



### Mini Review Article

## Role of extrusion technology in food processing and its effect on nutritional values

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### Abstract

Extrusion cooking is a multi-functional thermal/mechanical process, which has drawn wide attention in agro-food processing industries. This process has various beneficial effects like destruction of antinutritional factors, gelatinization of starch, increased soluble dietary fiber and reduced lipid oxidation. On the other hand, Maillard reaction also influence in the nutritional value of the food by the interaction between protein and sugars. The raw material and their composition along with the process condition also influence the nutritional value of the food. The extrusion cooking is widely applied for cereal and protein processing such that the mild extrusion condition (low temperature, low residence time and high moisture) improves the nutritional quality of food largely. In case of high extrusion condition such as high temperature <math><200^{\circ}\text{C}</math>, low moisture content (<math><15\%</math>) with the presence of high reactive sugars adversely affects the nutritional quality of food. In order to obtain a nutritionally balanced food control of process parameters along with the physico-chemical changes should be monitored properly at timely basis. This review also suggests the recent development in food industries regarding the extrusion technology.

**Keywords:** Extrusion cooking; Maillard reaction; Nutritional value; Temperature.

### Introduction

Proper nutrition involves intake of carbohydrates, fats and proteins at an appropriate level for balancing the body with fiber, vitamins, minerals and energy. As generation changes, globalization increases with consumption of fast food including high calorie food styles. This has brought a drastic change in day-to-day lifestyle with lot behavioral changes towards foods. Change in process technology and methods of agriculture from organic to scientific have brought changes in nutritional values. Due to changes and non-consumption of nutritious food, people are prone to non-communicable diseases, including obesity, diabetes and cancer (Allal *et al.*, 2014). Health and nutrition play a vital role in the society and it also remains as one of the challenging field in this era. It is always a necessary fact to monitor the nutritional quality of the food as it directly affects the health of an individual.

Processing of food at high temperature remains a challenge in food processing industries as it leads to deterioration of nutritive values in food. In order to avoid this, extrusion cooking is adopted as it has unique features when compared to the other heat process. Extrusion cooking is mostly preferred, as it owes high productivity

and significant nutrient retention. This process involves high temperature and short time as food materials are cooked in a tube by the combination of pressure, moisture and mechanical shear resulting in molecular transformation (Shivendra *et al.*, 2007). This high temperature short time process is known as extrusion technology, reduces microbial contamination, inactivates the enzymes as it is one of the methods which supports in the prevention of both cold and hot extruded products with the water activity of 0.1 to 0.4 (Bordoloi and Ganguly, 2014). The role of shear, temperature, moisture and feed composition are significant in the process of transformation of starch by extrusion.

### Characteristics of Extrusion Technology

The extrusion technology has become an important technique in food processing industries as it one of the cost effective method. The variability of the product and high quality, productivity of the new foods are the added advantage of this technology (Chakraborty *et al.*, 2009). This process tends to break the covalent bonds in biopolymers along with certain modification such as texturizing the food ingredients. This process also denatures the undesirable enzymes and other antinutritional

factors, by retaining the original colors and flavors of foods. Nutrition has reached the highest level of concerns, especially for dietetic foods and meat replacers using extrusion (Ulrich et al., 1994).

The extrusion process finds its application in the preparation of salty, sweet snacks, textured meat materials, ready to eat cereals and nutritious precooked food mixtures for infant feeding. Though, extrusion cooking has been applied with great commercial success for the production of shaped products and other breakfast cereals, the application of extrusion technology is gaining attention, especially on using vegetable proteins for the production of textured product. In recent times, changes at the molecular level are noted within the shear field of the extruders as the proteinaceous materials denatures and melts in the extruders itself. In order to understand the chemical changes in the extruders, it is necessary to know about the temperature, pressure and shear such that intermediate-moisture environment condition are to be noted as it affects the quality of the product (Ledward et al., 1994). The nutritional values are explained below.

### **Nutritional changes in food**

The nutritional value in vegetable protein is usually enhanced by mild extrusion cooking conditions such that it increases the digestibility due to protein denaturation and inactivation of enzyme inhibitors present in raw foods. The process variables such as temperature, feed ratio, screw speed and length to diameter ratio plays a significant role in protein digestibility. The antinutritional factors such as trypsin inhibitors and tannis are destructed during extrusion cooking. The destruction of trypsin inhibitors increases with increase in extrusion temperature and moisture content. It was reported that for protein such as casein, the temperature at 153°C, 20% moisture and 2 min residence time resulted with 89% reduction in trypsin inhibitors. Higher extrusion temperatures, lower feed moisture, longer residence time are key variables for the destruction of trypsin inhibitors (Bjorck & Asp, 1983). In addition, the Maillard reaction plays a vital role during the processing of foods. The reaction involving an amino group of protein and carbonyl group of reducing sugars results in browning and flavor production. This reaction significantly decreases the availability of amino acids involved in protein digestibility (Fukuie et al., 1993, Jaeger et al., 2010).

Lysine appears to the most reactive amino acid as it has two amino groups and it was reported that the availability of this amino acid are in range of 32 to 40% at 170°C, 10-14% feed moisture and 60 rpm screw speed. The availability of lysine is maintained by avoiding the extrusion temperature above 180°C at a water content below 15%. The amount of reducing sugars is also reduced during the extrusion process as they influence on the loss of lysine. As the extrusion process involves higher temperature, toxic compound known as acrylamide a probable carcinogenic agent is formed. The compounds are formed when the food substance is exposed to higher temperature <180°C (Studer et al., 2004). The extrusion cooking also influences the total dietary fiber as changes in dietary profile is primarily due to the shift from insoluble dietary fiber to soluble dietary fiber. The mild extrusion temperature solubilizes some fiber components and in severe condition, the content increases owing to its increases in soluble dietary fiber and enzyme resistant starch fractions (Vasanthan et al., 2002).

The presence of vitamins is also influenced by the extrusion process where minimizing temperature and shear within the extruders tends to protect the nature of vitamins present in the food ingredients. Various precaution are done for controlling the loss of vitamins during extrusion such that post extrusion application are carried out (Camire., 1998). The three main parameters, which influences on the consumption of food are product, nutritional and microbial quality. The products are subjected to high temperature that confers the crunchy nature of the product such that the texture and color are significant in terms of product quality. It is essential for the specialized nutritional foods such as infant and weaning foods to possess high starch digestibility as it has reduced calorie during the process of extrusion. The mild extrusion conditions tend to form nutritive foods as they provide high digestibility product. One of the most important criteria in terms of consumers' requirement is the microbial quality of the food. This process was found to be efficient as it involves higher temperature where the vegetative organisms are destroyed during the extrusion process (Dehghan et al., 2010).

### **Functional properties**

The type of extrusion depends mainly on the type and amount of the starch used in the process. Under high extrusion conditions, the

sensory and nutritional quality of the product is changed. Even the functional properties including the expansion ratio, bulk density, hardness and the water absorption index are also influenced by the process of extrusion technology. The expansion ratio mainly depends upon the temperature as an increase in temperature increases the screw speed with higher expansion ratio (Kothakota et al., 2013). It was reported that the bulk density decreases with increasing the temperature and the screw speed. The low screw speed was reported with increased textured rice bulk density, which was resulted due to the gelatinization of the starch (Pathania et al., 2013). The other factor that affects the extruded product is that the water absorption index. The increase in water absorption with increase in temperature was due to the increased dextrinization at high temperature (Hagenimana et al., 2006)

#### Recent advances in extrusion technology

The extrusion technologies in the production of dairy industries are carried out by functionalizing the whey proteins under super critical fluid extrusion. In addition, inclusion of whey protein crisps with pre-biotic fiber under super critical condition are investigated at recent times. The conventional processes just process the raw material ready to cook whereas the extrusion process converts the raw material (grains of density  $7.7 \text{ kg}/100 \text{ cm}^3$ ) to ready crunchy product with the density of  $0.6$  to  $1.6/100 \text{ cm}^3$ ). Thus, the application of extrusion cooking in food industries at controlled condition helps in maintaining the quality and nutrition of food to a great extent (Ramachandran et al., 2015).

#### Conclusions

Extrusion cooking is an ideal method for manufacturing various food products as it permits the utilization and coprocessing of various by-products. The ability of extruders to blend diverse ingredient in novel foods can be exploited in the development of functional foods. This process is known as a multivariate process such that it requires control for maintaining the quality of the product. Various areas require further research regarding extrusion and nutrition. Future research has mainly focussed on the relationships between compositional changes on product quality concerning both on the nutritional, sensory aspects, and the effects of interactions between complex extruder conditions on nutrient retention. High-moisture

extrusion and use of less reactive sugars may create a new line of research objectives.

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