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The Dry Extrusion Process

Prior to the Insta-Pro® extruder, relatively low feed prices and high equipment costs made extrusion processing too expensive to be widely used. But with the development and introduction of the versatile Insta-Pro extruder in 1969, the dry extrusion processing method can now be used to improve gain, feed efficiency and palatability as well as stabilize and utilize many by-products.

The Insta-Pro dry extrusion method utilizes friction as the sole source of heat accompanied by pressure and attrition compared to methods which use steam, water or other forms of pre-conditioning. Heat and pressure are developed by passing the product being extruded through a barrel by means of a screw with increasing restrictions. Then, the sudden decrease in pressure when the product is discharged into the atmosphere results in expansion of the product. By vaporizing moisture, starch cells are ruptured. The amount of expansion depends on several factors, such as the starch content of the product, temperature, pressure, and the amount of moisture.

There is a distinct difference between cooking and expansion, yet each serves a specific purpose. *Cooking* is a general term used to describe the effect of heat, pressure and time on the material being processed. Cooking is necessary for its effect on the protein portion of the ration where it acts to detoxify or denature enzymes. *Expansion* occurs by rupturing the cell structure and exploding the product.

With the Insta-Pro extruder, the same conditions of attrition, pressure, and time needed for developing heat are also used for expanding the starch portion of the ration. The cooking process takes place as the product moves through the barrel while the heat is progressively increased. Expansion takes place immediately after the product is discharged from the extruder orifice. The effect of cooking and expansion can be best described by considering the effect of extruding on the various components of the diet.

Effect on Proteins

Proteins are denatured by the cooking process, an effect related to the degree of temperature created. Proteins are made up of amino acids which are known as the building blocks of protein. Amino acids are held together by primary bonds whereas the molecules are held together by secondary bonds. The cooking action of the Insta-Pro extruder breaks down the secondary bonds but does not create sufficient heat to destroy the amino acids or the primary bonds.

This effect is similar to that caused by cooking an egg. The secondary bonds hold the protein in an egg together in a certain way. When the egg is heated, the protein is denatured or the secondary bonds are broken. When these bonds are broken, the product loses its distinctive physical appearance. If the egg was cooked to extreme temperatures, the primary bonds holding the amino acids together would be destroyed thus affecting their nutritional value. The Insta-Pro process does not adversely affect the primary bond, but does create sufficient heat to denature or break down the secondary bonds.

It is this effect of denaturization that is useful when extruding oil seeds. Soybeans have an enzyme, urease, which can be denatured by heat created in the extruder. Enzymes are made up of proteins and when they are denatured, lose their effectiveness. Urease breaks down urea to ammonia.

Another protein in soybeans that is destroyed by extrusion is the trypsin inhibitor which is produced in the pancreas. Without the action of trypsin, the animal cannot utilize protein, as it is trypsin that splits or hydrolyzes the protein molecule. Other less important enzyme inhibitors that are denatured by the Insta-Pro extruder relate to fats and the carbohydrate fraction of a diet.

Since the heat needed to deactivate enzymes is less than that needed to prepare oil seeds for oil extraction, the effect on the amino acids is much less severe thus making them more available to the animal or higher in digestibility.

Effect on Energy

The energy fraction of the diet can be broken into two parts, carbohydrate and fat. First, the carbohydrate fraction, which is primarily starch, is greatly affected by extrusion, or heat and expansion.

Starch is basically a granular mass of starch molecules. Each starch molecule is like a chain with many side branches and is inter-connected into a tightly held mass. Raw starch has little water absorbing capacity and if dried after being soaked goes back to its original state. One of the ways to test for starch is to pass light waves through the granule and measure its polarization. As starch passes through the Insta-Pro extruder, it is gelatinized and when it leaves the extruder it expands. This effect is caused by breaking down the granular structure and opening up the molecular chain. This is similar to the effect that occurs by cooking starch in the presence of heat and water. The difference is that with the Insta-Pro extruder, the effect takes place at much lower moisture levels and much quicker. Once the starch granule is gelatinized, it cannot revert to the original granular state and it now is water soluble and the light waves are not polarized as they pass through the material.

In the Insta-Pro extruder, the only moisture needed to gelatinize the starch is the amount needed to lubricate the extruder and allow the starch to pass out the orifice of the extruder. As the material leaves the Insta-Pro extruder, the inherent moisture vaporizes and the starch gel quickly stiffens after the liquid has vaporized. The amount of expansion which takes place is dependent on the amount of starch in the formula. With formulas containing 40-50% starch, the normal expansion will equal 2-3 times. For this reason, most extruded formulas are reground returning the bulk density more closely to the original product.

Effect on Fat

Extrusion, or heat and expansion, affects fat in two ways. First, fat or oil is encapsulated within the cells of oil seeds. When a raw oil seed is ground, the resulting product will be dry. During extrusion, the oil is released from the cells making the product oily. The extent to which the cells are ruptured in an Insta-Pro extruder has not been measured.

If starch is present when an oil seed is extruded, the fat and starch will form a complex which is not soluble in ether, the normal method used for fat analysis. Studies have shown that fat will enter a complex with starch on the basis of a 1 to 10 ratio. An acid hydrolysis is necessary to measure the correct and actual fat level in such a case.

Heat generated by the Insta-Pro extrusion method does not adversely affect fat quality. Temperatures of the magnitude of 350-400°F are needed to produce off odors and oxidation, while temperature for extrusion are generally in the 250-300°F range.

Effect on Fiber

The effect of extrusion on fiber is related primarily to its bulk density. Because of the mechanical action, grinding and attrition, the hollow structure of fibrous materials are crushed thus changing their bulk density. High fiber ingredients are normally low in moisture and take on moisture slowly which requires some type of pre-conditioning before extrusion.

Effect on Nutritional Value

The beneficial nutritional effects of extrusion will vary with species, age and type of ration being fed, but in general these benefits can be expected on the protein, energy and fiber content of the ration by:

- Denaturing the enzymes, urease, lipase, amylase and the trypsin inhibitors.
- Improving starch digestion as measured by rate and efficiency of gain.
- Increasing the bulk density of highly fibrous materials.

The mechanism by which extrusion improves the digestibility and utilization of energy are not fully understood. Certain studies would indicate that the combination of heat, pressure and moisture is involved in increasing the susceptibility of starch to enzymatic digestion.

Other studies would indicate that the protein binding effect of the starch granule may be disrupted allowing easier access of microbial and animal enzymes to the starch granule. In general, studies have shown a marked improvement in performance when extruded grains have been used in rations for young animals. This effect is due to the somewhat undeveloped digestive tract of young animals as compared to the older animal. Improvements in gain and efficiency have also been noted for animals on high concentrate rations. The denaturation of enzyme inhibitors allows the normal enzymatic breakdown and utilization of proteins, fats and carbohydrates.

Insta-Pro Extruded Products

The following products are being commercially produced by the Insta-Pro method:

- **Dry Extruded Whole Soybeans (DEWS).** The raw, whole soybean is processed by the Insta-Pro process resulting in an excellent protein, energy source for all species. Inhibitors are reduced to an acceptable level for maximum growth and feed efficiency.
- **Golden Pro.** A combination of non-protein nitrogen encapsulated by starch through the Insta-Pro process results in an economical, high-protein source for ruminants. The dry extrusion process results in the encapsulation of the urea by the starch source slowing the release of ammonia within the animal and making NPN feeding safer and more efficient.
- **Heat Treated Protein (HTP).** When natural proteins are heated, they become less degradable in the rumen thus escaping the breakdown to ammonia in the paunch of the ruminant animal. By-pass protein serves to improve the utilization of protein and to support higher rates of production.
- **Low Trypsin Inhibitor (LTI) Soy Flour.** Certain species are sensitive to minor residues of the trypsin inhibitor, these being fish, calves, baby animals and fur bearing animals. By special processing techniques, it is possible to reduce the trypsin inhibitor residue to approximately 5% as compared to a normal level of 20%. By reducing the level of trypsin inhibitor, the substitution of soy protein for more expensive protein sources becomes practical in these sensitive species.
- **Complete Diets.** Diets can be processed for a whole range of applications. The most common being the processing of complete dog foods. Benefits accruing to the extrusion process include everything from palatability to sterilization. The use and stabilization of by-products probably represents the greatest economic potential as we prepare to feed the world on limited resources.

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