A Cooker-Extruder for Deallergenation of Castor Bean Meal[1]

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We present a brief overview on the work Rhee and his colleagues at Texas A&M University have done on the deallergenation of castor bean meal and how a cooker-extruder can be used to accomplish it in a commercial plant setting. The extruder used is a high temperature, short residence time cooking extruder that generates frictional heat as it compresses and propels material within the barrel and out through the extrusion dies. Adjustment of water and steam input flow rates allow for selection of moisture levels of cook, and the selection of die size and number of openings allow for adjustment of temperature of cook. An important part of the process is the mixing, blending and absorption of chemical additives into intimate contact with the castor bean meal prior to entry into the extruder. Various methods for doing this are discussed, and a brief overview of what kind of equipment might be incorporated into a deallergenation process line is presented.

Castor bean meal has been used traditionally as a fertilizer rather than as a feed protein, because of the presence of toxins that rendered it unsuitable as a feed material. There is, in the world today, a short supply of feed proteins, especially in the countries that produce castor bean meal, so the United Nations Industrial Development Organization (UNIDO) sponsored a research program, conducted at the Food Protein Research and Development Center at Texas A&M University, to investigate methods to detoxify castor bean meal in an economically feasible way to permit the utilization of castor bean meal in the feed industry. The work done by Rhee and his colleagues was published by UNIDO (1).

Castor bean meal contains three toxins: ricin, a poisonous protein; ricinine, a poisonous alkaloid, and a very potent allergen known as CB-1A. The ricin is easily destroyed by heat and can be inactivated during the desolventization step following solvent extraction. The ricinine is present at very low levels and presents no problem in animal feeds, provided the feeds do not contain high levels of castor bean meal. The allergen CB-1A, however, requires a special processing step to deactivate it.

Some of the methods previously investigated for deactivating CB-1A resulted in substantial damage to the essential amino acids that make castor bean meal attractive as an animal feed. Rhee's objective was to find a method that would deactivate the allergen without causing this damage. He found that subjecting the castor bean meal to high temperature, high shear extrusion in the presence of various chemicals can accomplish what he was looking for. One of the chemicals found suitable is lime. His work ultimately led to experimentation with three commercially available high temperature, high pressure extruders, one of which is the Anderson Expander-extruder-cooker (Fig. 1).

This extruder-cooker is a fully-proven, state-of-the-art cooking extruder that has been on the market for 33 years and has been widely used for cooking and puffing animal feeds that contain vegetable proteins where there is a requirement that no significant damage be done to the amino acids. It is also used in other, similar applications, such as cooking and puffing of floating and sinking fish feeds, gelatination of starchy cereal grains to produce binders and adhesives, and the preparation of low cost human foods from vegetable and animal source materials.

This unit is very well accepted in these industries because its uncomplicated construction (Fig. 2) makes it simple to operate and inexpensive to purchase. It consists essentially of a cylindrical barrel containing a rotating shaft designed to generate a high shear churning-like action on the material within the barrel, working it and propelling it down the length of the barrel and generating frictional heat, as well as pressure, as the worm flights rub against the compacted material. This extruder does not require pretreatment to elevate moisture and temperature of animal feed formulations prior to extrusion. One can preheat and premoisten if one wishes, but it is not necessary, and very few users of this extruder bother with preconditioning. This is because the shaft itself provides a high shear kneading action due to the interrupted flights

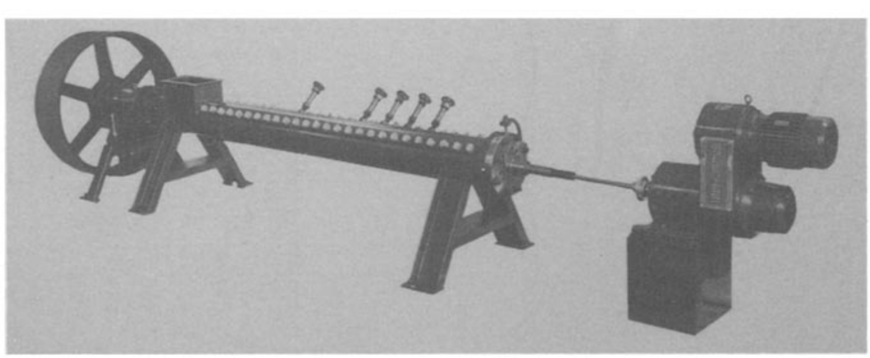

FIG. 1. The Anderson expander-extruder-cooker.

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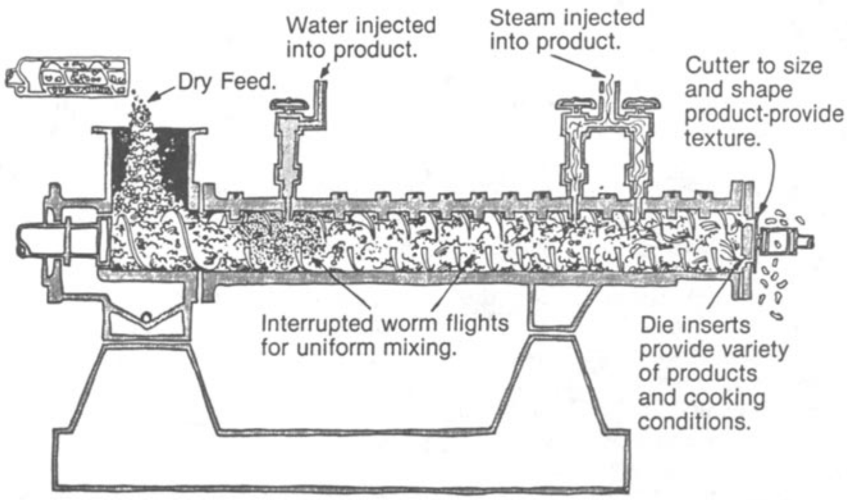

FIG. 2. Sectional view of the extruder.

interspersed with stator pins protruding from the barrel wall.

Water and steam can be injected directly into the material inside the extruder, and both will become thoroughly impregnated in the solid matter, the steam being compressed into a liquid due to the pressure generated by the worm shaft.

The material discharges through a flat plate containing a number of replaceable dies which can be of a variety of sizes and shapes. The sudden drop in pressure allows some of the internal moisture to vaporize, inflating the product with porous cavities which penetrate all the way through the extruded, and now expanded, product. These pores not only provide the expansion sought in many animal feeds, but also facilitate the drying of the product prior to storage.

The extruder Rhee and his collegues worked with at Texas A&M is 4.5″ in diameter with a 4.5′ long barrel, and powered by a 50-hp variable speed drive (Fig. 3).

A single die insert, of 7/16″ diameter, was used in the die plate (Fig. 4).

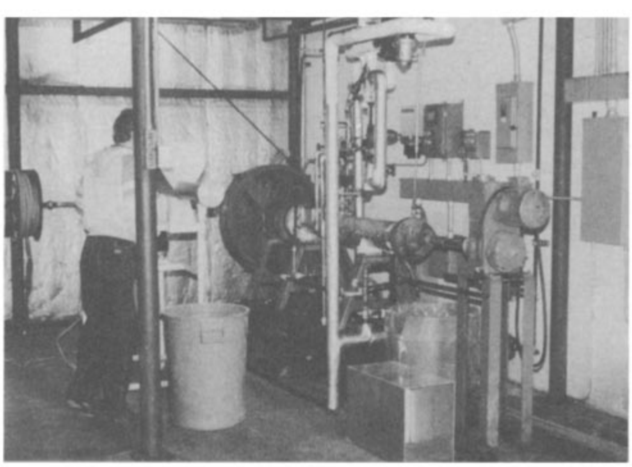

FIG. 3. The 4.5″ extruder used for pilot studies at Texas A&M University.

The incoming granulated (but not finely ground) castor bean meal (Fig. 5) was previously mixed with a solution of lime in a blender to ensure that the lime becomes evenly distributed, at the correct concentration, throughout the castor meal, and to allow some residence time for the lime to soak into the interior of the larger particles. The mixture of castor bean meal and lime solution was then passed through the extruder and subjected to high temperature, high shear and high pressure, for a short residence time, to enable the lime to react with the allergen to deactivate it.

The detoxified castor bean meal exited the extruder in a continuous strand (Fig. 6). (In field-sized units, there would be multiple strands coming out of a multi-hole die plate.) The strands break up into smaller pieces as they are conveyed away from the extruder (Fig. 7).

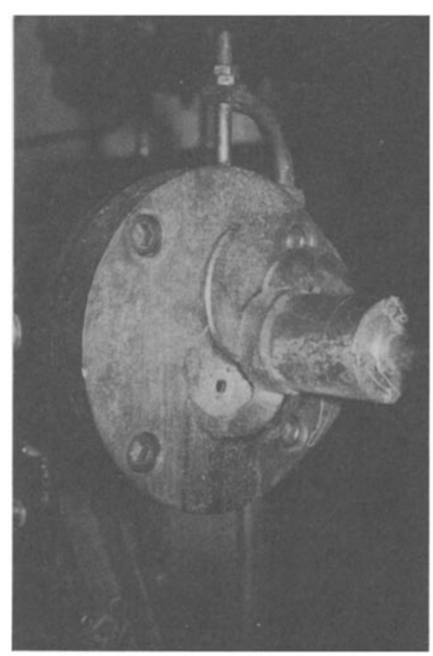

FIG. 4. Die plate and cutter assembly.

They are then passed through an apron-type dryer/cooler to reduce the moisture level to about 10% and cool the product sufficiently to allow bulk storage, or bagging. A suitable dryer/cooler capable of handling products like this, and suitable for most expander/extruder applications, is shown on Fig. 8.

The product is spread across a woven wire belt and transported through a housing while, first, hot air is blown through it to dry it, and then room air is drawn through it to cool it.

Selecting full-sized equipment to adapt this procedure to a continuous, commercial-scale operation presented no unusual problems with weighing, extruding, drying and transporting of the dry or of the wetted castor bean meal, but we did have problems in proposing equipment that could handle lime slurries on a continuous, trouble-free basis.

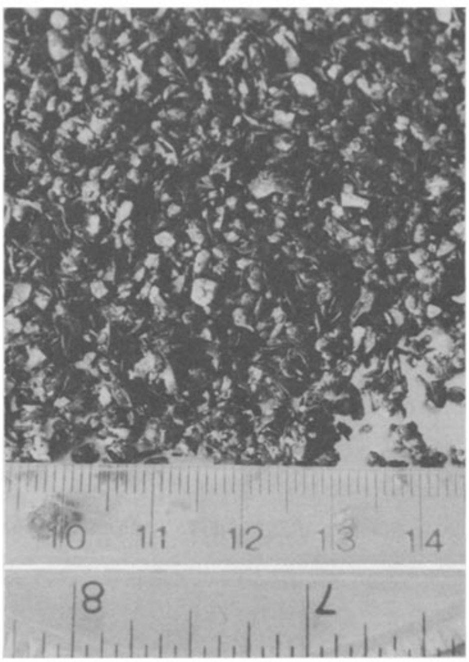

FIG. 5. Castor bean meal mixed with lime solution, ready to be extruded.

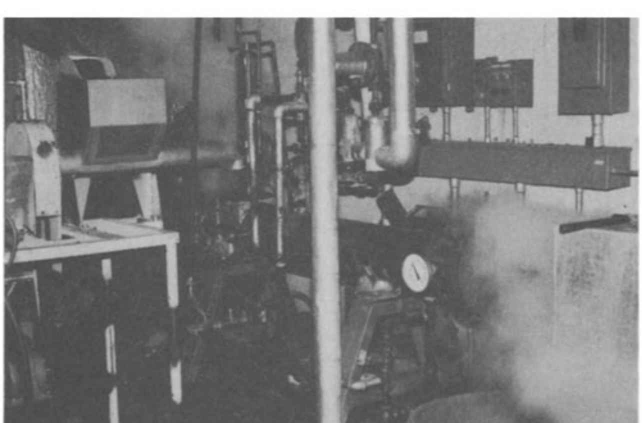

FIG. 6. The 4.5″ extruder in operation on castor bean meal.

The trouble with lime is that its impurities are only sparingly soluble in water, and it tends to form hard calciferous-like deposits on the walls of mixing tanks, piping, instrumentation and especially the nozzles through which the slurry must flow.

We looked at various methods of introducing lime. First of all, we looked at continuous mixers rather than batch mixers. With a continuous mixer, we would mix, on stream, a uniform flow of castor bean meal and a uniform flow of lime slurry (Fig. 9). This has the advantage that the lime slurry is used as fast as it is mixed, but the disadvantage that three separate flows of material—lime, water and meal—have to be controlled, on stream, to hold both the desired slurry concentration and the proper ratio of slurry with the castor bean meal.

Another way would be to mix a large quantity of slurry in an agitated slurry tank from which the slurry can be metered into the process (Fig. 10). Make-up slurry can be replenished, batch-wise, by adding fixed weights of lime, and fixed volumes of water into the slurry tank whenever the quantity of slurry drops below a predetermined level.

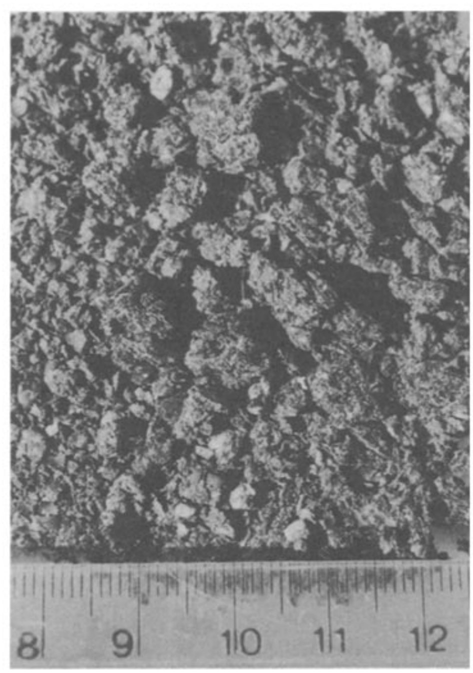

FIG. 7. Extruded castor bean meal.

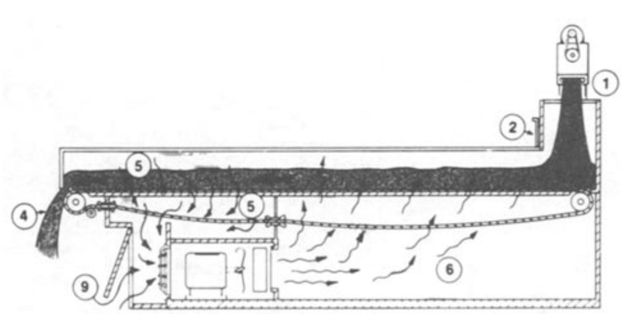

FIG. 8. Apron type dryer/cooler.

This has the advantage that only two flows have to be monitored on stream, the flow of slurry and the flow of castor meal.

There was also some concern that a continuous mixer might not be as effective as a batch mixer, and it was vitally important that all of the castor bean meal come into uniform contact with the lime, so we also considered a batch mixer with a weigh scale feeding it, each batch to receive a set volume of slurry from the slurry work tank.

We mentioned earlier that this extruder-cooker does not require preconditioning, but that is true for the addition of water and heat into material, which is the function served by a preconditioner on other extruders requiring them. With castor bean meal, the requirement is to get the lime spread evenly throughout the castor meal. This is a blending requirement, really a gross blending of a two-component formulation. Because the lime is in small particles and the castor meal is in larger particles, and because there is a low level of lime relative to the castor meal, there is a concern that the lime might adhere to the surfaces of some of the particles of castor meal at a higher concentration than with others, and there might be some particles of castor meal with little or no lime adhering to them.

It is for this reason that Rhee et al. (1) used a slurry of lime. It was an attempt to ensure that the lime spreads more evenly over the surface of all the

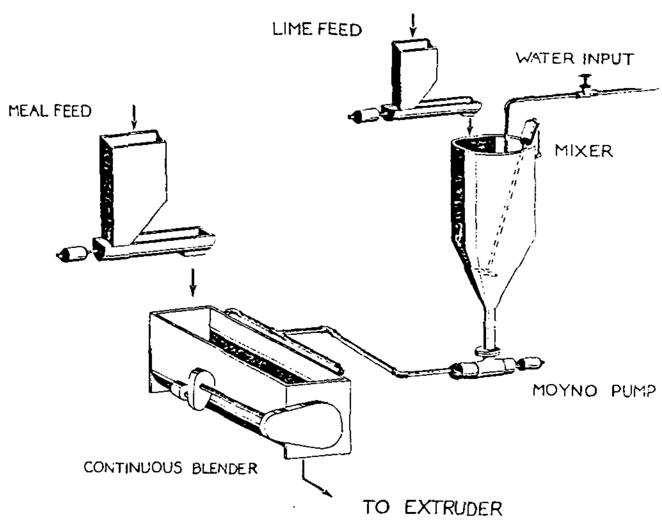

FIG. 9. One way of adding lime slurry in a continuous manner.

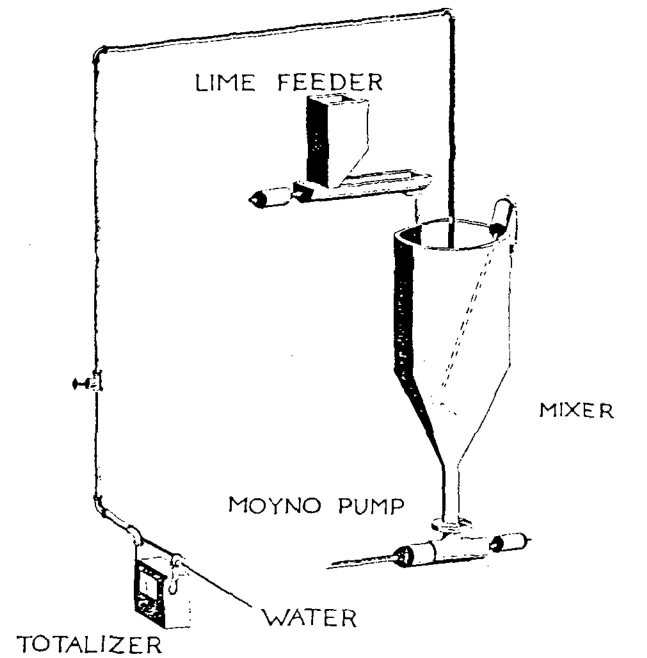

FIG. 10. Alternate way of adding lime slurry in a continuous manner.

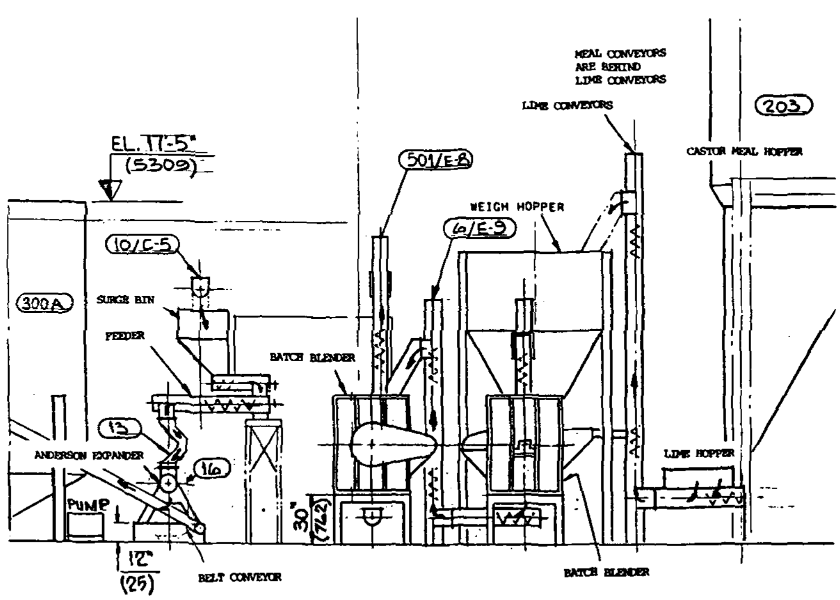

FIG. 11. Elevation view showing batch method for dry mixing of lime and the equipment selected.

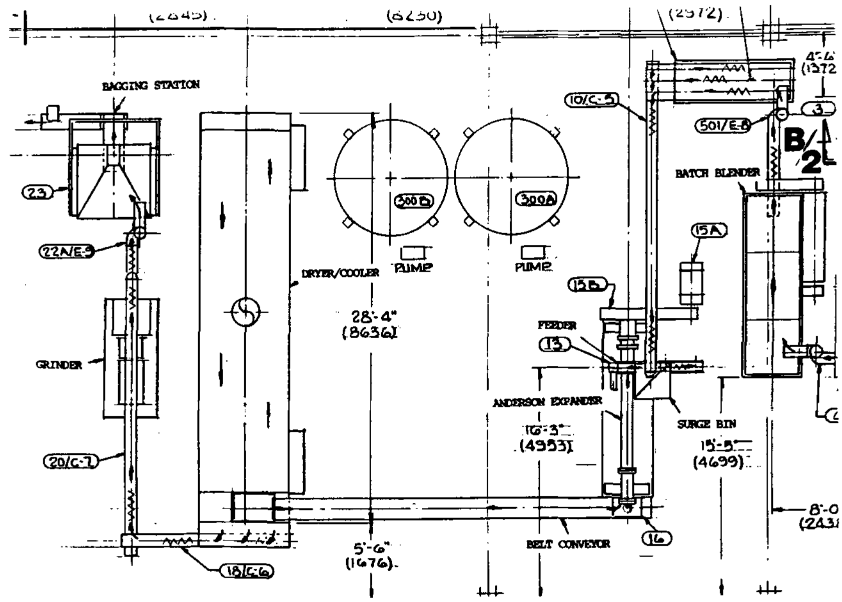

FIG. 12. Plan view showing batch method for adding lime and the equipment selected.

particles of castor meal before the mixture enters the extruder.

As mentioned earlier, there was concern about the precipitation of lime as a crust on the walls of the tank, the piping, the interior of the pump, and inside the totalizing instrument measuring the volume of slurry for each batch. If this is experienced in the plant, it could cause excessive downtime while the slurry equipment is cleaned to remove the scale, and it could also lead to the selection of more expensive equipment designed to minimize the opportunity for scale to accumulate or to facilitate the cleansing of the equipment once it does. Problems with buildup of scale also could dictate that a pure grade of lime be used rather than the much less costly technical grade. Pure lime doesn't scale as heavily as technical grade. We then considered a method to avoid making a slurry of lime. This could be accomplished by weighing batches of castor bean meal and the lime powder, dropping the batches into a batch blender, adding the proper volume of water into the blender while it is mixing, and then discharging the blended batch into a second blender to ensure that the blending of each batch is adequate, then discharging into a surge bin from which the lime-treated castor bean meal is fed continuously into the extruder (Fig. 11).

The rest of the process line, from the extruder through bagging, is typical of most extruder process lines. There is no particular difficulty in passing the freshly extruded castor meal into a conventional apron type dryer/cooler and grinding the finished product in conventional grinders (Fig. 12).

The product, if bagged and palleted, can be monitored for verification that the allergen has been deactivated by writing the time on each pallet and comparing the time on the pallet with the results of lab analysis of samples of the finished material taken periodically. The plant would have an automatic sampling device. Whatever samples are actually analyzed should be coded by time of production. If any samples test bad, the pallets packed at that time will be either reprocessed or diverted for use as fertilizer.

ACKNOWLEDGMENTS

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REFERENCES

1. Rhee, K.C., *The Production of Non Toxic Castor Bean Meal Free of Allergens,* United Nations Industrial Development Organization, Vienna, Austria, 1987.

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