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A REVIEW OF THE EFFECTS OF EXTRUSION COOKING ON THE QUALITY OF EXTRUDED FOOD PRODUCTS

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ABSTRACT

The effect of extrusion cooking on the quality of extruded food was studied. Extrusion cooking is a process of cooking by forcing it (food material) to pass through a die. This is a high temperature short time (HTST) process. The major components of the extruder are the pre-conditioning bin, feeding system, the screw, barrel sleeves, and the cutting machine. The two types of extruders majorly used in food processing are; the single screw extruder and the twin-screw extruder. During extrusion, the composition of a raw material can be altered through leakage of oil and evaporation of volatile compounds at the die. Amylose and amylopectin are partially hydrolyzed to maltodextrins due to high temperature and shear. Proteins undergo denaturation and antinutritional factors are

Introduction:

Extrusion is the process of shaping items by forcing them through a die, while extrusion cooking is the process of cooking food by passing them through a die. Extrudates, on the other hand, are items that have been shaped by passing them through a die (Dic. of Food Sci., and Tech., 2005). Extrusion cooking is an important processing technique in the food industry as it is considered to be an efficient manufacturing process. Extrusion combines a number of unit operations, i.e. mixing, cooking, shearing, puffing, final shaping and drying, in one energy-efficient rapid

deactivated. Under extrusion temperatures, Lipids act as lubricants because they reduce the friction between particles in the mix and between the screws; fibres are affected because of the redistribution of insoluble fibres to soluble fibres. Increase temperatures from 140-1800C result in proportional decrease in disulphide linkages. Temperatures lower than 90oC hinder expansion and layer formation. Most vegetative organisms yeast and moulds are destroyed under extrusion condition. Products obtain with high temperature and short extrusion normally present a porous open structure referred to as" crunchy" texture. Also, to obtain a nutritionally balanced extruded product, careful control of process parameters is essential.

Key words: Extrusion; Cooking; Extruder; Screw; Die; Quality

Continuous process and can be used to produce a wide variety of starchy foods, including snacks, ready-to-eat (RTE) cereals, confectioneries and extruded crisp loaves of bread (Harper, 1989; Suknark *et al.,* 1997). This process of high-temperature short-time (HTST) extrusion cause gelatinization of starch, denaturation of protein, modification of lipids and inactivation of enzymes, microbes and many antinutritional factors (Bhattacharya & Prakash, 1984).

Extrusion cooking was first introduced in food and feed processing in the late 1950s. Since then, the systems involved have grown in popularity, efficiency and flexibility. In the last decade, the development of extruders has evolved to yield sophisticated products, new flavour generation, encapsulation and sterilization. Thermoplastic extrusion is considered an HTST (High-temperature- short- time) process in the food industry, and it permits, with little or no modification of the basic equipment and appropriate process control, the production of a great variety of food and feed products (Camire *et al.,* 1990; Chang *et al.,* 2001; El-Dash, 1981). This technique has been widely used with raw materials such as corn, wheat, rice and, especially in recent years, soybeans (Chang *et al.,* 2001; Kadan and Pepperman, 2002). In recent years, extrusion has become one of the fastest-growing food processing operations. Due to the reduction of microbial loads, and the prevention of endogenous enzymes, extrusion technology improves the safety and quality of intermediate and final products. Besides, it can be used in the production of a wide range of products, such as snack foods, baby foods, breakfast cereals or pasta. Enrichment of extruded snacks with nutritionally valuable ingredients is increasingly practiced by many studies, wherein the leading is the addition of protein and fibre-rich ingredients, like legumes or whey protein, while the addition of fruit and vegetables has been studied to a lesser extent. Unfortunately, the production of nutritionally fortified snack products with acceptable physical properties, which are crucial for their actual acceptance, is not easy. The addition of high-fibre, high-protein alternate ingredients to starch significantly affect the texture, expansion and overall acceptability of extruded snacks.

Extruders

Thermoplastic extrusion in food processing is facilitated by the dynamism of extruders, which can be divided into two types: single-screw and twin-screw extruders (Riaz, 2000). The selection of each of these items will rely on the raw material used and the final product desired (Riaz, 2000). In the extrusion process, the dry or pre-conditioned material is introduced into the extruder through a screw feeder, reaching the feeding zone. The screw in this zone presents greater depth and pitch of the worm flight and has as its main function the transportation and homogenizing of the raw material. The material is conducted from the feeding zone to the compression zone. In the compression zone, there is a reduction in screw depth and pitch, with a consequent increase in shear rate, temperature (110 - 180ºC) and pressure (20 – 30 atm. In the subsequent high-pressure zone, the screw has its depth and pitch reduced even more, resulting in higher shear and maximum heat generation. The material, under high pressure, is expelled through the die and, in contact with ambient pressure, expands to its final format and cools rapidly through water flash-off (Fellow, 2000). In material that is not previously conditioned, water is added, in liquid or vapour form, during the process (El-Dash, 1981). The product that leaves the extruder is generally submitted to a

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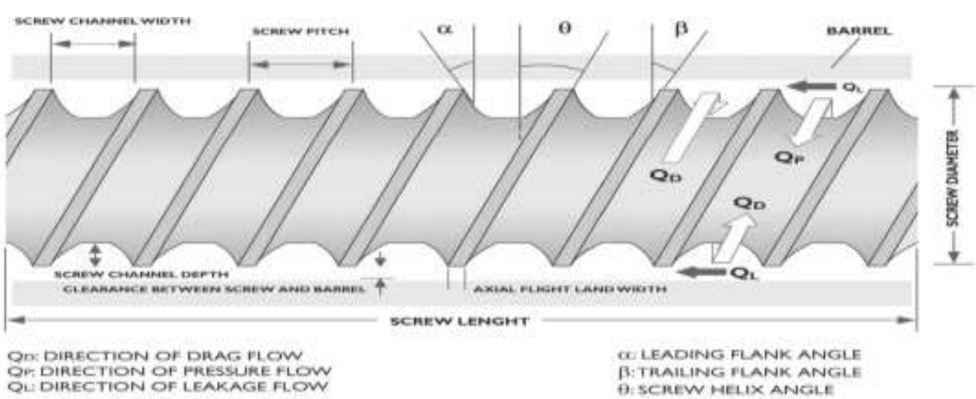
drying process, reaching values close to 3% moisture content, as is the case of extruded snacks (Riaz, 2000).
Most raw materials used in food extrusion are solid. The feeding system is normally composed of a holding bin where the material is loaded, and the discharge of the material can occur through a vertical feeding screw, a horizontal feeding screw, a horizontal vibrating trough system, a disk feeder or a volumetric belt feeder. When liquids are added, they can be dosed using a rotameter, orifice and Venturi meters, positive displacement meter, magnetic flow meter or metering pumps (Chessari and Sellahewa, 2000).

Screw

The screw of the extruder is certainly is most important component, not only to determine the cooking degree, gelatinization and dextrinization of starch and protein denaturation but also to ensure final product quality. Screws can be mono-piece (composed of a unique piece) or multi-piece (composed of various elements) (El-Dash, 1981). Screw elements can vary in number and shape, and each segment is designed for a specific purpose. Some elements only convey raw or pre-conditioned material into the extruder barrel, while other segments compress and degas the feedstock. Others must promote kneading, backflow and shear. The main characteristics of screw design include: (i) screw length; (ii) screw diameter; (iii) screw channel depth; (iv) screw channel width; (v) axial flight land width; (vi) clearance between screw and barrel; (vii) screw helix angle; (viii) leading flank angle; (ix) trailing flank angle; (x) screw pitch; (xi) direction of drag flow; (xii) direction of pressure flow and (xiii) direction of leakage flow (Figure 2)



2. Main characteristics of screw design

Fig. 1 Source; Leszek Moscick

Barrel or sleeves

The barrel is divided into feeding, kneading and high-pressure zones. The sleeves surrounding the screw can be solid, but they are often jacketed to permit the circulating of steam or superheated oil for heating or water or air for cooling, thus enabling the precise adjustment of the temperature in the various zones of the extruder. And most sleeves are equipped with pressure and temperature sensing and temperature control mechanisms as well (El-Dash, 1981). In twin-screw extruders, the sleeves are usually smooth but can be constructed with longitudinal or helical grooves (Huber, 2000). In single-screw extruders, the sleeves are usually fluted on the inside, with 2.5 die. The die presents two main functions: to give shape to the final product and promote resistance to material flow within the extruder, permitting an increase in internal pressure. The die can present various designs and a number of orifices (El-Dash, 1981).

Cutting mechanism.

The cutting mechanism must permit obtaining final products with uniform size. Product size is determined by the rotation speed of the cutting blades. This mechanism can be horizontal or vertical (El-Dash, 1981).

Types of extruders

Two types of extruders are used for food production: (i) single-screw extruders and (ii) twin-screw extruders. Single-screw extruders are the most common extruders used in the food industry. Twin-screw extruders are used for high-moisture extrusion, products that include higher quantities of components such as fibres, fats, etc. and more sophisticated products.

Single-Screw Extruders.

Single-screw extruders are the most common extruders applied in the food industry. The classification of single-screw extruders can be defined based on process or equipment parameters such as conditioning moisture content (dry or wet), solid or segmented screw, a desired degree of shear and heat source. For purposes, the main classification used considers the degree of shear and the heat source (Riaz, 2000). Regarding screw configuration, there are screws made up of only one piece or screws of multiple pieces. Single element screws may present different configurations: (i) screw with constant depth and flight-straight -; (ii) screw with constant flight and variable depth-tapered - (conical from the feeding extremity to the die extremity); (iii) screw with a reduction in depth just after feeding, becoming constant at the end – tapered-straight and (iv) screw with flight openings – interrupted. Single-screw extruders can be classified into four different types based on the degree of shear, as follows: Cold-forming extruders operate with moderate conditioning moisture contents (30 - 40%), low shear and smooth internal barrel surface, deep flight and low screw speed. These are not used for thermoplastic extrusion. They are used to form compact products such as pasta, cookies, pastry dough's, processed meats and certain candies (Riaz, 2000). High-pressure forming extruders – operate with low shear, grooved barrel and compression screw. They are used to produce pre-gelatinized flours and pellets (for post-expansion by hot air or frying) (Riaz, 2000). The latter are considered 3rd generation products. Usually involve external heating (steam jacket or electric resistance) to improve cooking with the objective of pasteurization, enzymatic inactivation, protein denaturation and/or starch gelatinization.

Twin-Screw extruders

Twin-screw extruders are composed of two axes that rotate inside a single barrel; usually, the internal surface of the barrel of twin-screw extruders is smooth. Depending on the position of the screws and their direction of rotation, four different types of configurations are possible: (i) co-rotating intermeshing screws; (ii) co-rotating non-intermeshing screws; (iii) counter-rotating intermeshing screws; and (iv) counter-rotating non-intermeshing screws. Conical intermeshing extruders also exist. Although intermeshing screws result in greater residence time of the material in the extruder, non-intermeshing screws cause greater degrees of shear, especially if they rotate in opposite directions. However, this type of extruder is little used in the food industry, even though they present more efficient displacement properties (El-Dash, 1981). The intermeshing configuration is more effective, as the two screws function as a positive pump, increasing the drag flow and reducing the slipping of material in the extruder. Non-intermeshing screws provide higher shear than intermeshing screws because of the open channel between them.

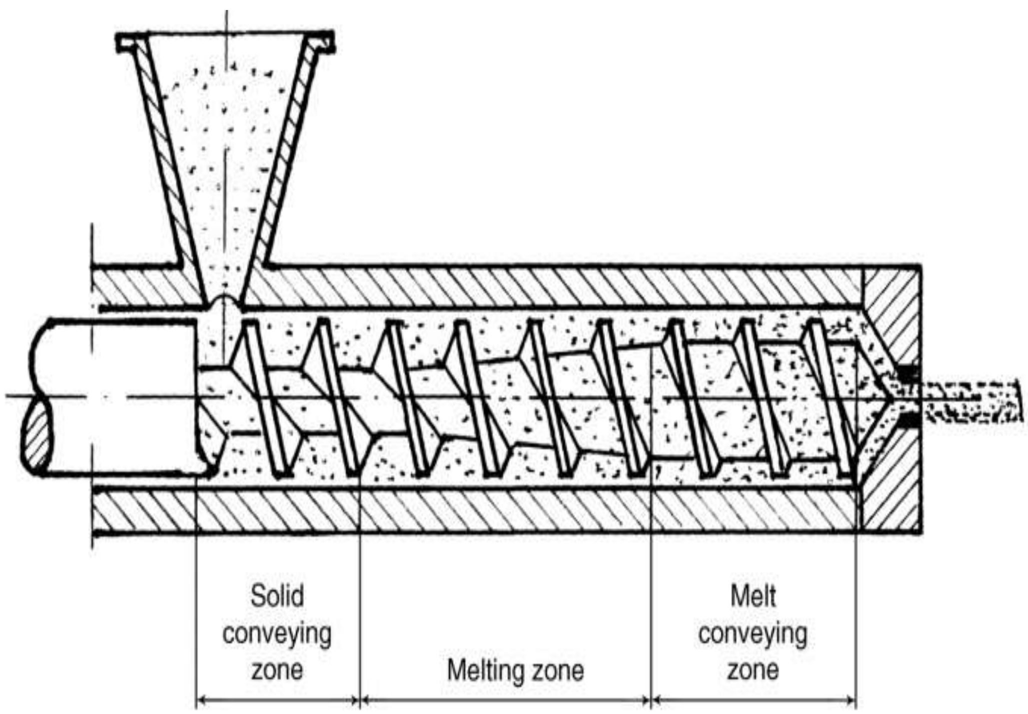


Fig. 2 A typical plasticating extruder: Source; Leszek Moscick

The composition of raw materials can be altered by physical losses including leakage of oil and evaporation of water and volatile compounds at the die. Since most chemical reactions occur in the high-pressure zone of the barrel, thermally labile compounds such as flavours and vitamins may be injected immediately before the die to minimize exposure to heat and shear (Riaz,

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2000). The structure of an extruded product is created by forming a fluid melt from a polymer and blowing bubbles of water vapour into the fluid to form a foam. The bubbles rapidly expand as the superheated water is released very quickly at atmospheric pressure. The structure of an extruded product is created by forming a fluid melt from a polymer and blowing bubbles of water vapour into the fluid to form a foam. The bubbles rapidly expand as the superheated water is released very quickly at atmospheric pressure.

In the extruded structure, the fluid melt of the polymers forms the cell walls of the gas bubbles. After gas expansion, the rapid drop in temperature caused by water evaporation and the rapid rise in viscosity due to moisture loss solidifies the cell structure. The rapid increase in viscosity is followed by the formation of a glassy state. Starch polymers are very good at this function and also expand well. Structure-forming polymers must have a minimum molecular weight sufficient to give enough fluid viscosity to prevent or control shrinkages of an extrudate after it reaches its maximum expansion (Guy, 2001).

Starch

The major difference between extrusion processing and conventional food processing is that in the former starch, gelatinization occurs at a much lower moisture content (12-22%). Starch is contained in a large variety of plant crops, such as cereals (50-80% dry basis starch), legumes (25-50% dry basis), and tubers (60-95% dry basis) (Colonna *et al.,* 1998. The highly-branched structure of amylopectin is more prone to shear, but both amylose and amylopectin molecules may decrease in weight (Collona *et al.,* 1998). Amylose is a basically linear polymer with linear -1-4 glucosidic bonds, a polymerization degree of 600 to 6000 glucose units and a molecular weight of 105-106 Da. Thermoplastic extrusion, depending on process conditions and raw material composition, causes swelling and rupture of the starch granule, completely or partially destroying the organized granule structure, reducing viscosity and releasing amylose and amylopectin (Camire *et al.,* 1990; El-

Dash *et al.,* 1983). During thermoplastic extrusion, amylose and amylopectin are partially hydrolyzed to maltodextrins due to the high temperatures and shear inside the extruder (Cheftel, 1986; El-Dash *et al.,* 1983). An important consequence of starch degradation is the reduction in expansion. Highly expanded products may crumble easily due to thin cell walls, while dense products are often hard (Riaz, 2000). Therefore, if high expansion is required in a low-moisture product, finely milled forms of harder endosperm types will give excellent results. If the product requires low to medium expansion, some of the hard material may be replaced by soft flour; and for low expansion in a dense product such as breading crumb, soft flour may be used (Guy, 2001). Inside the extruder, starch goes through several stages. First, the initial moisture content is very important to define the desired product type. Once inside the extruder and at relatively high temperatures, the starch granules melt and become soft, besides changing their structure that is compressed to a flattened form (Guy, 2001). The application of heat, the action of shear on the starch granule and water content destroy the organized molecular structure, also resulting in molecular hydrolysis of the material (Mercier et al., 1998). The starch polymers are then dispersed and degraded to form a continuous fluid melt. The fluid polymer continuum retains water vapour bubbles and stretches during extrudate expansion until the rupture of the cell structure. According to Colonna *et al.,* (1998), maximum expansion degree is closely related to starch content. Maximum expansion is obtained with pure starches (an increase of 500% in product diameter), followed by whole grains (400%) and with lower expansions for seeds or germ (150-200%); the starch content of these products is 100, 65-78, 40-50 and 0-10, respectively. The minimum starch content for expansion is 60-70% (Riaz, 2000).

Proteins

Proteins are biopolymers with a great number of chemical groups when compared to polysaccharides and are, therefore, more reactive (Mitchel and Areas, 1992) and undergo many changes during the extrusion process, with the most important being denaturation (Camire, 2000). Proteins are manufactured from a number of amino acids and have a wide range of physical sizes and forms in native raw materials. Proteins, in general, are classified, with respect to their solubility, in albumins, globulins, prolamines and glutelins with solubility in water, saline solution, alcohol solution and acid or alkaline solutions, respectively (Pereda *et al.,* 2005). During extrusion, disulfide bonds are broken and may re-form. Electrostatic and hydrophobic interactions favour the formation of insoluble aggregates. High molecular weight proteins can dissociate into smaller subunits (Guy, 2001). Enzymes, also proteins, lose their activity after being submitted to the extrusion process due to high temperatures and shear. Texturization processes by extrusion can be used to obtain products that imitate the texture, taste, and appearance of meat or seafood with high nutritional value (Cheftel *et al.,* 1992). The use of raw materials with high protein contents in extrusion began around the 1970s, with the use of soy for the manufacture of texturized soy products and meat analogues (Ledward and Mitchell, 1988; Mitchell and Areas, 1992). In extrusion, the proteins that have been found to form a continuous structure are globular proteins from oilseeds such as soybeans, sunflower seeds, common beans, peas and cottonseed and from cereals, especially wheat gluten proteins (Riaz, 2000 and Strahm, 2006). The extrusion process physically converts protein bodies into a homogeneous matrix, while chemically, the process recombines storage proteins in some way into structured fibres (Stanley, 1998. In dry extrusion, when the conditioned material passes through the die at a high temperature, the water in the material is changed into superheated steam, which expands the extrudate immediately. Texturization occurs between the molecules as they flow in the streamlines to form laminar cross-linked products. Evaporation of water in the mass creates gas bubbles that form alveolar structures held in place by cross-linking in the protein layers (Guy, 2001). Denaturation during the extrusion process of proteins results in a reduction of protein solubility, favours digestibility and inactivates antinutritional factors (such as antitrypsin factor, lectins, etc.).

During extrusion, protein structures are disrupted and altered under high shear, pressure, and temperature (Harper, 1984). In the extrusion of proteins, disulfide bonds are cleaved and undergo reorganization and polymerization. Thermal plasticization of the protein mix at high moisture contents (60%) is possible at relatively high extrusion temperatures (>150°C). Protein reactions, including both non-covalent and disulfide bonds, form upon cooling. Protein–protein interactions may be enhanced by decreased temperature and by macromolecular alignment. Therefore, hydrophobic, cation–mediated electrostatic interactions and covalent bonds also contribute to the stabilization of the three-dimensional network formed during extrusion (Areas, 1992). Also, during the extrusion process, high temperatures are normally used, and these favour the Maillard reaction. Reducing sugars can be produced during the process, and they can react with the free amine groups of lysine or other amino acids (Camire, 2000).

Lipids

Fats and oils can be described as lipids. Lipids have a powerful influence on extrusion cooking processes by acting as lubricants because they reduce the friction between particles in the mix and between the screw and barrel surfaces, and the fluid melt (Guy, 2001). In the extruder, fats and oils become liquid at temperatures > 40°C, are mixed with the other materials, and are rapidly dispersed as fine oil droplets. The presence of lipids in quantities lower than 3% does not affect expansion properties, however, in amounts above 5%, reduction in expansion rate is considerable (Harper, 1994). Collona *et al*. (1998) suggest that the increase in lipid content can be corrected through the reduction in conditioning moisture content, so as not to affect the expansion index of second generation products (directly expanded snacks). Moreover, in wet protein extrusion, the presence of lipids does not support protein fibre formation since the lubricating effect of lipids decreases the shear effects and particle alignment (Akdogan, 1999).

Fibres

The term "fibres" covers a great variety of substances with different physical, chemical and physiological properties. Dietary fibre consists of fractions of vegetable cells, polysaccharides, lignin, and associated substances, which are resistant to hydrolysis by enzymes present in the digestive system of humans; Research has shown that cooking fibres by extrusion can produce changes in their structural characteristics and physicochemical properties, with the main effect being a redistribution of insoluble fibre to soluble fibre (Camire *et al.,* 1990; Guillon *et al.,* 1992;

Larrea *et al.,* 2005). This effect would be the result of the rupture of covalent and non-covalent bonds between carbohydrates and proteins associated with the fibre, resulting in smaller molecular fragments that would be more soluble (Fornal *et al.,* 1987; Wang *et al.,* 1993). Various researchers have reported a reduction in expansion index (EI) when dietary fibre is added to the formulation (Hsieh *et al.,* 1989; Ilo *et al.,* 1999; Vernaza *et al.,* 2009). The reduction in the expansion index due to fibre addition can be explained through different mechanisms: (i) Fibrous materials found in the formulation of extruded products include materials composed of hemicellulose, cellulose and lignin. In normal extrusion conditions, these materials tend to remain firm and stable during processing without size reduction. The physical presence of fibres in air cell walls reduces the expansion potential of the starchy film (Guy, 2001); larger particles, such as bran, tend to rupture the air cell walls of the extruded product, causing a reduction in expansion index (Riaz, 2000); (ii) according to Colonna *et al.* (1998), a maximum degree of expansion closely related to starch content, with maximum expansion being obtained for pure starches. Formulations can be enriched by plasticizing substances or by non-plasticizing substances that retard expansion by diluting starch, as is the case of fibre (Colonna *et al.,* 1998)

Moisture and Temperature.

Water acts as a plasticizer for the starchy material that displaces itself within the extruder, reducing viscosity and mechanical energy, producing higher-density products and inhibiting bubble growth. Studies carried out with corn grits demonstrated that expansion is inversely proportional to the moisture content of the material being extruded (Chinnaswamy, 1993; Colonna *et al.,* 1998). With higher moisture, starch gelatinization is reduced, and bubble growth is retarded, resulting in denser and less crunchy final products (Ding *et al.,* 2005). Inside the extruder, the product that contains molten starch in its composition, when leaving the extruder, has part of its water rapidly evaporated. This water loss is 3 to 5% and contributes to cooling the product. Subsequent cooling occurs more slowly due to the low thermal conductivity of the extrudate. Also, when emerging from the die, the extrudate undergoes an abrupt pressure fall that also contributes to its expansion (Colonna *et al.,* 1998). The expanded final product presents air cells that are formed due to superheated water vapour pressure. As the temperature of the extrudate is reduced below its glass transition temperature, it solidifies and maintains its expanded form (Riaz, 2000). In high moisture extrudates, expansion occurs when the product exits the die, but the structure collapses before the necessary cooling, resulting in a dense and hard product (Harper, 1994). Another important parameter for extrudate expansion is process temperature. Products do not expand if the temperature does not reach 100°C. The expansion increases with the increase in temperature when the moisture content of the material is close to 20% due to lower viscosity, permitting a more rapid expansion of the molten mass or due to an increase in water vapour pressure. At low extrusion temperatures, expansion is reduced because starch is not completely molten. Radial expansion degree is proportional to temperature up to a certain value, decreasing at much higher temperatures. The reduction of expansion at very high temperatures is attributed to an increase in dextrinization, weakening starch structure (Colonna *et al.,* 1998. In high moisture extrusion, the properties of the protein extrudates are strongly influenced by extruder conditions. Melt temperature is a critical factor in protein cross-linking reactions.

Effects of Extrusion on Product Quality

Extrusion cooking is a process widely used in the food industry to manufacture snacks, crackers and expanded cereals. The degree of expansion in extruded products is an important characteristic which relates to the texture and sensory properties of extrudates (Lue *et al.,* 1990). Extrusion cooking has an important influence on product quality, emphasizing features like expansion, texture, shelf-life, colour and flavour. For extrusion cooking, changes in ingredients such as sugar, salt and fibre, or processing parameters like screw design or speed and temperature can affect extrusion system variables and product characteristics such as texture, structure, expansion and sensory attributes (Mendonça *et al.,* 2000). Products obtained with high temperatures and short extrusion process times normally present a porous, open structure, what confers to them a "crunchy" texture (Barrett, 2003). Expansion occurs in both radial and axial directions, at different degrees, depending on the viscoelastic properties of the melt. Vaporization of moisture and cooling of the extrudate serve to bring the product from a molten to a rubbery state; and further drying is usually used to produce the brittle, fracturable texture typical of these products (Barrett, 2003). Colour in extruded products is influenced by temperature, raw material composition, residence time, pressure and shear force (Guy, 2001; Mercier *et al.,* 2001

Classification of extrusion products

- Directly expanded types-; breakfast cereals and corn curls
- Unexpanded products; - pasta of intermediate moisture (40%)
- Texturized products: - meat analogues using plant proteins, fish paste
- Confectionaries: -chewing gums, liquorice and toffee.

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Other products include processed cheese and cheese analogues-Low moisture and temperature of 100 sec. residence time. Among baked foods: - Breads (crotons, bread sticks and flat breads, ready to eat snacks, pre- made cookie dough. Other products of extrusion include baby foods among baked foods: macaroni, fig newtons, jelly beans, French fries and some modify starch.

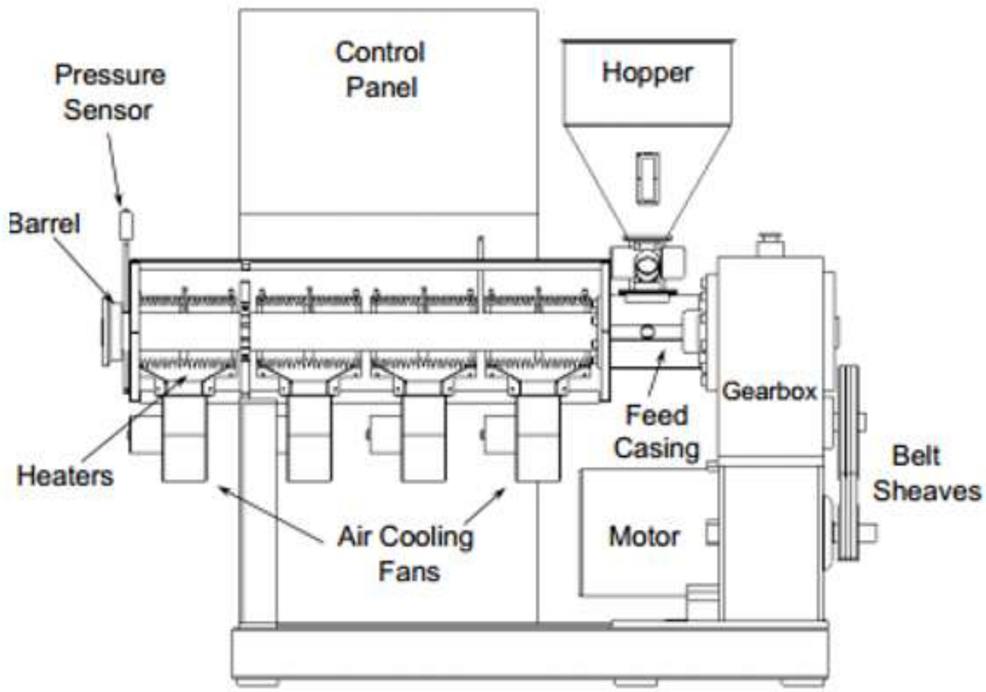

Fig. 3 Different component of an extruder. Source: William Kramer, American Khune

Recent trends in food extrusion has been devoted to;

1. Create porous powder with better rehydration time
2. Reduce conversion cost (energy and capital)
3. Overcome some limitation of spray drying and drum drying
4. Process complete formulation without further mixing
5. Leverage in-built extrusion flexibility

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The Effects of Extrusion on Nutritional Quality

The effects of extrusion cooking on nutritional quality are ambiguous. Benefits include the destruction of anti-nutritional factors, gelatinization of starch, increased soluble dietary fibre and reduction of lipid oxidation. On the other hand, Starch digestibility is largely dependent on complete gelatinization. High starch digestibility is essential for specialized nutritional foods such as infant and weaning foods. The nutritional value of vegetable proteins is generally enhanced by mild extrusion cooking conditions due to the increase in digestibility (Asp and Björck, 1989; Arêas, 1992), probably a result of protein denaturation and the inactivation of enzyme inhibitors present in raw materials, by the exposure of new active sites for enzyme attack (Colonna *et al.,* 1989). Mild extrusion conditions (high moisture content, low residence time, low temperature) improve nutritional quality, while high extrusion temperatures (higher than 200°C), low moisture contents (lower than 15%) and/or improper formulation (e.g. presence of high reactive sugars) can affect nutritional quality adversely. Also, to obtain a nutritionally balanced extruded product, careful control of process parameters is essential (Singh *et al.,* 2007).

Conclusion

Extrusion cooking which is the process of cooking food by forcing the food material to pass through a die is a high-temperature short time (HTST) process. It is usually carried out using extruders. The major components of the extruders are the pre-conditioning bin, the feeding system, the screw, the barrel sleeves and the cutting machine. Extruders permit the production of many foods of nutritional importance. The ability of extruders to blend diverse ingredients in novel foods can be exploited in the development of functional foods. Traditional snacks or breakfast cereals can be enhanced by the addition of extra fibres or whole grain flour as ingredients during extrusion, transformed into palatable cereal-based products that also promote beneficial physiological effects. Functional ingredients such as soy and botanicals (fruit, vegetables, cereals, etc.) that present high amounts of

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bioactive compounds can be used in the extrusion process to develop novel products with phytochemicals and other healthful food components. Improved chemical and immunoassay methods will undoubtedly facilitate research in this area. The market expects new food products: fancy in shape, taste and raw material composition as well as attractive from an economic point of view. Extrusion-cooking technology can meet these expectations; however, one needs specialized knowledge.

Recommendation

In the future science and technology of extrusion, field scientists and engineers should focus on the relationship between composition changes and product quality, evaluating and enhancing nutritional, sensory and functional properties of extruded food.

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A STUDY OF THE IMPACT OF BACTERIAL VAGINOSIS INFECTION ON THE SOCIAL AND EDUCATIONAL LIFE OF PREGNANT WOMEN IN DELTA NORTH SENATORIAL DISTRICT

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ABSTRACT

Bacterial vaginosis (BV) is one of the most prevalent vaginal infections among women in Africa. It is a polymicrobial syndrome resulting in a decreased concentration of *Lactobacilli* and an increase in pathogenic bacteria, mainly anaerobes in the vagina. This study investigated the impact of BV on the Social and Educational Life of Pregnant Women in Delta North Senatorial District and suggested possible interventions to avoid BV-associated complications in pregnancy. The women were studied at the different stages of their pregnancy. One thousand five hundred (1500) high vaginal samples were collected from pregnant women and examine for BV using Nugent criteria. A

Introduction:

Bacterial Vaginosis (BV) is a polymicrobial syndrome resulting in a decreased concentration of *Lactobacilli* and an increase in pathogenic bacteria, mainly anaerobes in the vagina (Kenyon *et al.,* 2013). While pregnancy (gravidity) is the time during which one or more offspring develops inside a woman (Awoniyi *et al.,* 2015). The vagina is a unique environment for bacterial colonization (*Zhou et al., 2004).* It is subject to dramatic changes over the course of a lifetime (Africa, 2014), induced by developmental and

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structured questionnaire was used to gather information on socio demographic characteristics, medical and treatment history of patients after informed consent by the patients. Statistical analysis was based on cross-tabulation of variables and association between different variables were determined using Chi-square. Two hundred and nineteen (14.6%) were at their first trimester, five hundred and eighty-five (39.0%) were at their second trimester and six hundred and nighty-six (46.4%) were at their third trimester. Eight hundred and eighty-nine pregnant women (59.27%) were BV positive. Of the 889 positive patients, 640 (72%) were symptomatic and 249 (28%) were asymptomatic. Bacterial vaginosis was more prevalent among pregnant women in their second trimester (64.9%) and age group 21 to 30 years (68.8%). Educational qualifications had no significant association with BV among pregnant women (P>0.05). All the patients using antibiotics were BV negative. Consequently, high rate of BV among pregnant women attending Anti-natal clinics Delta North Senatorial District demands adequate attention to prevent BV-associated complications in pregnancy and also reduce referrals that may ensue from such complications. Pregnant women attending antenatal clinic in various hospitals in Delta North Senatorial District should be screened routinely for BV to avoid infection sequelae. Adequate laboratory facilities should be provided and laboratory personnel should be trained in the use of Nugent criteria for effective diagnosis of BV since the method is convenient and reliable. This will aid prompt and adequate diagnosis of BV in pregnancy. Effort should be made to discourage promiscuity among sexually-active age group and self diagnosis/medication among pregnant women.

Keywords: Bacterial vaginosis, Gynaecological problem, Pregnancy, Complications, Anti-natal, Treatment

hormonal changes (*Witkin et al*., 2007;Jack, 2023). It is the portal of entry for numerous sexually and non-sexually transmitted diseases. A number of bacterial and non-bacterial infections exist that affect the