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Development and comparison of extruded breading with conventional bread crumbs for coating fish balls

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ABSTRACT

The use of extrusion technology for production of crumbs for coating on fish balls, was attempted in this study. Extruded breading was prepared using two different flour combinations and used for the comparative study. The first one consisted of wheat flour (maida), rice flour and black gram powder and the second comprised maida, corn flour and black gram powder. The flour mixture was extruded at 15% moisture level, using a twin screw food extruder. In the three different compartments of the extruder, the heater temperatures were maintained at 140, 90 and 45 °C . The feed rate was maintained at 200 g min^{-1}, screw speed at 350 rpm and the cutter speed at 670 rpm. The extrudate was powdered and sieved for uniform particle size. Both the extruded and conventional bread crumbs were coated on fish balls and packed separately in high impact polypropylene (HIPP) trays and sealed with polyester /polythene laminated film on top, under vacuum. The trays containing fish balls were frozen in a blast freezer and were maintained at -22 ± 2 ºC for shelf life determination. Samples were drawn periodically and analysed for physical, sensory and biochemical parameters. Evaluation of the product for six months indicated that the extruded crumbs are comparable to conventional bread crumbs.

Keywords: Bread crumbs, Extrusion, Fish balls, Frozen storage

Introduction

Extrusion cooking is used for the manufacture of food products such as precooked and modified starches, ready to eat (RTE) breakfast cereals, snack foods, bread substitutes, soft moist pet foods, full fat soya flour and textured vegetable protein. In extrusion cooking, food material is heated either by an external heat source or through heat produced by friction and forced through dies to expand and extrude in desired shapes (Linko *et al*., 1981). Food extrusions involve the use of piston or ram type extruders to stuff casings in the manufacture of processed meats (Harper, 1981). Extrusion is the process of cooking moistened, starchy, proteinaceous food materials by the combined action of pressure, temperature and mechanical shear. It is a high temperature short time (HTST) process. Extrusion cooking is a versatile and very efficient technology, and is widely used in food processing. There is a trend in the food industry to develop convenient extruded products, such as puffed snacks and breakfast cereals of high nutritional value. The main raw material used for extrusion is starch in combination with other macro or micro nutrients (Anderson *et al*., 1969; Mercier and Feillet, 1975). Suitable selection of extrusion parameters, raw material formulation and appropriate grinding of extrudates allow the production of extruded crumbs. Cereal flours are used for the production of extruded crumbs.

The application of batter and breading to minced fish and fishery products has helped in enhancing demand and value for the low value fishes. Batters and breading serve many functions as food coatings. The most important function of coating is value addition by increasing the bulk of the substrate and thus reducing the cost element of the finished product (Joseph, 2003). Breading is a dry mixture of flour, starch and seasonings, coarse in nature and is applied to moistened and battered food products prior to cooking (Suderman, 1983). The process of battering and breading increases the mass and cost of the coated product and therefore it is included in the value added products (Joseph, 2003). Battering and breading enhance appearance and organoleptic characteristics of the food products, in addition to improving its nutritional value. Coating acts as a moisture barrier, minimises moisture loss during frozen storage and reheating (Suderman and Cunningham, 1983). The important crumbs are cracker meal type, conventional bread crumbs, devitalised flours and crisp breads or extruded crumbs (Joseph, 2003). Conventional bread crumbs are manufactured from the regular production or bread or sometimes from stale or bread near to rejection (Teresa and Ana, 2012). Coated fish ball is a value added product made from minced fish meat with spices and other optional ingredients. Coating by battering and breading

enhances the product's characteristics such as appearance, flavour and texture, Extrusion cooking is a suitable process for producing gluten-free expanded crumbs for coating. The advantages are light texture, crispness and appearance, which contribute greatly to the quality of the finished product. Starch is the main component providing the desirable expanded structure in extruded foods. Suitable selection of extrusion parameters, raw material formulation and appropriate grinding of extrudates allow the production of extruded crumbs. Extruded crumbs can be manufactured from different varieties of starchy materials, including root crops. They can have medium to light density and a similar appearance to Japanese-style crumbs (Dyson, 1992). The present study was carried out to understand the possibility of using extruded crumbs as a coating on fish balls for frozen storage.

Materials and methods

Preparation of fish mince

Japanese threadfin bream (*Nemipterus japonicus*) locally called 'kilimeen' was procured from a landing centre near Cochin. The time of landing from catch was approximately 6 h. Fishes were properly washed with potable water, iced and brought to the laboratory in insulated boxes within 20 min. Fishes were de scaled and filleted and passed through a meat bone separator (Model SF-6, Safe world enterprise, SDN. BDH, Malaysia) to remove the meat from the bones and skin. The mince obtained was directly used for fish ball preparation.

Preparation of batter mix

The ingredients and their proportion used for the preparation of batter mix as per Central Institute of Fisheries Technology (CIFT) recipe are given in Table 1. All the ingredients were mixed thoroughly for 2 min and diluted with water before coating on fish balls.

Table.1. Ingredients for batter mix

Ingredients	Quantity (g)
Wheat flour (Maida)	1000
Corn starch	100
Bengal gram powder	100
Salt	15
Trisodium polyphosphate	5
Turmeric powder	5
Hydrocolloids (Guar gum)	5

Preparation of extruded crumbs

Extruded crumbs were prepared using a twin screw food extruder (EB-10 BTPL Twin Screw Extruder, Kolkata). Two different flour combinations were used for comparative study : the first one with a mixture of refined wheat flour (maida), rice flour and black gram powder in the proportion of 7:2:1 and with the second one with maida, corn flour and black gram powder in the proportion of 8:1:1 (Table 2 a and b). The flours were mixed thoroughly and the final moisture content was adjusted to 15% by adding calculated amount of luke warm solution containing 2% yeast in 2% sugar solution and fermented with the flour mixture separately. After proper mixing, the flours were sieved through a 1 mm mesh sieve to get uniform particle size. The sieved mixtures were then kept for conditioning in low temperature for 45 min. The heaters of the extruder were adjusted to 140, 90 and 45 °C. The high moisture feed mix was added into the feeding hopper. The extruder screw and cutter speeds and the feed rate were adjusted and as the extrusion progressed, the extrudates were collected in a tray and allowed to cool. Then the extrudates were powdered and sieved through 1 mm mesh sieve and the powder was used for the study. It was found that wheat, rice flour and black gram powder mixed in the proportion of 7:2:1 was most suitable for coating.

Table 2a. Ingredients for extruded crumb (flour-I)

Ingredients	Quantity (g)
Wheat flour (maida)	350
Rice flour	100
Black gram powder	50
Yeast	2
Sugar (sucrose)	2
Moisture content of the final mixture	15%

Table 2b. Ingredients for extruded crumb (flour –II)

Ingredients	Quantity (g)
Wheat flour (maida)	400
Corn flour	50
Black gram powder	50
Yeast	2
Sugar (sucrose)	2
Moisture content of the final mixture	15%

Preparation of conventional bread crumbs

The conventional bread crumbs used for coating on fish ball were prepared from locally available sliced bread after removing the crust portion with a sharp knife. The crust free loaves were blended in an electric blender for nearly one minute and this blended bread powder was dried in aluminum trays in a hot air oven maintained at 102 °C to a moisture level below 5%. The dried crumbs were then sieved to a medium particle size (1 mm) and stored in a cool, dry place in polyester polythene pouches.

Preparation of fish balls

The various ingredients used for the preparation of fish balls are given in the Table 3. Garlic and ginger were

made into a paste. The fish mince was mixed with salt and further all other ingredients were mixed thoroughly. Balls of about 10 g and 2-3 cm diameter were made manually. The balls were cooked in 1% boiling brine for 10 min, taken out, drained and allowed to cool. These were then predusted with dry batter and then dipped in batter solution using a bamboo skewer. The balls were equally divided into 2 sets and each set was coated with conventional and extruded crumb. The products obtained were in a ready to fry form. The coated fish balls (6 nos. each) were packed in high impact polypropylene (HIPP) trays and top sealed with polyester/polythene film using tray sealer (DynoPack 500VG, Norway). The packed fish balls were frozen in an air blast freezer (Model Icematic T 10, Italy) at – 40 °C for 1 h and kept in frozen storage at -20 ± 2 °C. Sampling was done once in a month.

Table 3. Ingredients used for the preparation of fish ball.

Ingredients	Quantity (g)
Fish mince	1000
Corn starch	50
Salt	10
Garlic	20
Ginger	20
Pepper	20

Analysis of biochemical physical and sensory parameters

Samples were analysed for moisture, crude protein, fat and ash contents (AOAC, 2000). biochemical parameters like total volatile base nitrogen (TVB-N) and trimethyl amine (TMA) (Conway, 1950), free fatty acids (AOAC, 1975), thiobarbituric acid (TBA) value (Tarladgis *et al.,* 1960) and physical parameters like texture profile analysis (TPA) (Lloyd instruments, Model LRX plus UK) and sensory evaluation (Peryam and Pilgrims, 1957) at monthly intervals during the storage period.

Statistical analysis

Two way ANOVA was carried out to analyse the direct and interaction effect of extruded and conventional crumb and period of storage on biochemical parameters like total volatile base nitrogen, trimethyl amine, free fatty acids, thiobarbituric acid and physical parameters like texture and sensory evaluation. Statistical analysis was performed using SAS version 9.2 for windows at 1% level of significance ($p \leq 0.01$).

Results and discussion

Proximate composition

The proximate composition of both conventional bread crumbs coated and extruded crumbs coated fish balls are presented in Table 4. The moisture content of extruded crumb coated fish balls was found to be less than the conventional coated one, which can be attributed to the temperature (120 °C) involved in the extrusion process. The protein content of the product was found to be high in extruded crumb coated balls which could be due to the different flour protein source used and subsequently there is a difference in ash and fat content as compared to the conventional coated fish ball. As the products were properly packed and stored at constant temperature, effect of dehydration and moisture loss and other changes in proximate composition were at a minimum level as observed in coated fish balls by Joseph and Perigreen (1988).

Table 4. Proximate composition (%) of fish balls.

Proximate composition	Conventional (Mean ± SD)	Extruded (Mean ± SD)
Moisture	65.30±.2	61.28±.1
Protein	15.23±.1	16.98±.1
Fat (DWB)	0.57±.02	0.89±.01
Ash	0.48±.01	0.81±.01

Total volatile base nitrogen (TVB-N)

The changes in TVB-N of conventional and extruded crumbs coated fish balls during frozen storage are shown in Fig. 1. The TVB-N of all samples increased significantly but was well within the critical limit during frozen storage. A TVB-N level of 30-35 mg N_2 100 g^{-1} is considered as the limit of acceptability (Lakshmanan, 2000). Based on two way ANOVA, it was found that the average TVB-N differ significantly with respect to treatments, storage period and their interaction at 1% level of significance. Initially the TVB-N values were high in both the samples. This may be due to the thermal break down of volatile base compounds during cooking stage of the fish ball preparation (Rodrýguez *et al*., 2008). The extruded products showed lesser values than others, which means the spoilage chances are comparatively less for extruded coated balls. The decline in the TVB-N values during storage is mainly because of the freezing temperature. The second chance of change in TVB-N may be due to continued enzymatic activity on

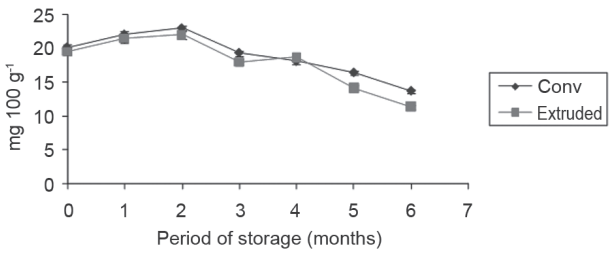

Fig. 1. Changes in TVB-N values in conventional and exctruded crumbs coated fish balls during storage

protein and the non protein nitrogen (NPN) content of fish. The high temperature and pressure during extrusion of the crumb decreases the enzymatic action of crumbs and hence the extruded products show less value of spoilage indices.

Trimethyl amine (TMA)

The observed changes in TMA values of conventional and extruded crumbs coated fish balls are presented in Fig. 2. The TMA is a volatile amine produced from trimethylamine oxide (TMAO) by the action of TMAO reductase positive organisms in marine fishes (Nair and Lahiri, 1968; Finne, 1992). The extruded crumbs coated fish balls showed lesser values of TMA than conventional bread crumbs coated ones. Statistically it was observed that there is a difference in TMA values on extruded as well as conventional coated balls ($p \leq 0.01$). The observed increase is attributed to the conversion of continued enzymatic degradation of TMAO to TMA which resulted in the increase in the values (Leelapongawattana *et al.*, 2005).

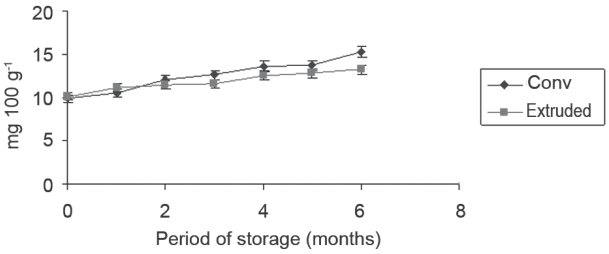

Fig. 2. Changes in TMA values in conventional and exctruded crumbs coated fish balls during storage

Free fatty acids (FFA)

The changes in FFA values of conventional and extruded crumbs coated fish balls are depicted in Fig. 3. Since mild lipid hydrolysis might have occurred during frozen storage, an increase in FFA values was observed in both the products ($p \leq 0.01$). Formation of FFA during frozen storage of seafoods is a factor that leads to the deterioration of protein quality (Dyer, 1951). Extruded crumb coated fish balls showed comparatively lesser values of FFA than conventional crumb coated fish balls. The high temperature and pressure in the extruder might have destroyed the lipolytic bacteria or lipase enzyme which can cause lipid break down (Raj *et al*., 2005) in the product.

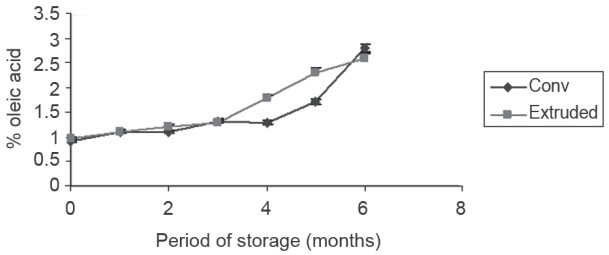

Fig. 3. Changes in free fatty acid in conventional and exctruded crumbs coated fish balls during storage

Tthiobarbituric acid (TBA)

The changes in TBA values of conventional and extruded crumbs coated fish balls are shown in Fig. 4. An increasing trend of TBA values was observed for all the products. Extruded crumb coated fish balls showed lesser values of TBA. The presence of air in the trays may be one of the reasons for the increase in TBA values. Lower values recorded for the extruded coated fish ball could be attributed to the protective layer formed by the crumb coating, which helps to reduce the entry of oxygen to the fish muscle from the tray . Statistically significant ($p \leq 0.01$) difference in TBA values were observed during storage, as well as between the extruded and conventional bread crumbs. However, all the values were within the acceptable limit. Acceptable limit of TBA values are 1-2 mg malonaldehyde kg^{-1} (Goulas and Kontominas, 2007).

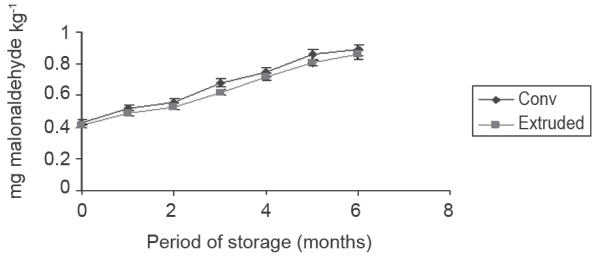

Fig. 4. Changes in TBA values in conventional and exctruded crumbs coated fish balls during storage

Changes in textural hardness

Texture is an important factor for the consumer acceptance. Changes in hardness of the samples are represented in Fig. 5. Hardness is the force required to deform the sample by a specified extension. It is the peak force during the compressive part of the test. The extruded crumb coated fish balls showed higher values than conventional bread crumb coated ones. This is because of the crispy feel of extruded products. Moreover the coating by the extruded crumb formed a layer over the fish ball,

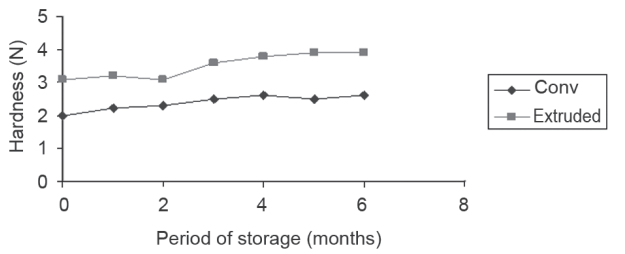

Fig. 5. Changes in textural hardness in conventional and exctruded crumbs coated fish balls during storage

which is responsible for the increase in the hardness compared to the conventional crumbs coated fish balls. The texture of the coated product also depends on the flour used for the preparation of the extruded crumbs. Dyson (1992) reported that the characteristics of extruded crumbs will behave in the order of firm to hard when it is coated with the products.

Changes in overall sensory parameters

Sensory characteristics were evaluated using a 9-point hedonic scale as described by Peryam and Pilgrims (1957). The overall acceptability scores were obtained by pooling the scores for each attribute *viz*., colour, appearance, texture, taste and odour. Both the conventional and extruded crumb balls were analysed after frying in refined sunflower oil (Sundrop Brand) with an oil temperature of 180 °C in electrical fryer. All the products got above average marks until the end of the study period. In the present study, extruded crumb coated fish balls got almost as the same marks as for the conventional coated fish ball. Extruded crumbs coated fish ball is having the characteristic mouth feel of the conventional crumbs. Changes in overall acceptability over the storage period are shown in Fig. 6.

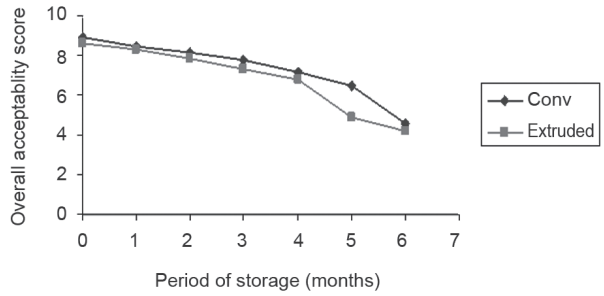

Fig. 6. Overall Acceptability of conventional and exctruded crumbs coated fish balls during storage period

Extruded crumbs developed during the present study, using maida, corn flour and black gram flour combination in a twin screw extruder were comparable to conventional crumbs for coating purposes. The fish balls had a shelf life of six months when packed in HIPP trays kept in frozen condition. The various physical, chemical and sensory parameters support the use of extruded crumbs for coating value added products like fish balls and other battered and breaded products.

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