Chapter 13

Extruded fish products

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Food extrusion technology is a popular means of preparing snacks and ready-to-prepare food items. It is a size enlargement process where in small granular food or powdered particles are reinforced into larger pieces with different shapes, texture, colour etc. Extrusion cooking or thermoplastic extrusion is a common extrusion technology which is considered a HTST (High-Temperature, Short-Time) process. It permits, with little or no modification of the basic equipments and appropriate process control, the production of a great variety of food products. Extrusion cooking is used for starchy and proteinaceous materials for the preparation of nutritious foods. Generally such products are rich in calories and incorporation of protein rich fish improves its nutritional value. Most of the extruded snacks are cereal based and were developed mainly from corn, wheat and rice. But these cereals (eg. rice) have relatively low protein content (6–8 g/100 g db) and an amino acid profile that is high in glutamic and aspartic acid, while lysine is the limiting amino acid. Therefore, addition of proteinaceous food ingredient (eg. fish) in the extruded snack products is recommendable to ensure rich nutritional diets.

Fish is known to be excellent sources of high nutritional value protein with balanced profile of essential amino acids and lipid that contains omega-3 fatty acids, especially, essential fatty acids such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). EPA and DHA are very essential for normal growth and development. These essential fatty acids are found to prevent or moderate coronary artery disease, hypertension, diabetes, arthritis, others inflammatory and autoimmune disorders. The advantages of fish-based extruded products will help in providing nutritious and balanced diets to a large population in the country like India.

Extruders and their classification:

Extruders are the tools used to introduce mechanical shear and thermal energy to food ingredients. Mechanical or thermal energy are used to transport the material through rotating helical screw/screws and the die brings about physical and chemical changes in the feedstock. The

extrusion process generally involves the conversion of a plasticized biopolymer based formulation into a uniformly processed viscoelastic mass that is suitable for forming or shaping into products by a die.

Extruders are classified into two categories according to operational temperature: Hot extruder (cooking extrusion) and cold extruders (non-cooking extrusion). ***Cooking extrusion***involves the raw ingredients being cooked by the combined action of heat, mechanical shearing and pressure (up to 250°C and 25M Pa). ***Non-cooking extrusion***transforms the feed into a homogeneous cohesive extrudate without cooking. Based on type of construction extruders are classified into: Single screw and twin screw extruder. ***Single-screw extruders***are most common extruders applied in the food industry. ***Twin-screw extruders*** are used for high-moisture extrusion, products that include higher quantities of components such as fibres, fats, etc. and for the production of more sophisticated products. Twin screw extruders are again classified as ***Co-rotating*** and ***counter-rotating*** types based on the direction of rotation of the screws. In the counter-rotating position the extruder screw rotates in the opposite direction, whereas in the co-rotating position the screw rotates in the same direction.

Extrusion and its principle:

Raw materials (fish mince and flours) are fed into the extruder barrel through a feeder and the screws convey along it. Towards the barrel end, smaller flights restrict the volume and resistance to movement of the food is increased. As a result, it fills the barrel and the spaces between the screw flights and becomes more compressed. As it moves further along the barrel, the screw kneads the material into a semi-solid, plasticized mass. The food is heated above 100˚C and the process is known as extrusion cooking (or hot extrusion). Here, frictional heat and the additional heating that is used cause the temperature to rise rapidly. The food is then passed to the section of the barrel having the smallest flights, where pressure and shearing is further increased. Finally, it is forced through dies (restricted openings) at the end of the barrel. As the food emerges under pressure from the die to normal atmospheric pressure and temperature, it expands to the final shape, gets characteristic texture and cools rapidly as moisture is flashed off as steam.

Product attributes are controlled by following factors:

- Raw materials
- Residence time of the product in the extruder
- Moisture content

- Barrel temperature
- Screw profile and speed
- Feed rate
- Degree of barrel fill

The independent process variables viz. screw speed; barrel temperature and feed moisture content have direct effect on the product quality. Bulk density is linked with the expansion ratio in describing the degree of puffing in extrudates. Characteristics of extrudate made from starchy ingredients depend on physicochemical changes which occur during extrusion process due to the effects of extrusion variables. In extrusion process, hydration of starches and proteins (structure formers) takes place due to heat and shear. Starch and protein are turned into melt where droplets of water are entrapped and thereby hydrated.

Coating:

The flavouring of extruded products follows a similar pattern to colouring. A product may develop flavour by thermal reactions between flavour precursors in the mix or be flavoured by adding synthetic or natural flavorings. The addition of flavouring is usually carried out on the dry extrudate by spraying or dusting, because of the changes caused by the losses of volatiles during extrusion. This can be performed with simple rotating drums with electric heaters installed or with a gas operated hot air installation.

Packaging:

One of the major properties of snacks is the crispness, which is achieved during the manufacture of the product. Retention of desirable texture (crispiness) is directly related to the moisture level in the product. The moisture content of snack is very low, and any increase due to the hygroscopic nature of the product may lead to loss of crispiness of the product. Moisture also accelerates other biochemical changes such as oxidative rancidity. Oxygen inside the package may be replaced by an inert gas like nitrogen. Low water vapour and gas permeability of the package is, therefore, a very critical requirement. Also the packaging material must be physically strong enough to withstand the processes of vacuumising/gas flushing. Metalized Polyester-Polyethylene laminated pouches with Nitrogen flushing are used for the packaging

Storage:

Extruded product can be stored at ambient temperature. Nitrogen flushed pouches can be bulk packed in carton box and stacked inside the store.

Advantages of thermoplastic extrusion:

Versatility, low costs, high production yields, good quality nutrient enriched products and no effluents.

Effect on nutrients:

Protein, lipids, vitamins and minerals are affected according to the independent variables of extrusion process. Higher temperature and pressure will have higher impact on the nutrients.

Flow chart for preparation of extruded fish product

Dressing of fish, meat picking, preparation of minced meat

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Mixing of minced meat with other ingredients in blender

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Setting of required moisture content in the mixed flour (10-20%) and conditioning for 30 minutes

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Hot extrusion through Twin-screw or Single-screw extruder

(High Temperature (100-140 ^{o}C), High Pressure, Short Time process)

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Drying by hot air (140-150 ^{o}C) to moisture content < 5%

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Coating of flavour (Dust coating of flavour powder along with hot oil-spray)

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Packing in Metalized Polyester-Polyethylene laminated pouches with Nitrogen gas flushing