Foods and Nutrition News

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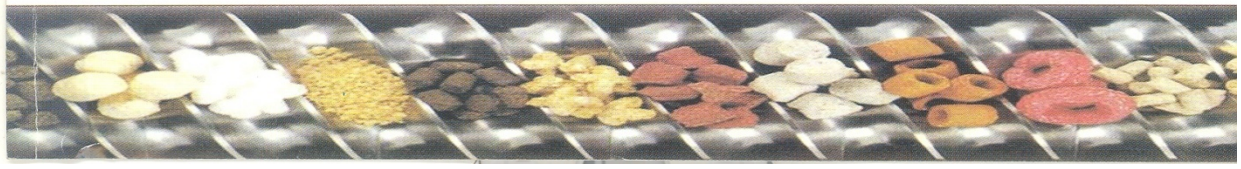
Extrusion Processing - Technology and Applications

Today, all over the world, extrusion processing is the technology that is being applied by many food industries to obtain attractive and marketable food products. In India too, there has been a favourable response to extruded products introduced into the market mostly by multinational companies. Many enterprising Indian food manufacturers are exploring the potential of this technology and are experimenting with a variety of extruded products.

The basic process of extrusion, which is the operation of shaping a dough like material by forcing it through a restriction or die is not new to Indian cooking. Hand operated extrusion equipment include vermicelli and noodle making machines, *muruku and sev* moulds etc. However further processing of the products is required i.e. the product has to be dried or fried in oil before use. The present day extruders not only extrude the food material introduced into them but also cook it, so that a ready to eat product emerges from the machine.

Thus food extrusion is a process in which a food material is forced to flow under one or more varieties of mixing, heating and shear, through a die which is designed to form and/or puff dry the ingredients

Extruders were developed in late eighteenth century. The new generation extruders which we see today were fabricated at the end of the twentieth century.

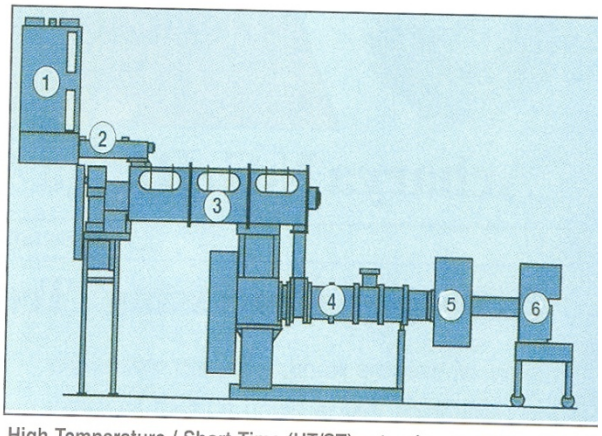


Extrusion is a high temperature short time (HTST) multi variable unit operation that involves mixing, shearing, cooking, puffing and drying in a single energy efficient, rapid continuous process which brings about gelatinization of starch, denatures proteins, modifies lipids and inactivates enzymes, microbes and many anti nutritional factors. Moistened, expansive, starchy and/or proteinacious food materials are plasticized and cooked in an extruder by a combination of moisture, pressure, temperature and mechanical shear resulting in molecular transformation and chemical reaction.

Extruders may be single screw or twin screw extruders and they are selected depending on the product to be prepared. An Indian made twin screw extruder is likely to cost about Rs. 12 to 15 lakhs.

Extruders of all types have similar, common sub components.

1. A holding bin for mixed raw material.
2. A feedline device to feed the raw, dry mixed ingredients uniformly and in an uninterrupted manner at the desired flow rate.
3. A pre conditioning unit in which liquids/ vapour (steam) etc. may be uniformly combined with the ingredient mix.
4. An extruder assembly for which the configuration of barrel segments, screws etc. have been pre selected to properly feed, knead and cook the dry or pre moistened process material.
5. A die to restrict the extruder discharge and shape the final product.
6. A cutting device to cut the extruded product to the desired length.



High Temperature / Short Time (HT/ST) extrusion cooking system

Five chemical/ physicochemical changes that occur during extrusion cooking include –

- Binding
- Cleavage
- Loss of native conformation
- Recombination of fragments
- Thermal degradation

Most chemical reactions occur in the portion of the barrel just before the die. During food extrusion, sufficient energy both thermal and mechanical is imparted to gelatinize the starch and denature the protein. Most of the extrusion cooking processes occur in the 10 – 30 % moisture range. Ingredient selection has a tremendous impact on product texture, uniformity, extrudability, nutritional quality, economic viability and ability to accept coatings.

Typical processing conditions of extrusion are

- **Extruder RPM 300-400**
- **Extruder barrel temperature 120-160°C**
- **Extruder barrel pressure 70-150 atmospheres.**
- **Feed rate 450 Kg/hour**
- **Moisture added into extruder 13 Kg / hour**
- **Moisture of extruded product 8-10 %**
- **Bulk density of extruded product 48-64 g/L**

The details of extrusion process for preparation of the product is given in Fig.1.

Fig. 1: The Extrusion Process

Many extruded products are bland since there is little time for flavour development. Thermal degradation of added flavours may also occur. Volatile flavours flash off with water vapour when the food exits the extruder. Post extrusion flavouring is often used.

The advantage of the extruder is the flexibility to quickly and easily change the processing steps for obtaining countless variations of ready to eat food products. Merely changing the processing conditions and/or extruder die will yield an abundance of shapes and textures of products. Adding or changing composition of food material will similarly allow for limitless opportunities. Further, coating the product with various flavours, colours and other additives will increase the variety of products. For instance, the same base product may be coated with sugar syrup to give a sweet product or it may be coated with tomato flavouring and colour to give a tomato flavoured snack item.

In this way extrusion cooking is a versatile process with a wide range of applications like ready to eat cereals, snacks, expanded products; textured meat like proteins, pre cooked infant foods, confectionary products, pet foods, aquatic foods etc.. It is remarkably adaptable in accommodating consumer demand for new products.Continued research and a better understanding of the extrusion process, raw material characteristics and behaviour, as well as energy and labour economics will all work

together to increase the marketable products provided using the extruder systems.

Advantages

Extrusion cooking offers several advantages over the processes it replaces.

Extrusion is a continuous process and pre blended dry powders can be continuously fed into it.

Quality control is maximized as poor quality products are immediately and easily recognized and corrective action can be taken.

Several processing steps are combined in the extruder hence, the need for extra pieces of complex equipment is eliminated and the installations are compact compared to other processing means. Water, steam, other liquids and solids can be continuously and uniformly combined.

As lower moisture levels for cooking are used, the overall utility consumption for extrusion is less than that of alternate processing. Besides, less heat is lost to the surroundings. Manpower requirements are less when using extrusion cooking.

The conditions of extrusion for different mixes on pilot scale extruder is given in Table 1.

Table 1: Conditions of Extrusion for different mixes on Pilot scale Extruder

Parameters	Sorghum + corn+ soy	Sorghum + corn+ legume mix	Sorghum + corn + WPI
Feed screw speed (RPM)	Low, 400	Low, 400	Low, 400
Shaft screw speed (RPM)	398	396	399
Motor load (%)	39	28	36
Temperature in barrel (°C)	32-87-109-130	23-86-110-130	29-85-110-139
Die temperature (°C)	143.8	145	145.1
Die pressure atmospheres	1000	1000	1000
Die diameter (mm)	3.2	3.2	3.2
Collect feed rate (kg/hr)	84	84	84

Extrusion being a versatile process, provides precise hardware and process control that permits the use of a wider range of raw material to produce a given product.

Nutritional changes during extrusion cooking

The high temperatures, pressures and shearing in the extruder can cause certain chemical / physicochemical changes which could affect the nutritional value of the foods produced.

Starches: Starches are gelatinized and their digestibility increased. Molecular degradation of starches also occurs. Manipulation of various processing conditions can be done to increase starch digestibility for weaning foods or to create resistant starch for therapeutic foods. Expansion can be increased or decreased similarly. Novel starches and gums can also be produced.

Extrusion has been found to increase soluble fibre content of foods.

Protein: Proteins are denatured and protein solubility decreases after extrusion. Maillard reaction occurs and leads to a loss of lysine and other essential amino acids.

Vitamins:Thermal degradation leads to losses of ß-carotene. All trans ß-carotene is reduced to its cis isomer. Vitamins D and K are fairly stable but A and E get destroyed in the presence of oxygen. Thiamine is very susceptible to thermal processing as is vitamin C.

Research work carried out in Department of Foods and Nutrition, ANGRAU

Several recipes/products were developed with cereals, millets and legumes suitable for various age groups, feeding programmes and for therapeutic use.

Low calorie, high fibre extruded snacks

Extrusion especially using a twin-screw extruder has provided a new and novel means of production of snacks and has revolutionized conventional snack manufacturing processes. In this study, low calorie, high fibre extruded products were developed using cereals (rice/ wheat flour/ corn flour) and defatted soy at 20 % level. Higher protein content of soy helped in obtaining products of higher protein value. Twelve products using different combinations of cereals and soy were prepared. The products were further enriched using ß-carotene rich sources such as carrot, spinach, curry leaves and red palm oil, all of which were added prior to extrusion. The energy value of these products ranged from 275 – 350 Kcals while protein was 10–21 g and fibre content ranged between 0-3g of extruded product. The products scored well on sensory evaluation; the product with rice scored the least. Storage studies showed that there was no deterioration in quality even after three months of storage. Thus extrusion was found to be a suitable process for enhancing the nutritive value of products.

Rita Patnaik & M.Uma Reddy (2000)

Nutritious Food Supplements for elderly

Nutritious food supplements were developed by the process of extrusion for institutionalized elderly keeping in mind their requirements. The ready to eat extruded snack items, both sweet and savory were made using cereals like wheat and maize. To enhance the protein content, protein rich foods such as soybean and legumes were added at 10% level. The products were enriched with vitamin A, thiamin, riboflavin and iron. The nutritive value of the product was determined in the lab. The prepared products were evaluated by a panel of judges in the lab and then by the elderly subjects. The products were well accepted by the elderly subjects who felt that they were crisp and crunchy with a mouth feel similar to traditional snacks without the use of oil.

N.Lakshmi Devi & Vijaya Khader (1997)

Extruded maize product suitable for vitamin A supplementary feeding

A nutritious product was developed using extrusion technology with maize grits and a blend of red palm oil and groundnut oil in 30 : 70 and 50 : 50 proportions.

Curry leaf powder and carrot powder were added at 30 % level to enhance the pro vitamin A content of the product. The product was well accepted by the target group. The nutrient content and the stability of these nutrients during storage was studied and it was found to decrease marginally. The product was found to be suitable for combating vitamin A deficiency among preschool children.

K.N. Bhavani & Kamini Devi (1994)

High fibre extruded product incorporating wheat bran and rice bran

A hand operated extruder was used for the development of high fibre vermicelli. Refined wheat flour incorporated with wheat bran and rice bran at 10, 20 and 30 per cent levels was used for the preparation of vermicelli. Sensory evaluation of the fresh products as well as those stored for four to six weeks was carried out. Proximate and minerals content were analysed. The vermicelli containing 10 per cent bran was found most acceptable even after storage.

N.Janaki & Kanwaljit Kaur (1994)

Collaborative Research Project on extrusion

1) Development of sorghum based nutritious snacks using extrusion technology

This project was carried out at the Department of Grain Science & Industry KSU, USA. (2008). Sorghum based extruded snacks were developed using lab scale and pilot scale twin screw extruders.

Blends of sorghum and corn along with different sources of protein like defatted soy flour and a legume mix in different proportions were used as raw material for extrusion. The effect of extrusion variables and sorghum to corn ratio on properties like expansion ratio, piece density, texture and proximate composition of extrudates was studied X-ray micro tomography imaging system was used to obtain structural images of extrudates. Based on trials the moisture level was fixed at 17%.The proportion of sorghum and corn and protein source were kept constant at two levels i.e.50:20:30 and 60 : 10:30. Pilot scale extrusion was done on a Wenger TX-52 twin screw extruder. Study of the physico chemical characteristics showed that expansion ratio decreased with addition of protein source.

The product developed was tasty, nutritious, crunchy and found to be suitable for all age groups.

N Lakshmi Devi, S. Shobha, Sajid Alavi (2008)

2) Extrusion technology for development of nutritious weaning foods & snacks for children

Project implemented at College of Home Science Hyderabad in the newly established extrusion unit.

Sorghum and rice based products incorporated with a high protein source like soy or legumes were developed. Malted ragi was added to the powdered extrudate to develop a low cost energy dense weaning food which is protein rich and easily prepared. The nutrient content of the mix was estimated and shelf life was studied. The weaning mix was well accepted by the mothers of infants and by preschool children in the rural as well as urban areas in and around Hyderabad.

N.Lakshmi Devi, S.Shobha & Sajid Alavi (2009)

EVENTS

❖ Dr. Sajid Alavi, Associate Professor, Department of Grain Science and Industry, Kansas State University, USA visited the College of Home Science on 21-07-2008 and made a presentation on `Processing of nutritious ready-to-eat products'. He interacted with the staff and representatives of industries and emphasised the need for public private partnerships.

- The Department of Foods and Nutrition was given FPO license for fruit and vegetable products prepared in the Department for a period of 1 year, 2008 - 2009. The license was issued to the Principal Investigator of the project entitled *Establishment of Rural enterprise for tomato products by women for food and nutritional security.*

ANNOUNCEMENT

A training programme on **'Nutritional Management Strategies of chronic diseases-Recent Concepts'** will be held by the Centre of Advanced Studies, Department of Foods & Nutrition, Post Graduate and Research Centre during June - July 2009. Exact dates will be informed later on. Lodging and Boarding will be taken care of by the host institution. The nominations of participants from State Agricultural University Teachers may be sent by **8th June 2009.**

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