International Journal of Farming and Allied Sciences
Available online at www.ijfas.com
©2015 IJFAS Journal-2015-4-4/352-354/ 30 April, 2015
ISSN 2322-4134 ©2015 IJFAS

The effects of extrusion cooking on antinutritional factors, chemical propertiesand contaminating microorganisms of food

Nooshin Nikmaram[1*], Mohammad Hassan Kamani[2] and Rezvan Ghalavand[3]

1.Department of Food Science and Technology, Faculty of Agricultural Engineering, Islamic Azad University of Sabzevar, Iran
2.Young Researchers and Elite Club, Sabzevar Branch, Islamic Azad University, Sabzevar, Iran
3.MSc Student of Chemical Engineering, Islamic Azad University of Qazvin Science and Research, Department of Mechanical and Industrial Engineering, Qazvin, Iran

Corresponding author: Nooshin Nikmaram

ABSTRACT: Extrusion cooking technology is a rapid processing method involving high temperature and pressure that is used to prepare a variety of processed foods. HTST processes are preferred because of the retention of nutrients in the product. In addition to the usual benefits of these processes,extrusion offers the possibility of modifying the functional properties of food ingredients and/or of texturizing them. Like other processes for heat treatment of food, extrusion cooking may have both beneficial and undesirable effects on nutritional value. Beneficial effects include gelatinisation of starch, destruction of antinutritional factors, increased soluble dietary fibres, reduction of lipid oxidation and contaminating microorganisms and retains natural colours and flavours of foods. Despite these advantages, occurrence of Mailard reaction that leads to reduce the nutritional value of the protein and loss of heat-labile vitamins are the disadvantages of this process. Careful control of process parameters is essential to obtain a nutritionally balanced extruded product. The present paper reviews the beneficial effects of extrusion cooking technology as a process with high performance in the food industry.

***Keywords*:** Extrusion Cooking, Contaminating Microorganisms, AntinutritionalFactors, Functional Properties

INTRODUCTION

Extrusion is a thermal processing that involves the application of high heat, high pressure, and shear forces to an uncooked mass, such as cereal foods to obtain a wide range of products including snacks, ready to eat (RTE) cereals, confectioneries and crisp breads (Kim , 2006). The shear forces created by the rotating action of the screws, together with frictional, compressive and pressure forces provide the necessary environment for rapidly cooking and transforming the food into visco-elastic melt (Firibu , 2011). Extrusion cooking may be defined as a thermomechanical process in which heat transfer, mass transfer, pressure changes and shear are combined to produce effects such as cooking, sterilization, drying, melting, cooling, texturizing, conveying, puffing, mixing, kneading, conching (chocolate), freezing, forming etc. HTST processes are preferred because of the retention of nutrients in the product. In addition to the usual benefits of these processes, extrusion offers the possibility of modifying the functional properties of food ingredients and/or of texturizing them. Like other processes for heat treatment of food, extrusion cooking may have both beneficial and undesirable effects on nutritional value. Beneficial effects include gelatinisation of starch, destruction of antinutritional factors, increased soluble dietary fibres, reduction of lipid oxidation and contaminating microorganisms and retains natural colours and flavours of foods. In addition, the extrusion process denatures undesirable enzymes and sterilises the finished product (Bjiirck, 1983 ; Singh , 2007). Despite these advantages, occurrence of Mailard reaction that leads to reduce the nutritional value of the protein andloss of heat-labile vitamins are the disadvantages of this process. As a complex multivariate process, extrusion requires careful control if product quality is to bemaintained.Maintaining and increasing the nutritional quality of food during food processing is always a potentially important area for research (Singh , 2007). Therefore, the research on the effects of extrusion cooking on nutritional value of food, is an important and expanding aspect in extrusion technology. This review will focus on the beneficial effects of extrusion cooking technology as a process with high performance in the food industry.

Destruction of antinutritional factors

The oilseeds such as sesame, are fairly rich in protein but presence of anti-nutritional factors limits their use. Tannin, a phenolic derivative of flavone, which occurs as glycosides in the natural states and forms complexes with the available protein thereby affecting the digestibility is the main antinutritional factor present in sesame (Sesamumindicum) meal. A single screw cooking extruder was used to reduce tannin in sesame oilseed meal. The process variables selected for the study were: extruder screw speed 63.18–96.80 rev min-1; barrel temperature 63.18–96.80 °C and moisture content of raw oilseed meal 31.59–48.41% . Results showed that extrusion cooking technology is very effective in reducing the anti-nutritional factor, tannin from sesame meal (Mukhopadhyay and Bandyopadhyay., 2003).

Soybeans are used as a protein and energy resource for animals and humans. However, a number of antinutritional factors (ANFs) are present in soybeans. The trypsin inhibitors (TIs) are generally considered to be the main ANFs in soybeans. In order to improve the nutritional valueof soybeans, a heat treatment such as steaming or extrusioncooking is generally used (Vandenhout , 1998). The compression ratio of the screw was 1.15 and different die diameters were used to impose different shear rates on the soy. The heating elements on the extruder barrel were turned off to avoid excessive heating of the soy. This experiment was performed without a die head to avoid excessively high temperatures. Shear forces also cause physical deformation of proteins and therefore possibly have an additional denaturation effect on TIs. In order to investigate the influence of shear forces on TIA experimentally, extrusion cooking experiments were performed. Results from extrusion experiments showed that the residual TIA levels predicted by a heat inactivation model was approximately equal to the measured residual TIA in the extrudates. The inactivation of TIs during extrusion cooking is caused by heat inactivation and the deformation of the TI molecules is not a relevant factor in the inactivation of TI during extrusion cooking.

In another study that was conducted in 2000 by Singh et al, extrusion (300-r.p.m. screw speed, 27-kg h-1)feed rate, 5/32 inches die size and 93–97 °C outlet temperature) causes complete destruction of trypsin inhibitor activity in extruded blends of broken rice and wheat bran containing up to 20% wheat bran (Singh , 2000).

In another study, without preconditioning prior to extrusion cooking (Lorenz and Jansen., 1980), atemperature of 143 °C, at 15–30% moisture andresidence time of 0.5–2 min, produced a product ofmaximum protein efficiency ratio, despite the findingthat only 57% of trypsin inhibitors are destroyed. Anincrease in feed rate, with similar process conditions, has been reported to result in less destruction of trypsininhibitors (Asp and Bjorck., 1989), presumably because of reduced residence time. In conclusion, high extrusiontemperature, longer residence time and lower feedmoisture content are the key variables for the destructionof trypsin inhibitors.

Increased soluble dietary fibres

Traditionally, the non-digestible constituents of plant cell walls, which consist of polysaccharides (cellulose, hemi-cellulose, mucilage, oligosaccharides, pectins), lignin and associated substances, such as waxes, cutin and suberin, have been described as dietary fiber. Extrusion cooking increased the total dietary fibre of barley flours. The total dietary fibre increase in waxy barley was the result of an increase in soluble dietary fibre. For regular barley flour, the increase in both insoluble dietary fibre and soluble dietary fibre contributed to the increased total dietary fibre content (Vasanthan , 2002). In another study, extrusion was applied to oat bran and soluble dietary fiber (SDF) was extracted. Compared with the SDF from untreated oat bran, SDF from extruded oat bran was found to have more aggregates, higher gelatinization temperature, higher solubility, swelling capacity and solvent retention capacity, an increase in the apparent viscosity and consistency coefficient, a decrease in the flow behavior index, and an improvement in foam ability. The extrusion process improves the functional properties of SDF from oat bran (Zhang , 2011).

Reduction of lipid oxidation

Metal chelating activity, reducing power, DPPH assay and total antioxidant activity are most commonly used for the evaluation of antioxidant activities (Sharma , 2011). In a study conducted by P. Sharma et al in 2012, the metal chelating activity was increased significantly upon extrusion cooking in all the cultivars tested as compared to their corresponding control samples. The increase in the metal chelating activity may be as a consequence of the formation of novel compounds such as melanoidins during thermal processing. Mailard reaction products are found to have strong antioxidant properties comparable to those of commonly used food antioxidants (Liu , 2013). The overall antioxidant properties of the food products may remain the same or even be enhanced by the development of Mailard reaction products, even though the concentration of natural antioxidants like phenolic compounds were significantly reduced as a consequence of the thermal treatments (Nicoli , 1977). The extrusion cooking showed a significant decrease in reducing power (Sharma , 2012). A similar decrease in reducing power has been reported by other authors upon thermal processing in different cereals (Xu and Chang., 2010). In summary, Extrusion cooking exhibited a significant effect on the antioxidant properties of barley extrudates. Reducing power decreased upon extrusion while metal chelating activity and 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity increased significantly (Sharma , 2012).

Reduction of contaminating microorganisms

Destruction of microorganisms during extrusion cooking is advantageous in foods. There has been little research on the destruction of bacterial spores during extrusion cooking. In 1990, a study by T.A. Likimani and J.N. Sofos were performed. The results of their study indicated that extrusion processing at low barrel temperatures (i.e., 80/100 ° C) resulted in injury to spores of B. globigii. Extrusion at the higher barrel temperatures in zone 2 i.e. 120 and 140 °C resulted in extensive spore destruction (Likimani and Sofos., 1990). Two related studies examined destructionof liquid or freeze-dried spore suspensions of Bacillus stearothermophilus during extrusion processing of a starch-protein-sucrose biscuit mix with a twin screw extruder (Bouveresse., 1982). Their results indicated major reduction (105-108) in spore numbers during extrusion at high temperatures (150-180 ° C).

Conclusions

Extrusion cooking is one of the most important food processing technologies which has been used for the production of breakfast cereals, ready to eat snack foods, and other textured foods. Effects of extrusion cooking on nutritional quality are ambiguous.In conclusion, this technology because of its beneficial effects such as destruction of antinutritional factors, increased soluble dietary fibres, reduction of lipid oxidation and contaminating microorganisms (as described above) plays an important role in the production of a wide variety of foods and ingredients.

REFERENCES

Asp NG and Bjorck I. 1989. Nutritional properties of extruded foods. In: Extrusion Cooking (edited by C. Mercier, P. Linkoand J.M. Harper). pp. 399–434. St. Paul, MN: American Association of Cereal Chemists, Inc.

Bjiirckt ING. 1983. The Effects of Extrusion Cooking on Nutritional Value -A Literature Review. J.Food Eng. 2:1-308.

Bouveresse JA, Cerf O, Guilbert and Cheftel JC. 1982. Influence of extrusion-cooking on thethermal destruction of Bacillus stearothermophilus spores in a starch-protein-sucrose mix. Lebensm.Wissensch. Technol. 15: 135-138. http://prodinra.inra.fr/record/78747

Firibu K, Saalia RD and Phillip S. 2011. Degradation of aflatoxins by extrusion cooking: Effects on nutritional quality of extrudates. LWT - Food Sci and Technol. 44: 1496-1501.

Kim JH, Tanhehco EJ and Ng PKW. 2006. Effect of extrusion conditions on resistant starch formation from pastry wheat flour. Food Chem. 99: 718-723.

Likimani TA and Sofos JN. 1990. Bacterial spore injury during extrusion cooking of corn/soybean mixtures. Int J Food Microbiol. 11: 243-250.

Liu P, Huang M, Song S, Hayat K, Zhang X, Xia S and Jia C. 2010. Sensory characteristics and antioxidant activities of maillard reaction products from soy protein hydrolysates with different molecular weight distribution. Food and Bio Technol. 5: 1775-1789.

Lorenz K and Jansen GR. 1980. Nutrient stability of full-fat soy flour and corn-soy blends produced by low-cost extrusion. Cereal Foods World. 25: 161–172.

Mukhopadhyay N and Bandyopadhyay S. 2003. Extrusion cooking technology employed to reduce the anti-nutritional factor tannin in sesame (Sesamumindicum) meal. J Food Eng., 56: 201–202. DOI: 10.1016/S0260-8774(02)00250-9

Nicoli MC, Anese M, Parpinel M, Franceschi S and Lerici CR. 1997. Loss and/or formation of antioxidants during food processing and storage. Cancer Letter. 114: 71–74.

Sharma P, Gujral HS and Singh B. 2012. Antioxidant activity of barley as affected by extrusion cooking. Food Chem. 131: 1406–1413.

Sharma P, Gujral HS and Rosell CM. 2011. Effects of roasting on barley b-glucan, thermal, textural and pasting properties. J. Cereal Sci, 53: 25–30. DOI: 10.1016/j.jcs.2010.08.005

Singh S, GamlathS and Wakeling L. 2007. Nutritional aspects of food extrusion: a review. Int J Food Sci and Technol. 42: 916–929.

Singh, D, Chauhan GS, Suresh I and Tyagi SM. 2000. Nutritional quality of extruded snakes developed from composite of rice broken and wheat bran. International J Food Propert. 3, 421–431.

Vandenhout R, Jonkers J, Vanvliet T, Vanzuilichem DJ and Vantriet K. 1998. Influence of extrusion shear forces on the inactivation of trypsin inhibitors in soy flour. Trans IChemе. 76: 155-161.

Vasanthan T, Gaosong J, Yeung J and Li J. 2002. Dietary fiber profile of barley flour as affected by extrusion cooking. Food Chem. 77: 35–40.

Xu B and Chang SKC. 2008. Total phenolics, phenolic acids, isoflavones, and anthocyanins and antioxidant properties of yellow and black soybeans as affected by thermal processing. J. Agri and Food Chem. 56: 7165–7175.

Zhang M, Bai X and Zhang Z. 2011. Extrusion process improves the functionality of soluble dietary fiber in oat bran. J. Cereal Sci. 54: 98-103.