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PREPARATION OF AN EXTRUDED FISH SNACK USING TWIN SCREW EXTRUDER AND THE STORAGE CHARACTERISTICS OF THE PRODUCT

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ABSTRACT

A value-added extruded fish product was prepared with corn flour (80%) and fish (sciaenid) powder (20%), using a twin-screw extruder. The effect of different parameters like moisture, temperature, fish powder concentration, speed of the extruder and die-diameter on expansion ratio and crisp texture were studied. The storage characteristics of the final product were studied using three different types of packaging under nitrogen flushing. The study revealed that aluminium foil is the best packaging material to keep the product acceptable for more than three months.

Key words: Extruded fish product, twin-screw extruder, storage characteristics

INTRODUCTION

Large quantities of marine by-catch are discarded at sea because it is currently uneconomic to preserve and bring them ashore. It has been estimated that the average global amount of discards of by-catches is 27 million tonnes per year (Alverson *et al.,* 1994). Due to the recent interest in deep-sea fishing in the exclusive economic zone, lot of deep-sea fishes are expected to land, which may not be immediately acceptable to the consumer due to the unfamiliarity with the shape, size, colour and flavour of the new varieties. The use of meat bone separator and extrusion technology will go a long way in the development of texturized fish products.

Extrusion cooking in a high temperature short residence time (HTST) process by which moistened starchy and proteinaceous materials are plasticised and cooked in a tube by a combination of high pressure, intense mechanical shear and heat to create fabricated, shaped products of varying texture (Smith, 1971). The role of extrusion was initially limited to mixing and forming cereal products. Extrusion of protein, specially related to seafood, has achieved only limited success. Suja and Basu (1998) attempted to prepare a ready-to-cook extruded fish product. The enormous potential of extrusion cooking to produce textured protein from seafood is yet to be exploited. So, an attempt was made to prepare an extruded snack using fish and corn starch, and to study its storage characteristics.

MATERIAL AND METHODS

Sciaenid fish (*Otolithus argenteus*) was brought under ice from the Versova landing

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centre. The fish were de-scaled, beheaded, eviscerated and washed with potable water. The dressed fish was cooked by boiling in water for 10-12 minutes under normal atmospheric pressure. The cooked fish was cooled, de-skinned and de-boned manually. The separated cooked meat was dried in an electrically heated drier at 43-45^{0}C. The dried fish muscle was powdered in a domestic mixer at the rate of 100 g/2 min. The fish powder was used for the development of the product. Corn flour procured from the market was used for the experiment.

A weighed amount of cooked dried fish powder was mixed with a known quantity of corn flour and measured volume of water. 2% of salt was added in all the experiments. These ingredients were hand mixed and left for equilibration for at least one hour.

The above mixture was passed through the twin-screw extruder (co-rotating twin screw extruder – Basic Technology Pvt. Ltd., Kolkata) operating at a particular temperature, moisture, speed of rotation, fish powder concentration and die diameter. Different trial runs were carried out to fix the process variables. The quality and characteristics of different extrudates formed after each trial were analysed.

The moisture, protein, fat, ash and thiobarbituric acid (TBA) number were estimated by AOAC (1995) method. The expansion ratio of the product was calculated by dividing the diameter of the extrudate by die diameter. The extruded products were fried in refined groundnut oil and packed in the following three different packaging material:

1. 12-µm polyester, 12-µm metalised Polyester, 60-µm polyethylene (metalised polyester A)

2. 12-µm metalised polyester, 37.5-µm polyethylene (metalised polyester B)

3. 12-µm polyethylene, 9-µm aluminium foil, 37.5-µm polyethylene (aluminium foil)

The fried products were packed with nitrogen flushing, and sealed and stored at room temperature for shelf life study. The organoleptic analysis was carried out on a 9-point hedonic scale, a score of five being the borderline of acceptability.

RESULT AND DISCUSSION

The proximate composition of the main ingredients, *viz.*, cooked fish powder and corn flour is presented in Table 1. The yield of cooked dry fish powder was found to be 13-15% of the fresh fish weight. Several trials were carried out changing different parameters to get a fish product with maximum expansion ratio and good soft crisp texture. The parameters studied were temperature, moisture, percentage of fish powder, speed of rotation and die diameter. The summary of all the trials showing the effect of different parameters on product quality are presented in Table 2 and the average organoleptic score of the dried product in Table 3.

Table 1: Proximate composition (%) of the main ingredients

Ingredient	Moisture	Protein	Fat	Ash
Cooked fish powder	8.50 ± 0.25	76.66 ± 0.78	8.50 ± 0.89	5.6 ± 0.45
Corn flour	9.25 ± 0.56	10.60 ± 0.23	2.03 ± 0.15	0.50 ± 0.10

Table 2: Summary of effect of different parameters on fish extrudate

Ingredient/parameter	Sample																			
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
Fish powder (%)	10	20*	30	40	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Corn flour (%)	90	80*	70	60	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
Moisture (%)	20	20	20	20	15	18	21*	24	21	21	21	21	21	21	21	21	21	21	21	21
Temperature (°C)	100	100	100	100	100	100	100	100	95	100	105*	110	105	105	105	105	105	105	105	105
Speed (rev/min)	350	350	350	350	350	350	350	350	350	350	350	350	300	350*	400	450	350	350	350	350
Die diameter (mm)	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3.5	4.0*	4.5
Expansion ratio	2.3	2.4	2.1	1.3	2.3	2.2	2.4	2.2	2.3	2.3	2.4	2.3	2.2	2.4	2.4	2.0	2.3	2.2	2.4	2.1

*Value of the parameter giving maximum expansion ratio was selected.

Table 3: Average organoleptic scores of fried fish extrudates for different treatments

Attribute	A	B	C	D	E	F	G	H	I	J
Flavour	7.26 ± 0.03	8.41 ± 0.04	8.63 ± 0.03	8.83 ± 0.02	8.41 ± 0.03	8.42 ± 0.01	8.49 ± 0.02	8.39 ± 0.01	8.29 ± 0.01	8.41± 0.01
Texture	8.63 ± 0.04	8.81 ± 0.03	8.21 ± 0.03	7.72 ± 0.02	7.42 ± 0.03	8.12 ± 0.01	8.41 ± 0.02	8.21 ± 0.02	7.93 ± 0.01	8.21 ± 0.01
Overall acceptance	8.03 ± 0.04	8.63 ± 0.03	8.21 ± 0.03	7.90 ± 0.03	7.81 ± 0.01	7.89 ± 0.01	8.01 ± 0.03	7.93 ± 0.06	7.83 ± 0.01	8.33 ± 0.01

Table 3 (contd): Average organoleptic scores of fried fish extrudates for different treatments

Attribute	K	L	M	N	O	P	Q	R	S	T
Flavour	8.39 ± 0.02	8.25 ± 0.04	8.29 ± 0.02	8.44 ± 0.03	8.39 ± 0.04	8.36 ± 0.04	8.31 ± 0.05	8.29 ± 0.01	8.25 ± 0.03	8.22 ± 0.02
Texture	8.59 ± 0.02	8.75 ± 0.03	7.05 ± 0.03	8.62 ± 0.02	8.51 ± 0.01	8.21 ± 0.05	8.13 ± 0.04	8.31 ± 0.02	8.59 ± 0.02	8.39 ± 0.02
Overall acceptance	8.66 ± 0.03	8.32 ± 0.03	7.93 ± 0.03	8.51 ± 0.01	8.43 ± 0.04	8.25 ± 0.03	8.21 ± 0.03	8.30 ± 0.03	8.40 ± 0.02	8.31 ± 0.01

The effect of different fish powder concentrations on extrudates are presented in trials marked A, B, C and D in tables 2 and 3. In all the four trials, moisture, temperature, speed and die diameter used were 20%, 100^0C, 350 rev/min and 4 mm, respectively. The ratio of fish powder and cornstarch used in different trials, ranged between 10:90 and 40:60. When fish percentage increased from 10 to 20%, the expansion ratio increased and other organoleptic parameters also changed favourably. But when fish concentration changed from 20 to 30 and 40%, the product became hard and the expansion ratio decreased. When the protein concentration was 20%, the expansion ratio was 2.4. Further increase in protein concentration resulted in a decrease in expansion ratio.

The effects of different total moisture concentrations on extrudate quality are presented in trials marked E, F, G and H in tables 2 and 3. The concentration of fish powder, temperature, die diameter and speed for these trials were 20%, 100^0C, 4 mm and 350 rev/min, respectively. As the moisture content increased from 15%, the expansion ratio also increased, but at low moisture, the surface was dry and split. Surface appearance improved with the increase in moisture and at 21% moisture, the surface became very smooth. Moisture content higher than 21% yielded product with tough centre core. Higher moisture yielded moist product, which needed to be dried in a drier before packing. So, it was found that with 21% feed moisture, the extrudate had soft and crisp texture, maximum expansion ratio and dry smooth surface with yellow colour and fishy flavour. The fried product had soft, crisp texture and acceptable fishy taste.

The effects of different die-temperature on extrudate quality are presented in trials marked I, J, K and L in tables 2 and 3. The protein concentration, moisture, die diameter and speed used for the trials were 20%, 21%, 4 mm and 350 rev/min, respectively. Most extruders operate with a temperature control and the degree of indirect heating and cooling depends upon how the extruder is operated. The pressure differential and shear stress influence reaction rate and generate frictional heat. Barrel heating also generates conductive and convective heat in filled and partially filled zones and the proportion of each heat source depends on the physical and rheological properties of the feed, the barrel temperature profile and the available motor power. Different trials were carried out at die-temperature ranging from 95 to 110^0C. It was found that at 105^0C, the product with dry-smooth appearance had a soft and crisp texture with an expansion ratio of 2.4. The fried product was quite acceptable with soft crisp texture and fishy flavour. Lower and higher temperature yielded hard texture and less expansion ratio.

The effect of different speeds of the extruder on extrudate quality is presented in trials marked M, N, O and P in tables 2 and 3. The protein concentration, moisture, temperature and die diameter used for different trials were 20%, 21%, 105^0C and 4mm, respectively. Screw speed directly affects the degree of barrel fill, residence time, distribution and sheer stress on the material being extruded. The measured torque and the die pressure change with the screw speed. As most ingredients used in food extrusion are thixotrophic/ pseudoplastic, there is a linear relationship between speed and torque/pressure. The length to diameter (L/D) ratio of the extruder used for our experiment was 10:3. The speed at which the extruder screw was operated ranged between 300 and 450 rev/ min. It was observed that 350 rev/min with optimum moisture and temperature gave the best acceptable product.

The effects of different die diameters on extrudate quality are presented in trials marked U, R, S and T in tables 2 and 3. The protein concentration, moisture, temperature and speed used for different trials were 20%, 21% 105^{0}C and 350 rev/ min, respectively. The diameter of the die used for the trials varied between 3.0 and 4.5 mm. The length of the die was 2.5 cm and it was constant for all the dies. The die diameter has got much effect on the puffing or the expansion ratio of the product. Expansion ratio is nothing but the ratio of the product diameter to die diameter. The feed passes through the barrel at high temperature and pressure. Through the die, operating pressure is suddenly reduced causing sudden expansion of the product with simultaneous loss of moisture. When the extruder was operated with a die of 3 mm diameter, it was observed that the expansion ratio was almost doubled. Keeping all other process parameters and feed variable constant, the trials were carried out using dies with 3.5, 4.0 and 4.5 mm diameters. The products showed noticeable changes in expansion ratio, texture and surface appearance. In further trials, it was confirmed that the process variable associated with feed preparation and the extrusion machine operation at its most favourable condition, an appropriate die diameter can produce the extrudate with an expansion ratio more than double. It was found that the die diameter of 4.0 mm gave the best acceptable product.

After optimising the parameters, *i.e.*, feed ratio 20 : 80 (fish : corn starch), moisture 21%, temperature 105^{0}C, speed 350 rev/min and die diameter 4 mm, a product was prepared using these parameters. It was observed that the extrudate had soft and crisp texture, maximum expansion ratio and dry smooth surface with bright yellow colour and fishy flavour. The fried product had soft, crisp texture and acceptable fishy taste.

The proximate composition of the final product before and after frying is presented in Table 4. The final fried product had a moisture content of 2.5% and was very hygroscopic. The fat content was 8.9%. The change during storage in the moisture content and TBA number are presented in Table 5 and change in organoleptic quality in Table 6. Weekly analysis of the samples revealed that moisture of the product slowly increased in all the packets, but the rate of increase was faster in metalised polyester compared to aluminium foil. It was found that when the moisture level crossed 5% level, the products were less crispy. Below 5% moisture level, the product remained crispy and was quite acceptable. It the case of the product in aluminium foil, the moisture was 3.12% after the 12th week. So, it is expected that the product will remain crispy in aluminium foil for some more period until the moisture reaches 5%.

Table 4: Proximate composition (%) of the developed product before and after frying

Parameter	Before frying	After frying
Moisture	6.20	2.50
Protein	26.4	25.70
Ash	4.50	4.30
Carbohydrate (by difference)	61.4	58.60
Fat	1.42	8.90

In the cases of metalised polyester A and B, the product had a slightly higher TBA value than the product in aluminium foil. The product was packed by nitrogen flushing. So, very little oxygen was left in the packs and the rise in TBA value was only marginal. This may be due to the oxygen permeability of the packs. The result showed that the oxygen permeability of metalised polyester was higher than that of aluminium foil leading to higher TBA value. However, the organoleptic evaluation (Table 6) revealed no rancid flavour in any product. So if the products are packed by

Table 5: Change in moisture content and TBA number of fried extruded fish product during storage in different packaging material

Storage	Metalised polyester A		Metalised polyester B		Aluminium foil	
period (wk)	Moisture (%)	TBA number	Moisture (%)	TBA number	Moisture (%)	TBA number
0	2.50	ND	2.50	ND	2.50	ND
1	2.74	0.18	2.65	0.18	2.56	0.14
2	3.00	0.23	2.88	0.24	2.62	0.19
3	3.24	0.29	3.15	0.30	2.67	0.24
4	3.50	0.33	3.35	0.36	2.75	0.29
5	3.72	0.38	3.60	0.43	2.81	0.35
6	3.98	0.44	3.85	0.49	2.87	0.39
7	4.20	0.49	4.05	0.56	2.93	0.44
8	4.42	0.54	4.30	0.61	2.98	0.49
9	4.66	0.60	4.50	0.68	3.03	0.54
10	4.78	0.67	4.68	0.74	3.06	0.59
11	4.94	0.72	4.92	0.79	3.09	0.62
12	5.40	0.79	5.10	0.83	3.12	0.66

Table 6: Sensory score of fried fish extrudates during storage in different packaging material

Container material	Attribute	Storage period (wk)											
		1	2	3	4	5	6	7	8	9	10	11	12
Aluminium foil	Flavour	9.0	8.8 ± 0.01	8.7 ± 0.01	8.6 ± 0.02	8.6 ± 0.02	8.5 ± 0.04	8.5 ± 0.03	8.4 ± 0.04	8.1 ± 0.03	8.0 ± 0.03	7.9 ± 0.03	7.7 ± 0.03
	Texture	9.0	8.7 ± 0.02	8.7 ± 0.03	8.5 ± 0.04	8.2 ± 0.04	8.3 ± 0.03	8.2 ± 0.02	8.1 ± 0.02	7.9 ± 0.02	7.6 ± 0.03	7.4 ± 0.02	7.2 ± 0.05
	Overall acceptability	9.0	8.8 ± 0.01	8.7 ± 0.01	8.5 ± 0.02	8.4 ± 0.02	8.3 ± 0.03	8.2 ± 0.04	8.2 ± 0.04	8.1 ± 0.04	7.9 ± 0.05	7.6 ± 0.05	7.5 ± 0.05
Metalised polyester A	Flavour	9.0	8.8 ± 0.02	8.6 ± 0.03	8.6 ± 0.04	8.6 ± 0.03	8.5 ± 0.04	8.4 ± 0.02	8.3 ± 0.03	8.1 ± 0.04	8.0 ± 0.04	7.9 ± 0.02	7.7 ± 0.05
	Texture	9.0	8.7 ± 0.01	8.6 ± 0.02	8.5 ± 0.02	8.2 ± 0.04	8.3 ± 0.03	8.1 ± 0.03	7.9 ± 0.02	7.2 ± 0.02	6.5 ± 0.03	5.7 ± 0.05	4.7 ± 0.02
	Overall acceptability	9.0	8.8 ± 0.03	8.7 ± 0.01	8.5 ± 0.03	8.4 ± 0.03	8.3 ± 0.02	8.2 ± 0.02	8.1 ± 0.03	8.0 ± 0.04	7.9 ± 0.05	6.9 ± 0.03	4.9 ± 0.03
Metalised polyester B	Flavour	9.0	8.8 ± 0.02	8.6 ± 0.03	8.6 ± 0.02	8.6 ± 0.02	8.5 ± 0.04	8.4 ± 0.04	8.3 ± 0.02	8.0 ± 0.02	8.0 ± 0.02	7.8 ± 0.05	7.6 ± 0.05
	Texture	9.0	8.7 ± 0.01	8.6 ± 0.02	8.5 ± 0.02	8.2 ± 0.04	8.3 ± 0.02	8.1 ± 0.02	7.8 ± 0.02	7.2 ± 0.03	6.4 ± 0.03	5.5 ± 0.04	4.6 ± 0.04
	Overall acceptability	9.0	8.8 ± 0.02	8.7 ± 0.01	8.5 ± 0.03	8.4 ± 0.03	8.3 ± 0.05	8.2 ± 0.03	8.1 ± 0.03	7.9 ± 0.02	7.8 ± 0.05	6.8 ± 0.04	4.7 ± 0.05

nitrogen flushing, rancidity will not be a problem for a quite long period in storage. So, the study revealed that the fried product packed in aluminium foil under nitrogen flushing would remain acceptable for more than three months.

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