Review Article

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

Nidhi Khanna*, Mohan Singh and Priti Jain

Department of Post Harvest Process and Food Engineering, College of Agricultural Engineering, JNKVV, Jabalpur, 482004, Madhya Pradesh, India

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

***Correspondence**

Author: Nidhi Khanna

Email: khanna.nidhi297@gmail.com

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 Filli *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].

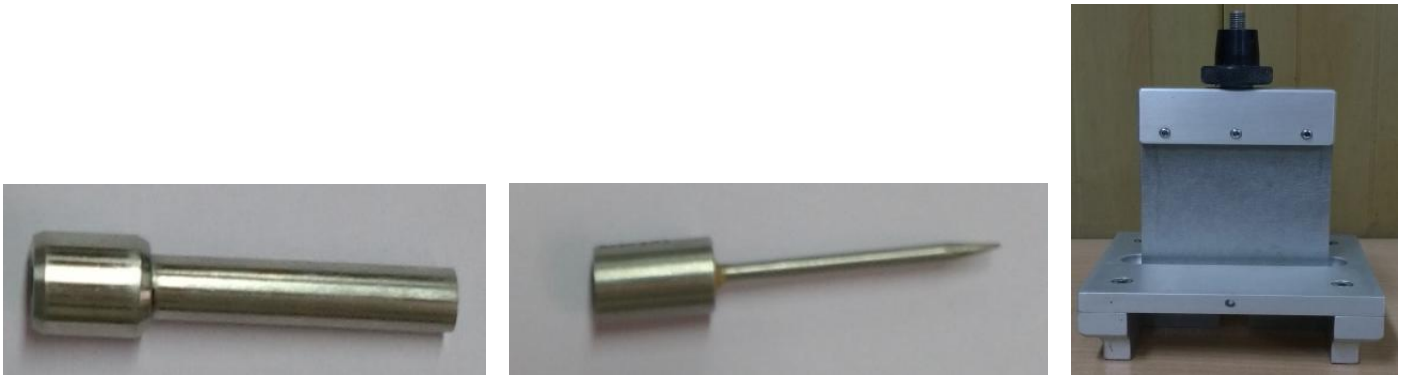
Texture is the combination of properties of food materials which are related with the response of the structure of food to applied forces and the physiological senses involved being vision, kinesthetic and hearing noticed by Kanojia and Singh (2016) [13]. Textural properties which show the value and 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 Brncic *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.*,

(2005) [17]. They absorbed moisture from an atmosphere. It is very important to store them appropriately for further testing.

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 Instron 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 Instron 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].



(a) (B) (c)

Figure 1 (a) Cylindrical Probe, (b) Needle Probe, (c) Warner Bratzler Blade

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 Instron 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

[1] Anton AA and Luciano FB. Instrumental Texture Evaluation of Extruded Snack Foods: A Review. Cienc. Tecnol. Aliment 2007; 5(4): 245-251.
[2] Barrett AH., Rosenberg S and Ross EW. Fracture intensity distributions during compression of puffed corn meal extrudates: method for quantifying fracturability. Journal of Food Science, 1994; 59: 617–620.
[3] Bhople S and Singh M. Extrusion Cooking Technology for Iron Enriched Foods: A Review, International Journal of Agriculture Sciences, 2017; 9 (24): 4278-4281
[4] Brncic M, Tripalo B, Jezek D, Semenski D, Drvar N and Ukrainczyk M. Effect of twin-screw extrusion parameters on mechanical hardness of direct expanded extrudates, Article in Sadhana 2006; 31(5): 527–536.
[5] Castells M, Marin S, Sanchis V and Ramos AJ. Fate of mycotoxins in cereals during extrusion cooking: a review. Food Additives and Contamination 2005; 22: 150–157
[6] Chen L and Opara UL. Texture measurement approaches in fresh and processed foods- A review, Food Research International 2013; 51 (2): 823-835.
[7] Deshpande HW and Poshadri A. Physical and sensory characteristics of extruded snacks prepared from Foxtail millet based composite flours, International Food Research Journal 2011; 18: 751-756.
[8] Filli KB, Nkama I, Jideani VA and IBOK, IU. System Parameters and Product Properties Responses During Extrusion of Fura from Millet-Soybean Mixtures, Official Journal of Nigerian Institute of Food Science and Techonology, Nigerian Food Journal 2012; 30 (1): 82 – 100.

[9] Gat Y and Ananthanarayan L. Effect of Extrusion Process Parameters and Pregelatinized Rice Flour on Physicochemical Properties of Ready-To-Eat Expanded Snacks, Journal of Food Science and Technology 2015; 52(5): 2634-2645
[10] Grenus KM, Hsieh F and Huff EH. Extrusion and extrudate properties of rice flour. Journal of Food Engineering 1993; 18: 229-245.
[11] Harper JM. Extrusion of Foods, Vol. 1, CRC Press, Inc. Boca Raton, 1981; pp: 101-155.
[12] Havck BW and Huber GR. Single screw v/s twin screw extrusion. The American Association of Cereal Chemists 1989; 34: 930–939.
[13] Kanojia V and Singh M. Extruded Product Quality Assessment Indices: A Review, Review article. International Journal of Agriculture Sciences 2016; 8(54): 2928-2934
[14] Kanojia V and Singh M. Assessment of Textural Properties of Brown Rice based Ready to Eat Extrudate Snacks Blended with Water Chestnut and Safed Musli Powder, Indian Journal of Science and Technology 2016(a); 9(38): 1-7.
[15] Lazoua A, Krokida M, Zogzas N, Karathanos V, Lentil-based snacks: Structural and textural evaluation, Procedia Food Science 1, 2011, 11th International Congress on Engineering and Food (ICEF11); 1593 – 1600.
[16] Pardhi SD, Singh B, Nayik GA, Dar BN. Evaluation of functional properties of extruded snacks developed from brown rice grits by using response surface methodology, Journal of the Saudi Society of Agricultural Sciences 2017; Article in Press, pp: 1-11
[17] Patil RT, Berrios Jose De J, Tang J, Pan J and Swanson B. Physical Characteristics of Food Extrudates –A Review, An ASAE Annual International Meeting 2005; Paper No. 056166, Tampa Convention Center, Tampa, Florida
[18] Seth D, Laxmikant SB and Vijayalakshmi G. Effect of feed composition, moisture content and extrusion temperature on extrudate characteristics of yam-corn-rice based snack food, Journal of Food Science and Technology, 2015; 52(3): 1830–1838.
[19] Seth NK. Studies on preparation of Ready – to - Eat Snacks from Rice – Defatted Soy – Flour and Winter Cherry Powder Blends by Using Extrusion Cooking Technology Ph.D Thesis 2008; JNKVV, Jabalpur, M.P.
[20] Sharma R, Kumar R, Srivastava T and Saxena DC. Textural and Microstructural Properties of Extruded Snack Prepared from Rice Flour, Corn Flour and Deoiled Rice Bran by Twin Screw Extrusion, International Journal of Computer Applications 2015; (0975 – 8887), pp: 33-38.
[21] Si-quan Li, Howard QZ, Tony JZ and Fu-hung Hsieh. Textural modification of soya bean/corn extrudates as affected by moisture content, screw speed and soya bean concentration, International Journal of Food Science and Technology 2005; 40: 731–741.
[22] Stanley DW. Chemical and Structural Determinants of Texture of Fabricated Foods. Food Technology 1986; 12: 65-76.
[23] Tiwari VK, Studies on Blending Whole Brown Rice for Nutrient Enrichment on Rice Based Extrudates Through Extrusion Cooking Technology, PhD Thesis, 2011, JNKVV, Jabalpur, M.P.
[24] Tunick MH, Onwulata CI, Thomas AE, Phillips JG, Mukhopadhyay S and Sheen S. Critical Evaluation of Crispy and Crunchy Textures: A Review, International Journal of Food Properties 2013; 16 (5): 949–963.
[25] Van Zuilichem DJ. Extrusion Cooking. Craft or Science? Ph.D. Thesis, 1992; Wageningen University, Netherlands.

Publication History
Received 15th Apr 2019
Revised 20th May 2019
Accepted 11th Jun 2019
Online 30th Jun 2019