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Heat Applications in Feed and Food Processing

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Abstract

There are many heat treatment applications, each different in the heat source, construction of the device or process parameters applied, and their efficiency depends on a range of factors. There are many possible combinations, and types of heat treatments in animal feed processing, and most frequently used are pelleting, extrusion, cooking, steam flaking, conditioning, expanding, roasting, popping, toasting and micronisation. Thermal processing increase feed intake and digestibility, improve feed conversion, carcass quality and/or yield grade, reduce in feed waste, transportation, storage costs and labor costs. The heat acts in the same manner as natural digestive enzymes to break down the complex carbohydrate bonds of the grain starch (i.e. gelatinize), which increases the availability of nutrients such as glucose in the small intestine. However, the heat technology used can destroy germs contaminating the oilseeds and remove certain anti-nutritional (antitrypsin factors in whole soya beans, rapeseed glucosinolates) and enzymatic factors (lipases and lipoxidases involved in the oxidation of oils for example).

Keywords: Thermal processing; Heat applications; Feed and food processing.

Introduction

Feed processing techniques have changed over time and now require greater precision. Today, livestock production must meet new demands from consumers, especially where the nutritional value of feed is concerned. Feed may look different varying from pellets to flaked grains and extruded nuggets depending on the processing method, but is this for visual reasons or are there nutritional purposes[1,2]. All questions will be answered in this short article, highlighting the three main processing techniques, we use here at the hygiene animal only feed mill, its differences and various benefits. Goals of heat treatment are increased feed intake and digestibility, improved feed conversion or efficiency, improved carcass quality and yield grade, reduction in feed waste, lower transportation and storage costs, reduced labor costs due to increasedmechanization.

The heat treatment under certain conditions of temperature, time and moisture, allows the elimination of salmonella in food. Moreover, the improving of the flow reduces the possibility of bacterial growth by preventing the retention and accumulation of the product (Fig. 1).

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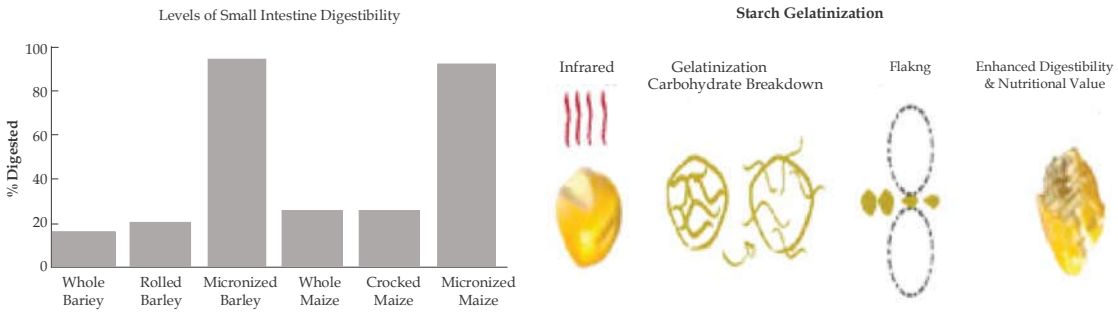

Fig. 1: levels small intestine digestibility and starch gelatinization in heat treatment[3]

Feed ingredients and animal feed are frequently contaminated with foodborne bacterial pathogens like campylobacter species and non-typhi serotypes of salmonella enterica, Toxin–producing strains of escherichia coli, and yersiniaenterocolitica.[4–7] Thermal processing of feed can improve the stability and hygiene of feed, might alter the chemical and physical characteristics of its constitutive ingredients, can improve the nutritional value of animal feeds. So thermal processing might have beneficial effects on the gastrointestinal function and the microbial status of gastrointestinal tract.[8,9]

In order to eliminate, inactivate or reduce the anti- nutrients and pathogens in the animal feed ingredients and feed, a simple heat processing method have been used for decades. This simple heat processing method could be dry or moist, and based on the purposes of the usage and its technical characteristics can be classified as cooking, roasting, toasting, autoclaving and long term conditioning. Grains are process or treat by mechanical, thermal or thermo-mechanical methods into dry or wet. Factors affecting starch digestion include the level of intake, the actual ingredient (e.g. oats, barley, maize) and how the grain was processed. The processing of grains is applied to maximize the small intestine digestibility of the grain in order to reduce the risk of digestible disorders whilst increasing the nutritional value of the feed.

Types of Heat Applications

Thermal processing are used to improve the nutritional, hygienic, physical and chemical of animal feed properties. The two most important factors on all heat treatments are temperature and time of their application, although the impacts such as humidity, pressure. Most of heat treatments that are used are hydro thermals because even when moisture is not introduced from the outside moisture released from the material to be treated participates in heat application. Another effect of factorsis mechanical and it can be located in or out of the heat processing device. The mechanical treatment causes an additional effect on animal feeds. Starch granules undergo gelatinization and melting by the action of heat and moisture onhydrogen binding among tightly packed polysaccharide chains in the granule structure. Under conditions of excess water, hydrogen bindings in the less ordered amorphous regions of the granule are disrupted first, allowing water to associate with free hydroxyl-groups. Swelling is the result and further opening of the granule structure to the action occurs. Thus, there are many possible combinations, and types of heat applications in animal feed processing. Most commonly used thermal methods in the world are pelleting, expanding, extrusion, steam flaking, conditioning, cooking, micronisation, roasting, popping, toasting e.g.).[10,11]

Pelleting

Pellet units are one of the technological processes in feed mill and it can be defined as a collection of single ingredients or combinations by pressing and making it through openings in the die and cutting off of the pressed feed forms to the preferred length. It is typical to condition animal feed before pelleting. In this technique, the temperature of the pellet feeds usually increases to about 70°C–80°C before inflowing the press matrix for pelleting. Supplementary heating is reached during the pelleting process by the use of mechanical act of power, two or more rollers, with the same or different diameters, which rotate sideways a horizontal die, or inside the circle die. Rollers pass over the mash feed and compress it. The pressure continuously increases from the point where the rollers touch the mash feed and start pushing it towards the hole on the die to the point where the pressure is big enough to insert a small disc of feed hooked on the opening of the die canal and unite which was already in it. The pressure extents its extreme at the point where the gap among the roller and the die is the least, so

that a part of the shaped pellet is hard-pressed out on the other sideways of the die opening. Forces can be enhanced by growing the pressure, which causes the rise in heat of the product as well.The selection of pelletizing press features, grinding, conditioning is possible to effect the saving of friction, or an rise of adhesion matrix that bind the particles in the pelleting procedure, and thus the quality of shaped pellets that are expressed as % of friction or hardness and consumption of press power essential to accomplish the vital pressure through the fitted power of electric engine.[4,13] The increased humidity and temperature are removed in the cooling procedureof vertical or horizontal coolers. It is essential to decrease these sizes into the storing stability. The developments of this pellet process tend towards advanced automation, which should allow continuous control and alteration of progression variables, its higher productivity, and better pellet feeds quality (chemical, nutritional, microbiological, physical e.g.).

Expansion

The extrusion and expansion methods are based on the similar principles. Fundamentally, the expanders are very like to extruders, and they vary in the method of forming of the last product and force of treatment.[14,15] Expanders are generally used as mechanical conditioners for feed process which are difficult to pelleting of feed, to improve the digestibility of cellulose and protein in order to make feed hijyenisation.[17]

Extrusion

The extrusion process begins with the grinding and mixing of ingredients such as grains, oil and fibresources. Extrusion is the procedure in which the feedstuff and compound feed is hard-pressed through the barrel by means of screws of altered formations and pressed through the die at the end of extrusion barrel. The basic model of extrusion procedure is high temperature, short time, whereby the high temperature is a direct outcome of dry extrusion or preconditioning and wet extrusion (steam addition), or a mixture of both. The moisture of treated feed and food in dry extrusion is about 30% while it is up to 80% in wet extrusion. Extruders can be sterilization as those with one or two screws, and the latter may have screws that are rotating in the similar or in contrary directions, and screws can also narrow in a conical form. Extrusion is the procedure in which the feed and food are exposed to high heats (up to 200 °C) for 1–2 minutes or more accurately the feed and food temperature risessuddenly within the last 15 to 20 seconds up to the optimal one to do the preferred effects. Thus, this procedure is categorized as heat treatment with high temperatures and short period of its action. The feed and food for extrusion are also exposed to reasonably high pressure, which can range up to 25 Mpa. The pressure difference between the inside of the extruder and the outside situation reasons part evaporation of water at the exit point, and thus the expansion of the feed and food. It is possible to do a range of special effects on the treated feed and food, such as grinding, hydration, cutting, sterilization, mixing, dispersion, compression, heat treatment, and inactivation of anti-nutritional substances, compression, and expansion,

binding of particles, formation of porous structure and partial dehydration and sterilization. The kind and force of induced variations depend on the added energy in relative to time and quantity of feed and food, design of screws (spiral shape, segments for slowing down, type and length of individual segments, the ratio between the length and diameter), type and structure of feed and food to be treated, humidity and fat content, capacity, additional heating and cooling of each barrel section, and die geometry.[16,17] Extrusion is a complex and complicated technicalprocedure, but it is very elastic and offers the possibility for processing of a range of different of stuff, feed and food.[8,9,17]

Steam flaking

Flaking is the procedure in which the grain feed are exposed to special effects of water steam in the situations of atmospheric or high pressure, and then rolled to get hold of thin sheets. The thickness of flakes is defined by correcting the spacing between the rollers and it ranges from 0.4 to about 2.0 mm. There are many differences of this process, depending on the pressure and temperature values and period of the process. Steam flaking is used as a heat treatment of all types of grains and cereals suchas corn, barley, wheat, etc. Moisture content in grain, thickness of flakes, grain temperature, and period of the progression affect the procedure efficiency. Grain heat during the treatment reaches about 100°C.[11,12,17]

Conditioning

Conditioning is a common term for procedures in which the material is prepared for the following industrial process. Conditioning commonly suggests preparation of raw materials or mixtures for pelleting or extruding and expanding in feed mill. Procedures of conditioning are water conditioning, steam conditioning (short and extended) and

mechanical conditioning. So, conditioning improved physical quality of the feed and food. The possibility to treat more feed and food materials Increased hygienic correctness of foodstuffs.[9,17] The simplest technique of conditioning is to add water into the conditioning machine. Humidity and heat are accomplished in a more effective way in steam conditioning procedure. Due to its vaporous state, steam spreads through the material in a more homogenous way. This procedure is carried out by direct injection of dry saturated steam into the feed and its heat can reach 95°C. The procedure of steam heating is restricted because it sources a rise in moisture content of the food and feed for 1% for every 12–15°C of temperature increase. The required condition for worthy conditioning is dry saturated steam pressure of about 8–10 bar with the temperature of 150–180°C.[12,11] Decrease of pressure on the spot of use by around 1.5–3.0 bar reasons steam temperature decline and the released heat or overheats it, if there is no condensate in it. In this way, the over-wetting of feed is evaded and it is heated in the most capable way. Using a lower steam pressure more moisture is presented in the feed for the same heating level (9;10;11). A thin water film is formed around a particle, which together with the increased heat facilitates binding of particles in during the steam condensation,. The main factors in conditioning contain the temperature, moisture content and treatment period. Temperature and moisture quantity are gotten by adding steam, and the time factor depends on the kind, size and functioning of the device. The device for short-term conditioning is a non-stop paddle mixer to which water or dry saturated steam is supplemented. The feed and food are conveyed through the feeder with variable rotation speed. First particles of the feed leave the mixer in only a few seconds and that time is not enough to use all the conditioning capacities. The average time of holding feed in this form of conditioner is 10 to 30 seconds. Chambers for lengthy conditioning allow better diffusion of moisture, and heat into feed and food particles.[9,17] Steam conditioning is not enough to achieve the satisfying pellet quality when feed of poor bonding properties are pelleted. Therefore, a combination of steam conditioning and mechanical conditioning is applied. Thickness of material layer on the die and rise of engine power of electric motors in thicker die, are theways to extend conditioning of feeds in the procedure of pelleting. Expander or extruder are fixed as special systems for mechanical conditioning in order to heat up the material to 100–140° and even up to 170°C before final pelleting. An increased consumption of energy is predictable, so that the application of this style of procedure is justified only in cases when the last price of the product can stand funds in equipment and production.[17,19]

Cooking

Raw seed are saturated in water and heated for 30 to 120 minutes, and then they are dried, and given to animals as feed, whole, milled, or rolled. Cooking is a comparatively easy to make technique. Pressure cooking is a difference of this procedure, when the management is carried out in closed containers under the pressure of steam that is produced. In this way, we can success heats higher than 100°C. These procedures have restricted use because they are not flexible adequate.[17,20] Hot-headed cooking is the cooking method in which raw feed is heated by steam. It takes place in the containers under the pressure of 2.3 to 3.0 MPa. Opening of the container upon end of treatment creates a sudden pressure loss in the container due to balancing by atmospheric pressure and make available for extra expansion of grain and extra influence on the treated feed. The procedure of explosive cooking is much more flexible than the formerly stated styles of cooking. This procedure can accomplish a wide range of different heats and pressures and is suitable for giving of all styles of granular raw materials.[8–10,17]

Micronisation

Grain can be heated by a variation of procedures that use spread of the waves, which vary in part of the electromagnetic spectrum that is used. Micronisation is a specific heat treatment in which the layer of grain on the conveyor belt is constantly carried below ceramic radiators emitting radiation with wavelength in the near infrared region ranging from 1.8 to 3.4 cm. The spread rays, which are engaged to a product, cause the frequencies from 80 to 170 million mega beets per second inside the grain, which leads to rapid heating, bigger stress of water vapour and rapid water evaporation. Micronisation reductions the moisture content of grain by 30–40%. The concentration of infrared rays' translation into heat and its influence depends on the type of feed to be treated.[21]. The conveyor belt within the microniser can waver in order to tumble the grain and expose well all its surfaces to waves influence. The most vital parameters of this treatment are the speed of the conveyor belt, thickness of product layer, space between the product and the radiation basis and certainly the accomplished temperature.[2,12,17] During the micronizing process, the grain is heated

using infrared heat until all moisture is vaporized (generally less than a minute). This ruptures the endosperm of the grain, leading the grain to become soft and pliable, causing the reconfiguration of the starch structure (gelatinization). Immediate flaking further gelatinizes the starch so as to significantly enhance the digestibility and nutritional value of the feed.

Roasting

Roasting is difficult dry heating of raw feed and food to the temperature of 110–170°C, depending on the style of device used and the wanted product value. If the roasting temperature is too high, it decreases the availability of nutrients in the shallow layers of grain, while the central portion may stay under-treated. The lower temperature reduces the risk of burning out and burning, but it also decreases the capability of the device. Many different systems of roasting are used all over the world. Most of these systems contain a throughinfluence of heat on kernel, and due to a direct contact with the grains of different types and sizes, the quality, stability and degree of roasting as well as grain colourcan differcommonly.[2,10,11,17] The simplest way of roasting of soybeans and other granular raw materials for animal feed is roasting in different types of dryers. The most commonly used structures are those that are based on rotating drum- type dryers because they are suitable for unimportant funds, and easy to handle, and as they do not need any great space to accommodate even large supporting installations. The grain in these devices is commonly heated directly by hot air heated by burning gas, solid or liquid fuels. The product is mixed by barrel rotation and fixed blades in its inside. Some apparatus of this type use microwave radiation in mixture with direct heating by hot air stream.[11,16] Conveyer dryers using air heated byheatexchangers as liquid are also used for roasting. The advantage of this type of device is that the grain is not exposed to direct flame and combustion products. A newer high efficacy drying technology of 13 fluidized bed type use dry overheatedair that is blown through the grain and that has the product in a permanent suspension and effort below the organized temperature and time of product retention. The grain is "cooked" by its own moisture, and this procedure provides a very hygienic product of uniform high value. The production hot air can be recycled, dried, and re-used thus growing the economic efficacy of the procedure.[2,9–11,17]

Popping

Popping is the method of roasting of dry grain on a hot plate (t < 400°C) in a short time. Such treatment of grain leads to quick loss of moisture, grain exploding into popcorn and increasing of its nutritive value. All varieties of grain can be applied this method, and it is the best to use this treatment on corn since the lowest share of un-popped grains is well known.[17] Rolling can be carried out after popping to rise the bulk density of the feed andfood.[2,21]

Toasting

Toasting that is introduced straight into the toasting vessel is a hot fluid in this procedure. The vessel may have different structures and it can have the units through which the produce passes. The treatment is the one with the time of holdingwithin the vessel from 10 to 20 minutes and the released temperature of up to 120°C. After heat action, mechanical pressure between two rollers can be used to form flakes, and then the product is cooled. This process can be useful to treat several types of raw materials. Common is its use in edible oil production, where it is used to extract the solvent from the meal after oil extraction. This process can be preferred due to decrease of anti-nutritive substances.[2,11,12,17]

Conclusion

Mash feed compound, soybeans and oilseeds or legumes provide a good example of improved protein digestibility andbioavailability of sulphur amino acids through thermal unfolding of the major globulins, and thermal inactivation of trypsin inhibitors and other growth-retarding factors such as lectins. However, extensive lysine loss can take place when legume or cereal legume blends are extrudedunder severe conditions of temperature or shear forces (>l00 rpm) at low moisture (<15%), especially in the presence of reducing sugars (23% glucose, fructose, maltose, lactose). This damage depends on the maillard condensation between &-NH_2 groups of lysine residues and C=O groups of reducing sugars. It is not fully understood whether the damaging effects. The nutritional value of lipids could be affected during extrusion as a result of oxidation, hydrogenation, isomerization or polymerization. The autoxidation of essentialfatty acids (linoleic, linolenic, arachidonic) renders them unable toprevent the dermatitis and poor growth associated with low intake of these nutrients. lsomerization of the double bonds from the cis to the trans form also destroys the essential activity of these PUFA. However, the amount of hydrogenation and cis-trans isomerization of

fatty acids that takes placeduring extrusion is too small to be nutritionally significant. Extrusion-inactivation of lipase and lipoxidase helps protect against oxidation during storage.

Higher temperatures reduce the lipase activity and moisture level, thereby decreasing favoring freefatty acids development. However, the expanded porous nature of the extrudate causes the feed tobe susceptible to the development of oxidation during storage, even though deterioration due toextrusion may not be immediately apparent. Dietary fiber; Modifications in particle size, solubility and chemical structure of the various fiber components could occur during extrusion-cooking and cause changes in bacterial degradation in the intestine andin physiological properties. Extrusion-cooking of white wheat flour (161–171°C; 15% moisture) was found to cause are distributionof insoluble to soluble dietary fiber. However, food and feed processing industry is to minimize the loss of nutrients during thermal processing while providing an adequate process.

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