Innovative Studies on "Analogue Shrimp Products" from Lizard Fish Using 3D Printing

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ABSTRACT

An attempt was made to explore the possibilities of better utilization of Lizard fish (*Saurida tumbil*) for the development of valuable imitation shrimp products. Minced meat, surimi and imitation shrimp products were prepared from Lizard fish. The aluminum and polylactic acid shrimp moulds were developed and to produce the imitation shrimp products. In the present study, the imitated shrimp products was observed for the wholesomeness.

Key words: Aluminium, Analogue shrimp, Lizard fish, Shrimp mould, Yield.

INTRODUCTION

Seafood analogue is a ready to make value added product prepared out of surimi. This technology offers a viable potential for converting the low cost fishes in to high valued products. Analogues are also called imitation products as it imitates the flavor and appearance of the products. The analogue fishery products are the sudden boost production and marketing of ever increasing varieties of analogue products world wide is due to many factors such as any kind of small sized fish and in conspicuous species, can be used successfully; the product has a very satisfactory shelf life without major change in the functional properties, a series of analogue products can be made because it can easily be made to attain desired shape and external outlook during formation. The cost of analogue is less compared to the original product though there is not much variation in the nutrition value and flavour. Low cholesterol value of imitation crustacean product increase the demand from consumer in developed countries (Nambudiri and Peter, 2012).

A little information is available about the processing of analogue seafood products till now. A process for the production of sea food analogue was described by Hartman and Delahunt (1993) and imitation of fish slice production, which consist of kneading of fish tissue with other ingredient was published by Yasumo (1992). A shrimp analogue was produced by mixing surimi paste with a mixture of glucomanan, carageenan, protein and starch and there after extrusion of the mixture (Wu 1991) Surimi based products, especially crab analogue has a great deal of acceptance in the US and European countries since the beginning of the 1980's and the prospects and future development of coated sea food analogues was studied by Roessink (1989) and Schubring (1995).

Imitation prawn analogue is also made using different formulations by the application of various texturising and moulding machineries. In the preparation of analogue seafood, various types of ingredients are incorporated with stabilised fish meat. Imitation shrimp products are made from deboned, washed and stabilised fish meat extracted from the white flesh of low cost fish, it possessed good gelling properties, using proper technology. In India, a number of fishes like Threadfin bream, Ribbon fish, Lizard fish, Jew fish, Cat fish, Big eye snapper etc. are available and their cost is also low. The fat content of most of these species is very low and they are ideal for the production of value added products (Benjakul *et al.* 2004: Guenneugues and Morrissey, 2005).

Because of abundant availability, low cost and its present use being confined to curing and drying Lizard fish (*Saurida tumbil*) is selected for this study. The species having a long belly cavity embedded with rib bones is not fit to be used for filleting. The meat is white in colour and has very good gel strength in fresh condition. If proper attention is provided, satisfactory gel strength can be maintained even during storage. By the development of suitable techniques, highly palatable and immensely valuable imitation products can be churned out from the lizard fish. The main objective of this study is to design aluminium and polylactic acid shrimp mould and to develop the imitated shrimp products from Lizard fish (*Saurida tumbil*).

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MATERIALS AND METHODS

Preparation of shrimp analogue product

Lizard fish (*Saurida tumbil*) belonging to the family, Synodontidae was procured as fresh from Thoothukudi Fishing Harbour, and brought to the laboratory in chilled condition with the ice to fish ratio (1:1) in insulated containers. Fish were washed with potable water to clean the dust, dirt, sand and other extraneous matter and dressed manually to remove the head, entrails and fins. The dressed fish were again washed thoroughly in chilled potable water. The temperature during all the processing steps was maintained between 5 and 10°C by using sufficient flaked ice made by using flake ice maker (ZBE 150 Nr 940062, Orlando, Germany). The dressed fish were then fed into a mechanical deboner/mincer (Baader/ 601, Berlin, Germany) to obtain minced fish meat. The yield of minced fish meat were calculated separately. To prepare surimi, the minced meat was washed with cold water (5°C) at a mince/water ratio of 1:3 (w/v), stirred gently for 4 min and then filtered with a nylon screen having a pore size of 0.2 mm. The washing process was repeated thrice. In the third washing step, cold 0.5% NaCl solution (5°C) was also used. To the washed minced fish, 4% sucrose, 0.25% NaCl, 4% sorbitol and 2.5% NaCl was ground well in a grinder for 15minutes to obtain a fine paste. At the end of grinding, synthetic shrimp flavor solution (2%) was added to the surimi paste. Then the paste was kept in aluminium shrimp mould and placed in a cooker. The paste was cooked at 90°C for 20 mins without developing pressure. Then analysed for the biochemical characteristics of minced meat, surimi and analogue shrimp products from lizard fish were determined (*Saurida tumbil*).

Designing of aluminium shrimp mould

Morphologically, real shrimps have full and smooth shape, with cross section area varying from head to tail; wholly nodular, dotted with alternately red and white strip-like pattern. The shape and pattern vary from shrimp species. Because of its large size and better shape, the shrimps products often use it as an imitation object. After that, we used the reverse engineering modeling technique was applied to produce the aluminium shrimp mould, using Unigraphics and Mastercam softwares. The technical course was as follows.

Designing of Aluminium Shrimp Mould

Shrimp object
↓
Draw the Picture
↓
Decide part dimension and features
↓
Generate/Import 3D Model using reverse engineering softwares (Unigraphics/Master Cam) (Fig 1)
↓
Generate cutterpath pattern
↓
Machining simulation
↓
Generate program code in post processor
↓
Aluminium Shrimp mould

Designing of polylactic shrimp mould

Morphologically, real shrimps have full and smooth shape, with cross section area varying from head to tail; wholly nodular, dotted with alternately red and white strip-like pattern. The shape and pattern vary from shrimp species. Because of its large size and better shape, the shrimps products often use it as an imitation object. After that, we useed the Fused filament fabrication technique was applied to produce the polylactic acid shrimp mould, using STL softwares. The technical course was as follows.

Designing of polylactic acid shrimp sould

Shrimp object
↓
Draw the Picture
↓
Decide part dimension and features
↓
Generate/Import 3D Model using Fused Filament Fabrication Technique (STL software) (Fig 2)
↓
Generate cutterpath pattern
↓
Machining simulation
↓
Generate program code in post processor
↓
Polylactic acid Shrimp mould

RESULTS AND DISCUSSION

Yield

The average length and weight of lizard fish used in the present study were 28.91 cm and 198.81g respectively and found to be suitable as raw material for the preparation of imitated shrimp products. The average dressing, minced meat and yield of surimi obtained during the processing of *S. tumbil* were presented in Table 1. The yield of dressed fish in the present study was 77.64%. (Sharma, 1989) was found 76% of meat recovery from lizard fish through mechanical separation and (Joseph *et al*., 1980) in lizard fish obtained a dressing yield of 50%. Dora, (1992) has reported 60 and 66% of yield in *Johnius* sp and *Nemipterus japonicus* respectively.

Table 1: Yield percentage of dressed fish, minced meat and surimi from lizard fish (*Saurida tumbil*).

Stage of processing	Yield percentage (%)
Dressing yield	77.64 ± 1.55
Minced meat from whole fish yield	56.19 ± 2.76
Surimi from whole fish yield	32.89 ± 1.25

Values are shown as mean ± standard error of triplicates.

Revenkar *et al*., (1981) acquired the dressing yield of 50 - 52% and 34 - 50% respectively in croaker and pink perch. Hema *et al*., (2012) reported that the dressing yield of short nosed white tripod fish was 47.43%. In general, dressed yield was directly proportional to the size of the fish. The fairly high yield obtained in the present study might be due to the comparatively bigger size of the fish used and careful handling during dressing.

Currently, deskining and deboning processes were carried out by machines that removed the muscle portion from the frames which includes skin, scales, fins and bones of fish. The average yield of minced meat was 56.19% in terms of minced meat from whole fish. The minced meat or deboned meat yields obtained from different fish have also varied considerably with species. Minced meat yields of Pacific hake and cod were 40 and 45% respectively (Crawford *et al*., 1972); in terms of dressed weight. According to Gopakumar *et al*. (1992), the yield of different types of tropical marine fishes processed by Baader 694 deboning machine was in the range of 32 to 54%. Lin and Morrisey, (1995) reported 27% of minced meat in Squawfish. The yields of minced meat from various fishes of Indian waters such as *Tachysurus* spp. (27%), *Megalopsis cordyla* (31%), *Johnius* sp. (34%), *Uppinus vittatus* (46%), *S. tumbil* (56%) and *Trichurus savala* (53%) are reported by Muraleedharan *et al*. (1996), lizard fish was 42.22% (Jitesh *et al*., 2011). Hema *et al*, (2012) reported minced meat yield obtained from white tripod fish was 26.11%. Rathnakumar and Pancharaja, (2018) reported 50% yield of minced meat was possible from whole fish. Compared to these results, the minced meat yield of lizard fish from the present study was higher (56.19%) in terms of total weight that could be due to the efficient deboning operation performed through improved machineries.

In the present study, the yield of surimi obtained was 32.89%. The average yield of haddock was 26.7% (Hastings *et al*., 1989). The yield of surimi from various fishes of Indian waters was in the range of 23-32% (Muraleedharan *et al*., 1996; Muraleedharan *et al*., 1997) and lower yield of 17% was reported in Northern Squaw fish (Lin and Morrisey, 1995). Kaba, (2006) reported that the yield of anchovy was 22%. Dey and Dora, (2011) reported 32.90% yield of gangetic croaker surimi. In the present study, the yield of surimi value was comparable with the value reported by Dey and Dora, (2011) in gangetic croaker (32.90%). Although the surimi yield percentage in the present study was slightly higher than the yield rate as reported by Sharma, (1989).

Proximate composition of minced meat

Proximate composition of the minced meat, in terms of wet weight for lizard fish (*Saurida tumbil*) was 80.5% moisture, 15.98% protein, 1.20% fat, 1.40% ash and 1.60% carbohydrate given in Table 2. According to Love, (1980), proximate composition of fish varies with age, sex, size, season, feed availability, species, place, type of muscle, time of spawning and environmental factors. Kongpun, (1999) reported that lizard fish had a protein content of 17.65% and moisture content of 79.03%, the fat content was 1.07%. Suwansakornkul *et al*. (1993) reported even lower level of fat contents in *S. undosquamis*, *S. wanieso* and *S. elongate* which was less than 1%.

Jitesh *et al*. (2011) analysed that the proximate composition of lizard fish (*Saurida tumbil*) had 78.43% of moisture content, 17.15% of protein content, 1.89% of lipid and 1.59% of ash content. Meena *et al*. (2015) has reported that the proximate composition of *Saurida tumbil* contained 76.87% of moisture, 19.34% of protein, 1.29% of fat and 1.83% of ash. Rathnakumar and Pancharaja, (2018) reported that the proximate composition of lizard fish minced meat has 76.99% of moisture, 19.01% of protein, 1.13% of fat and 1.31% of ash. Similar results were reported by many researchers (Numakura *et al*., 1989; Rathnakumar and Shamasundar, 1998). The present value was concomitant with value of Rathnakumar and Shamasundar, (1998) and Palanikumar *et al*. (2014). Researchers have detailed on the proximate composition and nutritive profile of lizard fish (Chattopadhyay *et al*., 2004). Palanikumar *et al.* (2014) studied the proximate composition of minced meat of lizard

Table 2: Biochemical Characteristics of Lizard fish.

Parameters	Minced Meat (wet weight)	Surimi (wet weight)	Analogue Shrimp Product (wet weight)
Moisture (%)	80.50 ±0.20	83.00 ± 0.50	87.00 ± 0.50
Protein (%)	15.98 ± 0.06	13.85 ± 0.07	10.15 ± 0.07
Fat (%)	1.20 ± 0.20	0.86 ± 0.005	0.04 ± 0.00
Ash (%)	1.40 ±0.02	0.80 ± 0.02	0.80 ± 0.02
Carbohydrate	1.60 ± 0.10	2.10 ± 0.10	2.50 ± 0.10
Acid insoluble ash	0.02± 0.00	Absent	Absent
TMA-N (mg %)	Absent	Absent	Absent
TVB-N (mg %)	1.4 ± 0.00	Absent	Absent
TBA	0.14 ± 0.00	0.3 ± 0.00	0.2 ± 0.00
FFA (% of oleic acid)	0.5 ± 0.04	0.98 ± 0.03	0.38 ± 0.03
PV (milli equivalent O_2 /kg fat)	0.8 ± 0.05	1.20 ± 0.00	1.00 ± 0.00
pH	7.02 ± 0.005	6.98 ± 0.005	6.95 ± 0.005

Each value represented as mean ± standard deviation n=3.

fish that contains 79.19% of moisture, 16.28% of protein, 0.29% of fat, 1.85% of ash and 0.09% of carbohydrate.

Proximate composition of surimi

Surimi of lizard fish (*Saurida tumbil*) had 83% of moisture, 13.85% of protein, 0.86% of fat and 0.8% of ash Table 2. The fat and protein contents of surimi were less when compared to minced meat because the fat content would be removed during the washing process Roussel and Cheftel, (1990) have assessed the quality of surimi produced out of Atlantic sardine by adding 4% sugar and 4% sorbitol as preservatives and stored at - 45°C for 8 months and revealed the moisture, protein and fat contents were 76%, 14% and 1% respectively at the end of the storage period. Washing helps to remove the pigments, blood, odour, enzymes, mucus and some water soluble proteins.

The protein content of surimi was higher than the minced meat in terms of dry weight due to the different washing steps. The present yield of surimi protein value was in concomitant with the values (79.5%) of Gopakumar *et al*. (1992). According to Suvanichi *et al*. (2000) surimi has lower levels of fat and ash content and increased moisture content than the unwashed minced meat. USDA, (2010) has reported that the standards for proximate composition of surimi was 76.3% moisture, 15.3% protein, 0.9% fat and 0.7% ash on wet weight basis. Huda *et al*. (2012) reported that moisture and protein contents of surimi made from threadfin bream were 81.31% and 16.04%, respectively.

The proximate composition of fish meat indicates that the fish used was lean. The proximate composition of fish meat before and after water washing showed a significant leap of moisture content from 80.5 ± 0.20% to 83 ± 0.50%, significant reduction in protein (15.98 ± 0.06 to 13.85 ± 0.09%), fat (1.2 ± 0.20% to 0.86± 0.00%) and ash (1.4 ± 0.02% to 0.8% ± 0.02%) contents. The reduction of protein was due to loss of water soluble proteins, removal of water soluble mineral caused the decrease in ash content (Sijo *et al*., 2002) and an increase in moisture content was owing to the hydration process of myofibrillar proteins (Suvanich *et al*., 2000). A good quality surimi should contain low fat content.

Biochemical changes

In the present study, biochemical changes of lizard fish minced meat and surimi such as free fatty acid, peroxide value and pH values are shown in Table 2. Lizard fish minced meat contained free fatty acid (0.5%), peroxide value (0.8 miilli. eq O_2/ kg), TBA (0.14µM/g), pH (7.02) and lizard fish surimi had free fatty acid (0.98%), peroxide value (1.2 miilli. eq O_2/ kg), TBA (0.3µM/g) and pH 7.02. Jitesh *et al*. (2011) reported that TVB value of lizard fish was 12.13mg/100g. In the present study, test values of free fatty acid, peroxide value (PV) and TBA in minced meat and surimi were found to be within the limit of with no mark of any rancidity.

Designing of aluminium and polylactic acid shrimp mould

In the present study, designed the aluminium shrimp moulds such as individual shrimp mould and combined shrimp moulds (nine shrimp moulds) (Fig 1) processed by Unigraphics and Mastercam softwares is completed modeling and design applied reverse engineering technique as shown as Fig 1 and Fig 2. These softwares establish like shrimp model using contour tool path can make die cavity surface smooth, achieving realistic appearance and smooth surface.

	
Designing of shrimp model using Unigraphics and Mastercam softwares.	

	
:Designed the aluminium shrimp moulds	Cooked Analogue Shrimp Product using Aluminium Shrimp Mould

Fig 1: Analogue shrimp product from lizard fish using Aluminium Shrimp Mould.

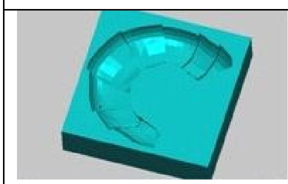
Designing of shrimp surface using STL softwares and Polylactic acid shrimp mould	Ready to eat analogue shrimp products
	

Fig 2: Analogue shrimp product from lizard fish using Polylactic acid Shrimp Mould.

Wei *et al* (2010) obtained through scanning of shrimp (boiled, head and shell removed) point cloud data which is processed by CATIA V5 R16 and then completed modeling and design applied reverse engineering technique. Ping (1997) reported that the geometric properties of the curved surface, it is processed with milling cutter of 5 mm diameter with tolerance for 0.02 mm. According to precision requirements, through ISO-scallop method, all the knife contacts are gained, further calculating the corresponding points. So the cutter path is derived, which is made up of discrete cutter locations on the whole surface. Longhan (2004) reported that simulation renderings in the cavity surfaces using NURBS, which have very good smoothness. Finally conclude that, the contour tool path can make mould surface smooth and realistic appearance of the shrimp model.

Proximate composition of Ready to eat Analogue Shrimp Product

Proximate composition of the ready to eat analogue shrimp product, in terms of wet weight basis for lizard fish (*Sauridatumbil*) represents 87% moisture, 10.15% protein, 0.04% fat, 0.80% ash and 2.50% carbohydrate respectively provided in Table 2. However, no one reported the ready to eat analogue shrimp products from lizard fish (*Saurida tumbil*).

CONCLUSION

Lizard fish is suitable for the production of analogue shrimp products. Aluminium and polylactic acid shrimp mould used for the production of analogue shrimp products.

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