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Utilization of croaker (*Johnius dussumieri*) to develop ready to eat puff snack product using extrusion technology

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An attempt was made to develop nutrient rich extruded product from underutilized protein rich fish flour Croaker (*Johnius dussumieri*) with mixture of cereal flours using twin screw extruder. Ready to eat snack was developed using fish flour (12%, 15%, 18% and 21 %) mixed withmixture of rice, corn and soybean flour and taste enhancer. Extrusion cooking formulation consisting of fish flour and cereals mixture were extruded at moisture content 15 per cent, screw speed 480 rpm, sectional barrel temperature of 30º, 60º, 130º and 160ºC at four stages and 2 mm diameter of die. Extruded product was friedin edible oil.The resulting extrudedwas analyzed for physical characteristic, texture profile, proximate composition,microbiological analysissensory acceptability.Among the different blends studied, the most acceptable were T_3 (with 18 % fish flour) with the best performance in terms of quality and acceptability.This research demonstrated that fish flour at 18 per cent can be successfully incorporated into mixture of cereal flours for extrusion and develop a 19.88 per cent protein rich ready to eat snack food with good storage stability at ambient temperature.

Key Words : Ready-to-eat snack**,** Extrusion cooking, Croaker fish flour, Quality characteristics

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INTRODUCTION

Ten per cent of the total catch of world consists of fish that are underutilized because of undesirable features like small size, dark meat, strong flavour, unacceptable textural properties. Utilization of low-value fishes is of great importance in developing countries. However, due to the undesirable features mentioned above, underutilized fishes are discarded rather than consumed. Processing such fishes using high temperature or pressure, called extrusion cooking, will help modify the texture and other physical properties and make them suitable for human consumption.Deterioration of nutritional quality, owing to high temperature, is a challenging problem in most traditional cooking methods. Extruded exhibits better nutritional quality compared to other traditional cooked products (Bressani *et al.*, 1992).The current market studies indicate that extruded products is shifting from baby foods to the adult market which needs to improve the eating quality with respect to texture, colour, flavour and most importantly the nutritional facts. With the growing demand for convenience foods, sales of ready to cook and ready to eat packaged foods are constantly on the rise.

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Many manufactured snacks are high in calories and fat but low in protein, vitamins, and other nutrients (Ranhotra and Vetter, 1991).Snack products, which normally contain mainly carbohydrate and fat, can be made with increased protein content and nutritional value by fish flour. A number of studies have reported successfully incorporation of fish flesh or fish powder into starch-based materials by extrusion process to produce nutritious extruded products that were acceptable by consumer (Gogoi *et al*., 1996; Suknark *et al*., 2001; Shaviklo *et al.*, 2011). Large amount of low cost fishesare wasteddue to lack of proper preservation and utilization method. Among themcroaker (*J. dussumieri)* is a local variety of marine fin fish caught by bottom trawl net on Gujarat coast. Such resources can be considered as protein sources in snack food development. Extrusion process has been considered potential solution to utilization of the low economic value fish by using twin screw extrusion process, where fish flour and rice, corn and soybean flour mixtureare extruded to improve the nutritional quality of extruded product.

METHODOLOGY

Production of fish flour and procurement of ingredients :

Fresh Croaker (*J. dussumieri*) samples was procured from Veraval fishing port, and transported to fish processing hall under iced condition. Fishes were washed thoroughly with potable water and beheaded, gutted and fillets were made and boiled for 10 min and meat was separated manually as per the method described by Majumdar and Ratankumar Singh (2014) shown in Fig. A. The dried meat was pulverized using grinder to obtain fish flour.

Raw material fish
↓
Washing
↓
Fish dressing (descaling, beheading, eviscerating, filleting)
↓
Washing
↓
Cooking (in boiling water for 10-12 min)
↓
Separation of cooked meat
↓
Drying of boiled meat
(43 – 45ºC)
↓
Pulverizing in grinder
↓
Packing in polythene pouch and storage at ambient temperature

Fig. A : Flow chart for production of fish flour

Rice flour, corn flour and soybean flour were procured from the super market and sieved with 4mm size sieve.Other food ingredient such as sunflower oil, table salt, chili powder, spices (chat masala and garam masala), and food colour were procured from same local market for extrusion process. Fish flour prepared at was mixed with various cereal floursat various levels for extrusion (Table A). The final moisture content of the mixture was adjusted to 15 per cent by adding required amount of water. The blend was then equally mixed with food colour at 0.06 per cent (w/w) level in all trials. The sieved mixture was then kept for equilibration time of 30 minutes. After equilibration, once again the sample was sieved and kept ready for extrusions as a function of barrel temperature, screw speed and die diameter. Feeding rate of cereal-fish flour mixture was adjusted to 20 kg/hr.

Extrusion condition :

The twin screw extruder (SYSLG-IV, Jinan Saibainuo Machinery Co. Ltd, China) consisted with barrel temperature at 4 section was maintained at 30°, 60°, 130°, and 160°C, respectively. Machine variable screw motor, feeder motor and cutter motor were maintained at a speed of 480, 240,180 rpm, respectively. The die diameter used was 2 mm. Prepared extruded products were subjected to frying at 180°C for 20 second. Taste enhancers including chili powder, chat masala and garam masala at 2.85 per cent, 0.78 per cent and 0.28 per cent (w/w), respectively were added to enhance taste the final extruded product.

Physical analysis :

Expansion ratio (ER) :

Expansion ratio (ER) was determined by the cross-sectional diameter of the extruded was measured with a Vernier caliper. The ER values were obtained from 4 random samples with three locations in each for each extrusion condition from each treatment replication. The ER was calculated described by Ding *et al*. (2005) as the cross-sectional diameter of the extruded divided by

Table A : Percentage of fish flour mixed with other food ingredients

	Trials →	(Combination 1) T_1	(Combination 2) T_2	(Combination 3) T_3	(Combination 4) T_4
Sr. No.	Composition	%	%	%	%
1.	Croaker fish flour	12	15	18	21
2.	Rice flour	51	48	45	42
3.	Corn flour	30	30	30	30
4.	Soybean flour	5	5	5	5
5.	Common salt	2	2	2	2
	Total	100	100	100	100

the diameter of the die opening and expressed as percentage.

Bulk density (BD) :

Bulk density (BD) was determined following Hood-Neifer and Tyler (2010). by weighing the quantity of 5 cm long pieces required to fill a 500 mL beaker.The extruded pieces were randomly added to container and the container was shaken several times during filling.

Porosity (PO) :

Porosity (PO)of the extruded snack was calculated according to Wang *et al*. (1999).

Colour analysis :

Colour of the extruded products was determined using a colour reader (CR-10, Konica Minolta Sensing, Inc., made in Japan). Extruded products were powdered using a mixer. A uniform thick layer of the powder was taken in the sample holder of the colorimeter and values corresponding to L^*, a^* and b^* were measured. Colour value L^* (100 = white; 0 = black) is an indication of lightness; a^* measures chromaticity, with positive values indicating redness and negative values indicating greenness; while b^* also measures chromaticity, with positive values indicating yellowness and negative values indicating blueness.

Texture profile analysis :

Texture analysis of extruded products from mixture of cereal flours and Croaker (*J. dussumieri*)was carried out using the CT3 texture analyzer (Brookfield engineering laboratories, Inc. USA). After a trigger force of 3 g was attained the probe then proceeded to penetrate into the extruded product to a depth of 4 mm. At this depth the maximum force reading (the resistance to penetration) was obtained and measured as texture of the product.

Proximate composition analysis :

Moisture content of extruded products was measured using moisture balanced meter (Mac 110 N/H, EU) according to AOAC (2006). Carbohydrate content was estimated by the difference. The energy values of the extruded were determined by computation and expressed in kilo calories. The crude protein content of the samples was estimated using Microkjeldal method AOAC (2006) and calculated as the product of per cent nitrogen and a multiplication factor. The amount of fat in the food mixes was determined using Soxhlet method AOAC (2006). Ash content of the sample was estimated by AOAC (2006) method.

Microbiological analysis :

Determination of TPC, *E. coli* and *S. aureus* were measured in all extruded using standard method recommended by AOAC (2006).

Sensory analysis :

Sensory evaluations were conducted using a ten panel members. Panelists were trained to evaluate the extruded for general appearance, surface texture, favour, crispiness and overall acceptability on a 0-5 Hedonic scale (Larmond, 1977) and the results were averaged.

Statistical analysis :

Data were analyzed using IBM BASIC windows software release 1.13. Mean and standard deviation for four replicates were calculated.Significant ($P < 0.05$) differences between means were determined by Duncan's *post hoc* test using SPSS release 16.0.0.

OBSERVATIONS AND ASSESSMENT

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Physical characteristics :

Expansion ratio :

Non-significant (p>0.05) changeswere observed inexpansion ratio in all treatments.The highest expansion ratio were recorded for T_1 (3.37mm) followed by T_2 (3.32), T_3 (3.20) and T_4 (3.10)which was inversely correlated with percentage of protein (Table 1). This is similar to finding of Aderson *et al.* (1998) showing higher the protein content of extruded the less in expansion. Expansion ratio increaseswith increasing in starch content was documented by several workers (Lawton *et al.*, 1972; Guha and Ali, 2006 and Upadhyay *et al.*, 2008). This may be attributedto higher gelatinization of cereal starch in comparison to T_2, T_3 and T_4 by expansion under high temperature and pressure of extrusion.

Porosity :

Porosity measures the air pockets with variable pore size during extrusion giving expanded products with lower bulk densities. Thymi *et al.* (2005) and Yanniotis *et al.* (2007) suggested that porosity created during extrusion can be used to describe the expansion properties of the extruded products. Porosity of extruded product recorded was as 20.09 ± 0.342 per cent for T_1, 21.65 ±0.937 per cent for T_2,17.13 ± 1.294 per cent for T_3 and 15.87 ± 5.338 per cent for T_4. Significantly (p<0.05) highest porosity was recorded in T_2 followed by T_1, T_3 and T_4 presented in Table A. According to Majumdar and Ratankumar Singh (2014) recorded porosity ranged from 45 to 54 per cent of fish based expanded product. Less porosity exhibited in these treatments may be due to change in moisture content and the ingredient composition of extrusion mixture.

Table 1 : Physical, colour, proximate composiational, microbiological, sensory characteristics, and texture profile, of ready to eat fish flour based snack foods

Parameters	T_1 (12% fish flour)	T_2 (15% fish flour)	T_3 (18% fish flour)	T_4 (21% fish flour)
Physical characteristics				
Expansion ratio (mm)	3.37 ± 0.074^a	3.32 ± 0.102^a	3.20 ± 0.070^a	3.10 ± 0.099^a
Bulk density (g/cm^3)	0.25 ± 0.003^a	0.25 ± 0.007^a	0.26 ± 0.004^a	0.27 ± 0.004^a
Porosity (%)	20.09 ± 0.342^b	21.65 ±0.937^b	17.13 ± 1.294^a	15.87 ± 5.338^a
Texture profile characteristics				
Hardness (gm)	1443 ± 172.175^a	1554 ± 95.476^b	1689 ± 88.931^c	1714 ± 70.653^c
Cripspiness (gm)	423 ± 63.421^a	482 ± 19.483^b	559 ± 67.810^c	620 ± 57.411^c
Proximate composition characteristics				
Protein (%)	12.65 ± 0.277^a	16.75 ± 0.045^b	19.88 ± 0.255^c	20.05 ± 0.165^c
Moisture (%)	0.08 ± 0.059^a	0.85 ± 0.010^b	1.01 ± 0.022^b	0.95 ± 0.032^b
Fat (%)	25.47 ± 1.080^a	26.08 ± 1.708^a	26.73 ± 1.756^a	25.80 ± 0.007^a
Ash (%)	2.80 ± 0.163^a	3.02 ± 0.191^b	3.53 ± 0.129^b	3.45 ± 0.035^b
Carbohydrate (%)	58.28 ± 1.001^c	53.3 ± 1.809^b	48.85 ± 1.829^a	49.3 ± 1.120^a
Energy value (Kcal)	582.95 ± 5.445^d	534.84 ±8.031^c	515.49 ± 9.191^b	509 ± 9.143^a
Microbiological characteristics				
TPC (log cfu/g)	0.36 ± 0.033^a	0.34 ± 0.036^a	0.34 ± 0.019^a	0.33 ± 0.110^a
Staphalococcus aureus	Nil	Nil	Nil	Nil
E.coli	Nil	Nil	Nil	Nil
Sensory characteristics				
General apperance	3.40 ± 0.000^a	4.44 ± 0.316^b	4.92 ± 0.000^b	4.02 ± 0.290^a
Surface texture	3.18 ± 0.541^a	4.06 ± 0.527^b	5.00 ± 0.316^c	4.14 ± 0.322^b
Flavour	3.04 ± 0.483^a	3.94 ± 0.000^a	4.92 ± 0.516^b	4.06 ± 0.163^b
Crispiness	2.92 ± 0.150^a	4.08 ± 0.483^b	4.94 ± 0.000^c	4.02 ± 0.820^b
Overall acceptability	3.20 ± 0.000^a	3.96 ± 0.516^a	4.94 ± 0.422^b	4.12 ± 0.381^b

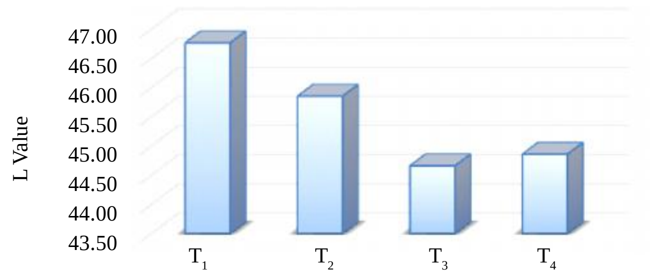
Mean values in rows for all the samples with different superscripts are significantly different (P < 0.05). Values are mean ± SD (n = 4)

Bulk density :

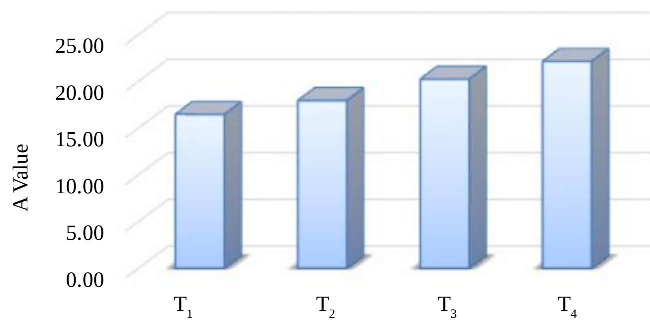
The bulk density, which considers expansion in all directions, is an index of the extent of puffing. Bulk density of extruded product recorded was 0.25 ± 0.003 (g/cm^3) for T_1, 0.25 ± 0.007 (g/cm^3) for T_2, 0.26 ± 0.004 (g/cm^3) for T_3 and 0.27 ± 0.004 (g/cm^3) for T_4 shown in Table A. There were not much significant difference ($p>0.05$) in bulk density of all treatments. In present study expansion ratio and bulk density were found inversely related (Table A) which is similar to observation made by Pansawat *et al*. (2008). As degree of gelatinization increased during extrusion, the expansion of puffed product increased indicating the increase in expansion ratio and decrease in bulk density (Case *et al*., 1992).

Colour :

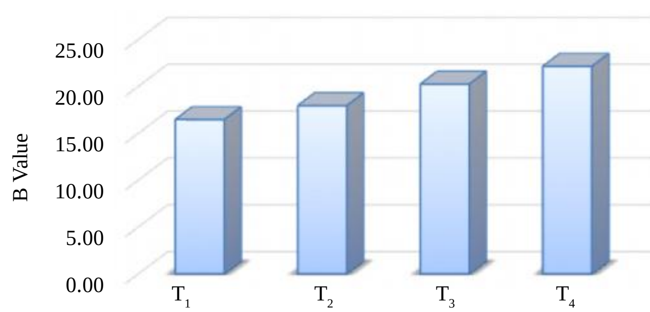
The significant difference ($p<0.05$) in colour of all extruded products were noted. Hence, the apparent change in value may be due to effect of change infish flour composition in each treatment. The colour developed after extrusion with different blend was most acceptable for ready to eat snacks. While *a** and *b** values are appears that directly correlated with percentage of fish flour (Fig. 1).Similar result was reported by Shaviklo *et al*. (2011) for corn-fish extruded product where value of *L**, *a** and *b** were 33-36, 9-11, 20-24, respectively. Colour in extruded products is influenced by temperature, moisture, raw material composition (Mercier *et al*., 1998; and Kumar *et al*., 2010). The same effects have affected the final finished product of T_1, T_2, T_3 and T_4.



Comparison of '*L*' value of fish flour based extruded product



Comparison of '*a*' value of fish flour based extruded product



Comparison of '*b*' value of fish flour based extruded product

Fig. 1 : Colour characteristices of the fish flour based extruded product

Texture profile characteristics :

Hardness value for T_3 and T_4 were almost similar as 1689 ± 88.931gmF and 1714 ± 70.653 gmF, respectively (Table 1). The values were comparable and acceptable for extruded product. Significant ($p<0.05$) difference observed may be due to degree of interference in gelatinization of cereals and protein. Choudhury and Gautam (2003) have reported that incorporation of fish protein in feed material reduce expansion and increases hardness and reduce crispiness. Incorporation of higher fish flour may be responsible for relative hardness in treatment.Similar to the hardness, T_3 and T_4 were crispier than other of treatments asshown in Table 1 with significant ($p<0.05$) among the treatment. It is combine effect of differential expansion ratio, bulk density and gelatinization giving desire crispiness. Addition of more meat based ingredient will cause stronger interaction of flour-fish meat mixture and may lead to formation of stronger bonds, which will make the product tough. Probably, in case of higher fish four, the cross linkage of protein and development of a protein network as a result of starch protein interaction have increased the maximum force of hardness with reduced crispness (Jeyakumari and Rathnakumar, 2006).

Proximate composition characteristics :

Moisture :

Highest moisture content was recorded in T_3 as value of 1.01 ± 0.022 per cent followed by T_4 (0.95 ± 0.032 %), T_2 (0.85 ± 0.010%) and 0.08 ± 0.059 T_1 fish flour based extruded products (Table 1). However, there were no significant differences in water content of all the three extruded showing 1-2 per cent water. This is good sign for crispy snack food. Lakshmi Devi *et al.* (2013) also noted similar result where moisture content of extruded pasta ranged from 1.13 to 2.10 per cent. Moisture content of fish powder used to develop extruded product was very low ranged from 0.19 to 0.27 per cent described by Kuna *et al.* (2013).

Protein :

Significantly ($p<0.05$) highest protein content was observed in T_4 (20.05%) and T_3 (19.88%) than T_2 and T_1 based extruded products. Homchoudhury *et al*. (2011) recorded 6.9 per cent protein from mixture of rice and shrimp (*Metapenaeopsis stridulans*). Enhancement of protein supplement in extruded product through sea food was from 10 to 15 per cent protein as reported by several authors (Kuna *et al*., 2013). In comparison to above listed study, present study has shown the highprotein content ranged from 12 to 20 per cent. This value is higher than those obtained in other study, which is positive for developing protein rich snack food.

Fat :

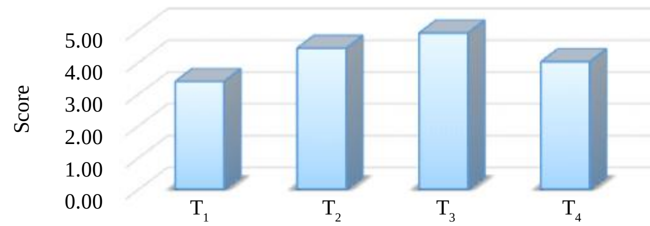
T_3 had recorded insignificantly ($p>0.05$) highest fat content followed by T_2,T_4 and T_1 fish flour based extruded products (Table A). Similar result was observed by Shaviklo *et al*. (2011) where fat content recorded was 30.6 to 31.7 per cent after frying the product. Variation noted in present study is due to differential composition of fish flour used in feed mix as well as time and method of frying.

Ash :

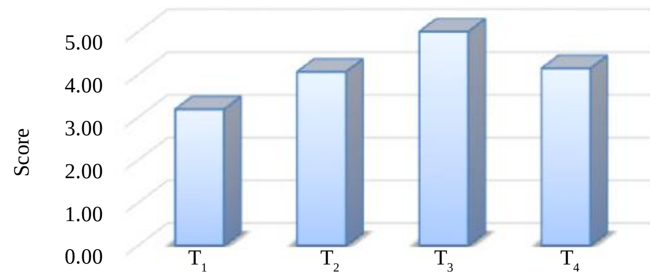
Ash representing mineral contents of sample were 3.53 ± 0.129 per cent in T_3 and 3.45 ± 035 per cent in T_4 followed by in T_2 as value of 3.02 ± 0.191 per cent and T_1 2.80 ± 0.163 per cent with in significant ($p>0.05$) difference (Table A).The extruded product made from incorporating fish powder was having similar ash content (1.37-1.63%) as described by Lakshmi Devi *et al*. (2103) and Kuna *et al*. (2013). Ash content in fact is effect of mineral present in to rice, corn and soybean flour.

Carbohydrate :

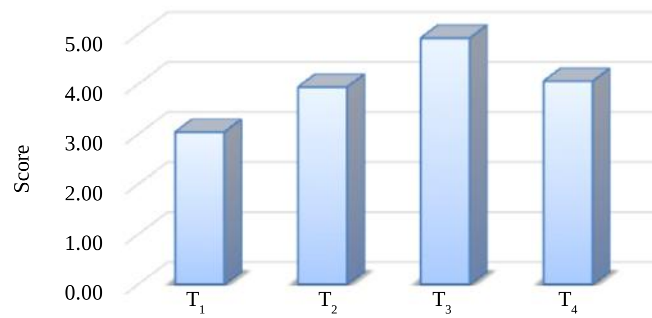
Carbohydrate of extruded product was recorded



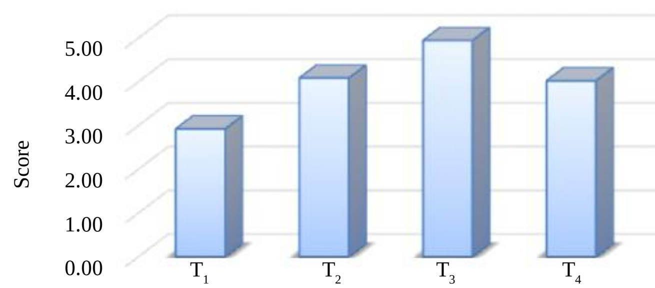
(a) General appearance of extruded product



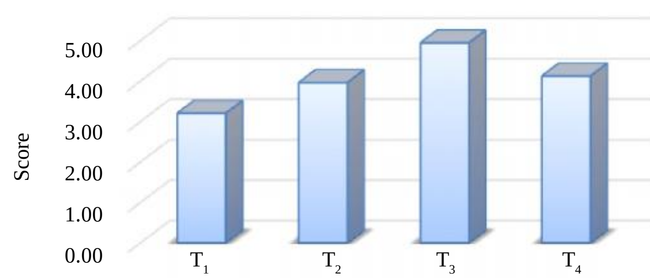
(b) Surface texture of extruded product



(c) Flavour of extruded product



(d) Crispy nature of extruded product



(e) Overall appearance of extruded product

Fig. 2 : Sensory characteristics of fish flour based extruded product

58.28 ± 1.001 per cent for T_1, 53.3 ± 1.809 per cent for T_2, 48.85 ± 1.829 per cent for T_3 and 49.3 ± 120 per cent in T_4 sample. However, carbohydrate content in all samples were insignificant (p<0.05). Kuna *et al*. (2013) also made similar observation were content carbohydrate ranged from 61 to 72 per cent inproduct made from fish powder with rice and corn at ratio of 20:40:40.

Energy value :

Energy values of extruded product were almost similar value that ranged from 510 to 590 Kcal (Table 1). The energy value of extruded product made from fish powder with various cereal flour ranged from 392 to 437 Kcal (Kuna *et al*., 2013). Present study showed energy value ranged between 509 to 582 Kcal. This difference is due to proportion of energy giving martial used in the sample and the fat absorbed after frying. Same explanation is valid for variation of energy content within the sample.

Microbiological characteristics :

Microbiological characteristic presented by TPC was 0.36 ± 0.033 log cfu/g in T_1 whereas the observed TPC of T_2 was 0.34 ± 0.036 log cfu/g, 0.34 ± 0.019 log cfu/g T_3 and 0.35 ± 0.047 logof T_4 extruded products. TPC value were more or less similar in all samples with in-significant (p>0.05) difference. No *E.coli* and *Staphalococcus aureus* was detected in all extruded treatments. Shaviklo *et al.* (2011) recorded TPC less than 1×10^3 cfu/g. Very low TPC observed in present study provesthe microbial safety of extruded products.

Sensory characteristics :

All sensory characterstics such as general apperance, surface texture, flavour, crispiness and overall acceptibility were obtained more score in 18 per cent fish flour (T_3)compared with T_1, T_2 and T_4 fish flour based extrude products (Fig. 2). T_4 extruded product containing 21 per cent fish flour was dislikedby panalist due to strong fishy odour. However, these changes were not much significant (p>0.05) differnce in sensory characteristics that had been noted by the treatment and found satisfactory. Sensory characteristics were influenced by extruded raw materials, concentration of fish flour, starch content, feed moisture content (Kumar *et al.*, 2010), extruder screw speed interaction between ingredient (Osuna-Garcia *et al*., 1997), packaging and storage condition (Kim *et al*., 2002).

Present study with 18 per cent fish flour in food mix at given instrument parameters can produce nutrient rich extruded snack with good overall acceptability from underutilized fisheries resources with better returns in turms of value.

Conclusion :

Development of extruded products using cereal flour with fish flour, without compromising on the quality of final product, would help to improve the nutritional quality of cereal and pulse based snack food apart from adding distinct flavour and taste. The underutilized croaker fish will not only be utilized for value addition but also for development of products with enhance nutritional value of ready to eat snack foods. On the basis of texture and sensory evaluation, the best product made was with 18 per cent fish flour (T_3). The evaluator had disliked the strong fish flavour in 21 per cent based fish flour (T_4). The well accepted extruded product that were developed in the study can be scaled up for potential commercialization and marketing. Extrusion of cereal flour with 18 per cent fish flour protein rich can be used to produce high-protein products that would be an option to provide nutrient snacks for consumers and to increase fish consumption in diverse form.

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