Effect of Extrusion Cooking on Textural Properties of Extrudates-
A Review

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Abstract

Ready-to-Eat extruded snacks are very much popular among consumers due to their fulfilment of daily nutrition and calorie intake to consumers. Cereals, starch / protein are the important raw material for food extrusion cooking. The highly expanded, low-density Ready-to-Eat extruded products having unique textural properties can be obtained by extrusion cooking processing. Consumer acceptability of extruded products is dependent on its textural properties. Textural properties such as hardness, cutting strength, breaking strength, crispness of extruded product are dependent on feed parameters and operational parameters. Effect of extrusion cooking on textural properties of extrudates observed by various researchers and found that textural qualities are highly influenced by the blend ratio, feed moisture and extrusion temperature. Hardness of extrudates increased with increase in feed moisture while crispness decreased with it. Cutting strength decreased with increase in screw speed. Extrusion temperature showed the reciprocal effect on hardness.

Keywords: Extrusion cooking, Feed parameters, Operational parameters, Textural properties, Hardness, Cutting strength, Crispness

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Introduction

Today food consumption pattern of consumers has changed due to their busy life style. They are more inclined to the convenient and healthy food. Now a day, Ready-to-Eat extruded snacks are more popular among consumers. Because, extruded snacks fulfil the requirements of daily nutrition and calorie intake to consumers. Cereals, starch and vegetable protein are the popular raw material for extrusion of food. These play the vital role to obtain the desired structure, texture, mouth feel, and many other characteristics of final products reported by Anton and Luciano (2007) [1]. The nutritional value of extruded snacks can be improved by an inclusion of other ingredients such as fruits and vegetables.

Principle of operation behind extrusion cooking is raw materials are fed into the extruder barrel and screw then convey the food along it. Castells et al., (2005) [5], Deshpande and Poshadri (2011) [7] and Havck and Huber (1989) [12] found that the shear and frictional force exerted by the rotating screw and heating of the barrel, moistened starchy or proteinaceous food material is heated to its melting point or plasticising point, resulting in functional changes (molecular transformation and chemical reactions) occurred that modifies the rheological properties of raw materials, Tiwari (2011) [23] and Van Zuilichem (1992) [25]. Extrusion cooking is a powerful processing operation which utilizes highly expanded, low-density products with unique textural properties noted by Fili et al., (2012) [8]. The porous and crunchy or chewy textured extrudates obtained due to high-pressure operation in extruder that provides sudden expansion of the processed product found by Patil et al., (2005) [17].

Texture is the combination of properties of food materials which are related with the response of the structure of food to applied forces and the physiological senses involved being vision, kinesthetic and hearing noticed by Kanojia and Singh (2016) [13]. Textural properties which show the value and appearance of extruded products are important for acceptability of consumers, Harper (1981) [11]. Textural properties such as hardness, cutting strength, breaking strength, crispness or crunchiness are very important for the control of processing operations to obtain desired quality attributes of finished product as found by Kanojia and Singh (2016) [13]. Textural properties of finished product are very much dependent on critical parameters induced in raw materials such as blend ratio, feed moisture as stated by Brnic et al. (2006) [4], Kanojia and Singh (2016) [13], thermal energy input, mechanical energy input and retention time of product in any specific region as well as feed rate, screw speed, barrel temperature and barrel pressure observed by Anton and Luciano (2007) [1]. Though, extrudates are highly hygroscopic in nature noted by Patil et al.,

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Various approaches have been used to evaluate the textural properties of foods. It can be estimated by sensory (subjective) evaluation by observing the penal members and instrumentally (objective) method using instruments like Texture Analyzer and Intron Compression Testing machine enquired by Kanojia and Singh (2016) [13] and Patil et al., (2005) [17]. Texture measurement instruments range from simple handheld device to the Intron machine. Texture attributes are calculated from force-time or force-displacement data, Chen and Opara (2013) [6].

Probes Used for Textural Properties

Different types of probe are used to analyse the textural properties of extrudates such as cylindrical probe for hardness, needle probe for crispness and Warner Bratzler blade for cutting strength showed in Figure 1a-c observed by Bhople and Singh (2017) [3] and Kanojia and Singh (2016) [13].

Textural Properties

Hardness

It is defined as the maximum force required to compress a final product between the molar teeth (in the case of solids) or between the tongue and palate (in the case of semisolids) accentuated by Kanojia and Singh (2016) [13] and Patil et al., (2005) [17]. Hardness revealed the surface property of product and minimum hardness of extrudates showed higher acceptability found by Kanojia and Singh (2016) [13]. The hardness of the rice flour based extrudates was estimated by Grenus et al., (1993) [10] through the Intron machine and the Warner-Bratzler cutting device using the ratio between the shear force and cross-sectional area of the product.

Effect of extrusion cooking parameters on extrudates textural properties have studied by many researchers. Use of pre-gelatinized rice flour showed the decreased value of hardness, Gat and Ananthanarayan (2015) [9]. Increased level of feed moisture showed increase in hardness observed by Lazoua et al. (2011) [15], Gat and Ananthanarayan (2015) [9], Pardhi et al., (2017) [16] and Sharma et al., (2015) [20]. Hardness of extrudates was decreased with increase in temperature found by Pardhi et al., (2017) [16] and Sharma et al., (2015) [20]. Hardness showed the positive correlation with yam flour level and feed moisture content of corn and rice based extrudates observed by Seth et al., (2015) [18]. Hardness of the extrudates significantly decreased with increase in the level of soya bean flour in the mix and screw speed observed by Si-quan et al., (2005) [21]. Kanojia and Singh (2016a) [14] observed the effect of different blends of rice and safed musli on hardness of extrudates studied and found that hardness showed the positive correlation with blend ratio and feed moisture content. Hardness of extrudates reduced with decreased level of ashwagandha in blend ratio, increase in die head temperature and increase in screw speed observed by Seth (2008) [19]. Feed moisture content, screw speed and temperature showed significant effect on extrudate hardness, while feed rate does not have any significant effect on it, observed by Brncic et al., (2006) [4].

Crispness

Crispiness is “The perceived horizontal force with which the product fragmented into two or more distinct pieces during a single bite with the incisors in mastication process. A rapid and complete failure of the product is required in this process” claimed by Barrett et al. (1994) [2]. Typical sound produced during mastication that contributed as crispness of relative product. Crispness is very important parameter in the enjoyment of many foods Tunick et al.,
2013 [24]. Kanojia and Singh (2016) [13] and Stanley (1986) [22] found the crispness of extrudates by observing the number of positive peaks on force–deformation curves. The crispness of extruded product varying with the difference between peak and valley in the curve. More difference shows crispier and harder product while less difference reveals the crispy and soft product.

Extrusion parameters reveal the significant effect on crispness found by various researchers. Higher crispness value i.e. 22 at 13% of feed moisture content with 3% concentration of safed musli powder at 180 rpm screw speeds, 188°C barrel temperature and 170°C die head temperature observed by Kanojia and Singh (2016a) [14]. Concentration of safed musli powder in extrudates showed the negative effect with crispness. They were also found that crispness of extrudates decreased with increase in feed moisture content. While screw speed and barrel temperature showed the positive correlation with crispness of extrudates. Crispness of extrudates decreased with increase in feed moisture content [16]. Si-quan et al., (2005) [21] found that an improved porous texture and crispy extrudates obtained by addition of soya bean flour. Crispness of extrudates decreased with increase in blend ratio of raw materials found by Seth (2008) [19]. It may be due to increased level of fibre content in blend ratio. Increased barrel temperature and increased level of screw speed also showed the positive effect on crispness.

Cutting Strength

Kanojia and Singh (2016) [13] stated that the cutting strength is same as the hardness but it is measured by different probe i.e. blade with knife, having more surface area. So, the surface area of cutting is increased. That is why the value of cutting strength is always higher than hardness of product. Hardness of extrudates increased with increase in feed moisture content found by Gat and Ananthanarayan (2015) [9], Pardhi et al., (2017) [16] and Seth et al., (2015) [18]. The cutting strength reduced with increase in screw speed, which may be due to greater shear rate generated by screw resulted for uniform, porous, soft textured extrudates obtained by Seth (2008) [19].

Conclusion

Extrusion cooking process showed the significant effect on the textural properties of extruded products. Following conclusion can be drawn from this review:

- Textural qualities highly influenced by the blend ratio, feed moisture and extrusion temperature.
- Hardness increased with feed moisture but decreased with increase in temperature.
- Crispness decreased with increased in feed moisture and increased with increased in barrel temperature and screw speed.
- Cutting strength is same as the hardness but it is measured by different probe. Cutting strength reduces with increase in screw speed.

References


