an advantage from the economic point of view. The obtained results were in harmony with that of Lee (1984), while Kaba (2006) and Jin et al., (2007) recorded lower results.

Proximate chemical composition of the produced surimi is presented in Figure 1. Grass carp surimi proved high-moisture, protein and low lipid containing fish product, where moisture, protein, lipid and ash content were 78%, 17.61%, 2.19% and 1.45% respectively. High moisture content may be as an effect of washing fish mince. Hossain et al. (2004) found that washed muscles have tendency to retain some water during washing even washed with salt water. Also low lipid content could be explained by the fact that grass carp is low fat fish in addition to lipid substances were removed effectively by washing. Chemical compositions are an important role in surimi quality. In that regard Luo et al.

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(2004) reported that the protein concentration greatly affected the gel properties of alaska pollack and common carp surimi. while Smith (1987) stated that lipids in surimi products may bring about an adverse effect on the surimi quality, because the oxidized lipids interact with proteins, causing denaturation, polymerization and changes in functional properties.

Fatty acid profile of Grass carp surimi

The fatty acid composition of lipid from grass carp Surimi is shown in Table (2). Total saturated fatty acids (SFA) accounted for 46.29% of the total fatty acids. The most predominant saturated fatty acids were14:0, followed by 16:0 and 12:0; 18:0. While, total monounsaturated fatty acids (MUFA) constituted 24.9% of the total fatty acids, and the major MUFA were 16:1, and 18:1. On the other hand, the content of polyunsaturated fatty acids (PUFA) was 26.74%. Recently, effects of fish consumption for human health were elucidated, and 20:5n-3 and 22:6n-3, have been noted as useful substances (Dunstan et al., 1999 and Rose &Connolly, 1999). The content of 20:5n-3 and 22:6n-3 in grass carp Surimi was 0.74 and 0.84%, respectively. These levels of 20:5n-3 and 22:6n-3 was lower than those of marine fish (Ackman, 1989). Varieties of fatty acid composition of fish is influenced by their diet (Stansby et al., 1990), therefore fatty acid profiles of cultured fish can be controlled by their diet (Kaneniwa et al., 2000).

Physico-chemical changes of Grass Carp Surimi during frozen changes

The mean values of pH, folding test, TBA-value and instrumental colour at zero time and during frozen storage period are presented in table (3).

pH: Grass carp surimi revealed alkaline pH-value (7.15) at zero time, with no significant change ($P<0.05$) in the pH during the three months of frozen storage. Similar results were recorded by Jin et al. (2007) and Turan and Sönmez (2008). The higher alkaline pH-value of produced surimi may be referring to the high ultimate pH of fish flesh and also the addition of Sodium tripolyphosphate as cryoprotactant agent.

Folding test: folding test is a simple test to measure gel strength with good correlation with the instrumental method and could be used as a tool to differentiate between high and low quality surimi gel (Mahawanich, 2008). The produced surimi gel showed a good gel strength for the first month of storage and revealed significant reduction ($P<0.05$) in the second and third month to be 3and 2 respectively which indicate the occurrence of cracks when surimi gel slices were folded into halves. These results could be explained on the base that freezing and frozen storage of surimi had

denaturation effect on myofibillar proteins leading to the loss in protein functionality mainly gel forming ability (Benjakul et al., 2005).

TBA-value: TBA-value was increased as the storage time increased, however, the increase rate was slow and all recorded values were far from oxidative rancidity level (Huss, 1988). Low starting TBA-value (0.065 mg mal/Kg) was recorded thus could reflect freshness condition of grass carp fish and low fat content of (2.19%) of the produced surimi as a result of washing process. The obtained results were similar to that obtained by Köse and Uzuncan (1999) and Köse et al. (2000). Lipid oxidation occurred during frozen storage might cause the denaturation of proteins. As proteins exposed to oxidizing environments are very susceptible to chemical modification, such as amino acid destruction, peptide scission and formation of protein–lipid complexes (Saeed and Howell, 2002 and Xiong, 1997).

Instrumental color:

Grass carp surimi had a high lightness and whiteness properties which is one of most important factor in quality of surimi (Ochiai et al., 2001). The mean values of lightness (L*) and whiteness of grass carp surimi were 86.5 and 85.15 respectively at zero time. The high whiteness (W) and lightness (L*) values of surimi may be due the use of the white muscle only in its production. In addition, washing steps during surimi production eliminate most of blood and fat (Pacheco-Aguilar et al., 1989). Moreover, no significant reduction ($P<0.05$) in the lightness and whiteness values could be observed during the three months of frozen storage at -18°C.

Total Aerobic Bacterial Count: The total bacteria count in grass carp surimi at zero time (unfrozen) was 5.6 log cfu/g, as shown in table (4). This high bacterial count might be originated from the contamination during the manual processing of surimi. Furthermore, significant bacterial count reduction ($P<0.05$) was noticed of the examined surimi samples during third month of frozen storage. The total bacterial count reached to 2.8 log cfu/g at the end of storage. Similar results were recorded by Kaba (2006). On the other hand, no S.aureus could be detected in any of surimi samples.

CONCLUSION

In this study, the quality changes of the surimi produced from aquacultured grass carp and stored for 3months at -18°C were investigated. It was found that surimi production could be carried out from aquacultured grass carp with high yield percentage. Moreover, it was determined that the spoilage was low during the 3

months of storage. Surimi production and surimi technology have the capacity to add a new aspect in Egyptian fish industry and encourage the consumption of this fish. Further research is required for improving the gel forming ability during frozen storage.

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Table (1). Fillet and surimi yield from grass carp fish.

Production step	Amount / Kg	(%)
Whole fish	17.25	100
Fillet (Muscle/Fish)	8.4	51.3
Surimi/Fillet	3.9	52.7

Table (2). Fatty acid Profile of grass carp Surimi

FA	Mean ± SE
12:0	10.71 ±0.64[a]
14:0	17.99 ±1.03[b]
16:0	13.38 ±0.76[c]
18:0	4.21 ±0.24[d]
Total SFA	**46.29 ±2.67**
16:1n	5.68 ±0.32[a]
18:1n	19.23 ±1.1[b]
Total MUFA	**24.91 ±1.44**
18:2n-6	23.85 ±1.37[a]
18:3n-3	1.31 ±0.07[b]
20:5n-3	0.74 ±0.04[c]
22:6n-3	0.84 ±0.04[c]
Total PUFA	**26.74 ±1.55**

Values in the same raw withinthe group followed by a different letter are differ significantly at P<0.05.

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Table (3). Physico-chemical changes of grass carp Surimi during frozen changes

	Zero time	1st Month	2nd Month	3rd Month
PH-value	7.17±0.41[a]	7.15±0.41[a]	7.2±0.41[a]	7.18±0.41[a]
Folding test	4±0.23[a]	4±0.23[a]	3±0.17b[c]	2±0.11[b]
TBA-Value mg mal\kg	0.065± 0.007[a]	0.088±0.005[bc]	0.097±0.005[bd]	0.19±0.009[b]
Instrumental Colour				
L*	86.5±4.99[a]	85.16±4.92[a]	81.3±4.69[a]	79.46±4.59[a]
a*	19.1±1.10[a]	19.5±1.13[a]	21.4±1.24[ab]	24.4±1.41[b]
b*	0.45±0.026[a]	0.52±0.029[ac]	0.64±0.035[bc]	0.7±0.041[b]
W	85.15±4.92[a]	83.66±4.83[a]	79.5±4.74[a]	77.36±4.47[a]

Values in the same raw followed by a different letters are differ significantly at P<0.05.

Table 4: TBC & S. aureus count (log10 cfu /g) of grass Carp Surimi during frozen storage

	TBC	S. aureus
Zero time	5.6± 0.32[a]	$<10^2$
1st Month	4.1± 0.23[b]	$<10^2$
2nd Month	3.7± 0.21[b]	$<10^2$
3rd Month	2.8± 0.16[c]	$<10^2$

Values in the same raw followed by a different letter are differ significantly at P<0.05.

Fig. 1: Mean Values of chemical composition of grass carp surimi