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COST OF EXTRUSION PROCESSING OF COTTON GIN BY-PRODUCT AS LIVESTOCK FEED

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Abstract

Extrusion processing can be used on cotton gin by-product (CGB) to produce livestock feed (roughage) products. Using the economic-engineering approach, estimates of unit processing cost for CGB livestock feed products were developed, indicating economies of size, with average per-ton cost as low as $39/ton.

Introduction

Over four million bales of cotton lint (25% of U.S. production) are produced in Texas each year. A significant residual of the cotton lint ginning process is cotton gin by-product (CGB). CGB is composed of leaves, stems, burrs, immature seed, and lint fibers, stripped from the plant along with the cotton lint during harvest. CGB currently has little economic value and is disposed of at an average cost to the gin plant of $1.44 per ton (Castleberry and Elam, 1998). Over 1.1 million tons of CGB are produced each year in the Texas High Plains, with a total annual disposal cost of almost $1.6 million.

Several methods of CGB disposal are in common use. CGB is disposed of by inclusion in livestock feed, soil amendment, and compost. A recent study reports that the nutritional value of CGB (based on nutrient composition of CGB), when used in cattle feeding rations, may approach $70 per ton, far surpassing the disposal cost (negative return) of $1.44 per ton (Castleberry and Elam, 1999). This disparity suggests that the full potential value of CGB as livestock feed is not being realized, likely due to undesirable physical properties of CGB. The physical properties of CGB bring about a lack of palatability in animal diets, abrasiveness (wear) to milling machinery, and low bulk density that leads to high transportation costs. These effects reduce the feasibility of using CGB as livestock feed.

Experimental processing techniques have been identified that mitigate the physical barriers, limiting the value of CGB in livestock feeding. Engineers at the Lubbock, TX, USDA-ARS cotton-ginning laboratory have achieved promising results in tests of a CGB extrusion process (using an Insta-Pro dry extruder) that uses starch in solution to reduce wear on the extruding machinery (Holt and Laird, 2000). The patented process is known as the COBY (COtton BY-products) process. The COBY process includes the application of a slurry (comprised primarily of gelatinized starch and water) to the CGB, the blending in of various additives that are either helpful in processing or add value to the final product, and the extrusion of the CGB mixture to cook, gelatinize, and sterilize the product. The final product is a livestock-roughage-feed product that has potential market value to cattle feeding operations.

The extrusion equipment used in the COBY process is adaptable, allowing for processing of multiple ingredients, such as whole cottonseed, simultaneously with raw CGB. CGB contributes fiber (roughage) to the feed product, while whole cottonseed can be added in varying proportions to supply specified amounts of protein, energy, and fat. The extrusion process can be altered to produce feed products of various types, including range cubes/pellets and loose feed, each having improved palatability over products containing raw CGB. Another advantage of the process is the increased bulk density of extruded CGB, decreasing transportation costs of CGB feed products and increasing the size of the area where products can be feasibly marketed. The physical restrictions that have limited the value and use of raw CGB in livestock feed products can be overcome by the use of the CGB extrusion process; however, the economic feasibility of such a system that processes raw CGB into a livestock feed product with optimal nutritional and physical characteristics has not been established.

The research reported here is a subset of the project components that make up a comprehensive research effort. The research effort is designed to determine the technical and economic feasibility of using extrusion processing of raw CGB to produce desirable livestock feed products and to determine the potential demand for such products. The components of the feasibility study include estimation of: (1) the acquisition/transportation cost of raw CGB from the gin to the plant site; (2) the cost of storing and handling raw CGB at the plant site; (3) the cost of the CGB extrusion process (COBY); (4) the cost of storing and distributing the output feed products to final demand markets; and (5) the final product demand for CGB livestock feed products.

The objective of this project component study is to estimate: the costs of acquiring, handling, and storing raw input products at the plant (items 1 and 2 above); the cost of processing (COBY process) and assembly of the CGB feed product (item 3); and the cost of short-term storage and out-loading of the final livestock feed product (part of item 4). The specific objectives are to design and specify model CGB livestock feed production plants of varying sizes and to estimate the cost structure of each model plant. The cost functions of the plants are synthesized using the economic-engineering approach. A long-run cost curve is estimated to determine the economies of size for increasing sized production plants.

The outline of the remainder of the paper is as follows. The following section explains the economic-engineering approach used to estimate CGB livestock feed production cost. Results of the analysis are found in the third section. The fourth section includes a discussion of the limitations of the analysis, and the final section provides a summary and plans for future research on the project.

Economic-Engineering Approach

Production of CGB livestock feed products from raw CGB and other inputs using the COBY process consists of a series of operations including input procurement, transportation, preparation, processing and product storage and disposition. Like many other manufacturing processes, the CGB livestock feed production system is relatively straightforward and does not require exceedingly complex components. Therefore, the process is technically feasible in a wide range of production configurations including small gin-scale operations as well as sophisticated, high-volume automated enterprises. Along with the ranging set of feasible technical configurations, the per-unit production cost varies. Therefore, analysis of the full range of plant cost structure can provide insight into the long-run cost structure and economies of size in the production system. The analysis of plant cost structure was carried out through estimation of investment and operating costs for four model plant systems that differ in plant size (throughput). For each model plant, the economic-engineering approach was used to develop a total cost per unit of plant output.

The economic-engineering approach does not strictly require the use of particular methods, however, it more generally prescribes a set of guiding principles that have come to be accepted as “standard good practice” (French, 1977). Statistical analysis of accounting records is the most common alternative method to the economic-engineering approach for evaluating cost structure. One advantage of the economic-engineering approach over the statistical analysis of accounting records is that the economic-engineering approach can be applied when accounting record data are not available, as in the current case of a new CGB livestock feed production system. However, a major limitation of the economic-engineering approach is the high cost of implementing the approach. Estimation of stage production functions and a complete synthesized cost function requires a significant amount of detailed technical data about each production stage.

Following the economic-engineering approach to estimate the production cost structure for each model plant, a series of four procedural steps were followed. The steps include (1) development of a description of the CGB livestock feed production system, (2) specification of the alternative production and processing stage techniques that are technically feasible, (3) estimation of the production functions for each stage or component in the feed production system and accumulation of the stage functions into a system production function, and (4) synthesis of the feed production system cost functions by applying input factor prices.

A description of the complete CGB feed production system, including consideration of alternative processing techniques and production function definition, was developed through: extensive discussion with USDA, ARS engineers; on-site examination and discussion with plant managers of plants using similar techniques; and live trial runs of a small-scale prototype design of the extrusion process.

In general, six production stages are defined in the livestock feed production system. Of the six stages, four are direct applications of components in the COBY process and are carried out in the main processing facility at the plant site. The stages include (1) receipt, storage, and initial preparation of input feed ingredient materials (occurs in the outdoor staging yard), (2) intake, preparation, and mixing of raw inputs (occurs in the COBY process facility), (3) preparation and mixing of additive inputs (occurs in the COBY process facility), (4) extrusion of mixed materials (occurs in the COBY process facility), (5) compression, drying, cooling, and transfer (to the storage location) of the feed product (occurs in the COBY process facility), and (6) handling, storage, and out-loading of final feed product (occurs in the adjacent product barn). Production costs for each of the model plants were synthesized from the combination of estimated stage production functions and average factor prices for production inputs. Details of the cost synthesis follow.

Standard economic cost procedures were used to synthesize production costs including fixed and variable operating costs. Interest, depreciation, maintenance/repair, insurance, and property tax costs are calculated based upon the total investment cost for plant building, machinery, and equipment. Building, machinery, and equipment investment costs are based on purchase of new facilities/fixtures without consideration of the cost and availability of used equipment. (Planned future work on this project includes development of investment cost estimates based on selective use of investment in used equipment and machinery where good quality is available at a reasonable cost.) The cost of millwright services for installation and assembly of machinery and equipment and for fabrication is included in the investment cost. Cost of the plant control system is included along with the cost of electrical wiring and hookups.

Interest cost includes financing interest on the building, machinery, and equipment and is calculated as the annual interest rate (8%) multiplied by half the total investment cost of the plant. The interest cost approximates the "average" interest cost over the lifetime of the plant (as the value depreciates over time). The operation of the plant was assumed to require operating debt equal to three months of expenses, with interest on operating debt calculated using an annual interest rate of 8%. The straight-line depreciation method was used to calculate depreciation cost of the building, machinery, and equipment to be fully depreciated over a useful life of 30 years with zero salvage value. Depreciation was designed to represent the obsolescence of machinery and equipment. Annual maintenance and repair cost was estimated by a feed processing facility contractor, with cost varying by plant size. The maintenance and repair estimate assumes that all machinery and equipment is maintained in "close-to" new condition. For example, in the case of a screw conveyor, maintenance and repair include routine maintenance such as lubrication, replacing bearings, and welding, as well as replacing major conveyor pieces such as tubing and flights. Insurance cost is calculated using a typical commercial insurance rate for the given model plant and includes workers compensation and employee liability coverage, commercial property coverage, and commercial general liability coverage. Estimated commercial property taxes were calculated using tax rates from local taxing entities and a taxable value equal to the initial building, machinery, and equipment investment cost.

Variable operating costs, including labor, energy, water, and materials, are synthesized from the stage and component production functions of the plant process and from off-line activity costs such as managerial and clerical labor. Variable operating costs are based on a production plant operating 24 hours per day, six days per week, and 49 weeks per year, with three weeks per year shut down to allow for annual repairs and adjustments to machinery and equipment. The operating schedule requires three daily working shifts of two to four in-line employees. Three off-line employees are required for management, sales, and service activities. The total annual salary package (labor cost) for in-line employees, including fringe benefits, was estimated at $30,000. The three off-line employees include (1) two plant managers responsible for production, management, and marketing of plant output, with a salary package (labor cost) of $38,000 per manager per year (including fringe benefits), and (2) a secretary-bookkeeper responsible for daily bookkeeping and secretarial duties, with a total salary package of $30,000 per year.

Plant energy cost includes electricity cost primarily relating to operation of motors throughout the plant and natural gas cost of operating the steam boiler and the product dryer. Estimation of electricity cost was made using the five-year average of industrial usage unit price for electricity ($0.0454 per kilowatt hour) and the total horsepower requirement for plant machinery and equipment. The cost of natural gas to power (1) the steam boiler used to supply heat to the starch cooking kettles and (2) the burners on the product dryer is based on the five-year average of industrial usage unit price ($3.18 per MMBTU). The loader and telehandler are fueled with diesel fuel at the five –year average cost of $1.12 per gallon with fuel efficiency eight gallons per hour. The cost of water is calculated based on estimated plant water usage and local commercial water/sewage rates.

Raw CGB is included at $8/ton acquisition cost ($3/ton cleaning and loading cost at the gin plant and $5/ton transportation cost from the gin plant to the CGB processing plant). Whole cottonseed are purchased at $100/ton and incorporated into the input mixture at 10% of total product weight to increase the protein, energy, and fat level of the final processed feed product. Starch ($80/ton) is used in the COBY process at a rate of 4% on a dry matter basis.

Results

Model Plant Flow Diagram

The specific model plant designed here incorporates flexibility to produce both roughage products as well as value-added products with enhanced nutritional characteristics (energy and protein). Particularly, the model plant is designed to handle whole cottonseed along with CGB as primary inputs to the process. The output product is livestock roughage feed product having added value from the additional protein and energy from the whole cottonseed.

The layout of the entire feed production plant site (on 25 acres of land) is shown in Figure 1. Raw CGB is stored on the plant site (uncovered) to wait processing (at the top of Figure 1). Stored CGB is pushed with a wheel loader onto a concrete pad and loading bay where it is picked up by a bucket elevator that lifts the material up and into the plant process building. An input commodity shed is available to provide covered storage for whole cottonseed. The wheel loader is used to push the whole cottonseed into the loading bay where a bucket elevator lifts the seed into the plant building. The raw CGB and whole cottonseed are processed in the COBY process building (with office included). After processing, the output (livestock feed) product is conveyed with an overhead product conveyor to the product storage barn for short-term storage (at the left of Figure 1). A telehandler is used to move and out-load product into trucks and a truck scale provides truck weights.

The stages of the COBY extrusion process (inside the COBY process building) can be seen along with component equipment in the COBY plant flow diagram shown in Figure 2. The reader should follow the discussion while viewing Figure 2. Keep in mind that an automated plant control system processes feedback data on product throughput and equipment parameters from each stage in the plant process in maintaining proper flow of intermediate materials. Raw CGB and whole cottonseed are brought into the plant building in separate lines and are stored in surge bins (separately) at the top left side of the plant flow diagram. The CGB and whole seed surge bins use live bottom augers with variable rate feeders to feed the raw CGB and whole seed into a combining auger that flows to the mixing auger where the CGB and seed are mixed and moved with a conveying auger (along the top of Figure 2) to a set of surge bins (one for each single-extruder processing line) that will each feed the mixed CGB and seed to an extruder. Bin-level indicators (bindicators) control the flow of CGB/seed into the surge bins to maintain the appropriate fill-level of input product. Each surge bin is equipped with a live bottom auger and a variable frequency drive. The plant control system regulates the flow of CGB/seed from the surge bins based on the optimal throughput of the extruders. A mixing auger (middle right of Figure 2) attached to each surge bin is used to mix a gelatinized starch solution (and other additive ingredients) with the CGB/seed. Remember that the starch is added to "grease" the flow of the abrasive CGB as it moves through the extruder (to reduce wear and tear on the extruder) and to add value to the feed product.

The starch solution processing equipment is located in the center section of the plant flow diagram in Figure 2. The starch solution processing equipment includes a bag splitter that splits the bags of starch for loading into the starch bin (the desired feed-grade starch is typically sold in 50 and 100 pound bags—not bulk). The stored starch is taken from the bin and lifted, using a bucket elevator, to the conveying auger and dropped into weigh feeders that weigh out specified amounts to produce a given batch of starch solution. The dry starch is dropped into the two cooking kettles to mix with water and cook to form the starch solution used to coat the CGB/seed before it passes through the extruders. A low pressure, forced draft steam boiler (bottom center section of Figure 2) supplies heat to the starch cooking kettles.

Continuing with the discussion of the flow of the process, the starch-coated CGB/seed is fed into the extruders with 35 - 45% moisture (the moisture is added as part of the starch solution). The temperature in the extruder rises to approximately 230°F as the CGB/seed mixture is forced through a set of rings in the barrel of the extruder. The high temperature kills weed seeds and other living organisms in the CGB/seed mixture. The extrusion process produces a loose, fibrous feed product with a mild aroma and a medium-dark brown color.

From the extruder, the product drops into a conveying auger and into a single-pass belt dryer (bottom of Figure 2). Coming out of the extruders, the extruded product contains 25 - 30% moisture. The dryer further reduces the moisture to 14% to accommodate densifying the product in compression machinery, if desired. The reduced moisture level is needed to maintain the form of the compressed product. The final step in the production process is to cool the extruded product in a cooler where the moisture level is reduced to 8 - 10% to accommodate short-term storage before shipping.

Required Investment Cost

Building a CGB production system requires considerable investment capital. Required investment costs for varying-sized model plants are shown in Table 1. Total investment cost is $1.719 million for the single-extruder plant and $3.203 million for the four-extruder plant. The largest component of investment cost is for plant machinery and equipment used to process the raw CGB and whole cottonseed (found inside the COBY process building). Table 1 includes operating capital required for purchasing variable operating inputs, such as raw inputs (CGB and whole seed), utilities, and monthly salaries for three months.

Plant Cost Estimates

Estimates of the cost of processing CGB and whole cottonseed into a livestock feed product in four varying-sized model extrusion plants were developed. The total cost estimate includes: (1) the cost of acquiring, handling, and transporting raw input products, (2) the cost of processing CGB/seed inside the COBY process building, and (3) the cost of storing (for short periods) and loading the output feed products. The cost estimates are shown in Table 2 for each model plant (starting with a single-extruder plant processing 4 tons per hour up through a four-extruder plant processing 16 tons per hour). Total processing cost is $1.565 million for the single-extruder plant processing a total of 28,224 tons per year and $4.244 million for the four-extruder plant processing 112,896 tons per year. The largest component of cost is for raw input materials, ranging from $0.567 million (36 % of total cost) for a single-extruder plant up to $2.267 million (53 %) for a four-extruder plant.

Average cost (per ton of output) was calculated for varying-sized plants (bottom of Table 2). For the single-extruder plant, average cost is $58 per ton, with raw input materials representing the largest component of cost at $20 per ton, or 34 % of all costs, while for the four-extruder plant, average cost is $39 per ton, with raw materials inputs again representing the largest cost component at $20 per ton, or 51 % of all costs.

Economic cost curves were developed to reflect the change in average (per-ton) cost with varying-sized plants (Figure 3). The top curve in Figure 3 includes all components of cost, while the other curves reflect particular components of cost. For the all-components cost curve, economies of size are achieved with increasing plant size. Average processing cost is $58 per ton for the 4-ton per hour plant capacity and decreases to $39 per ton for the 16-ton per hour plant capacity. The long-run average cost curve turns approximately flat when plant capacity reaches 12 tons per hour (three extruders), with average cost of about $40 per ton and decreases only slightly for the largest size plant.

Like the all-components cost curve, the individual component cost curves in Figure 3 (with the exception of raw material inputs that are proportional to output) exhibit economies of size. With increasing plant size, the greatest reduction in component cost is taxes and insurance, followed by depreciation and labor (with roughly equal reductions).

Discussion

Important to point out are some of the limitations of the economic-engineering approach to estimating processing cost so the reader will have a better understanding of the results presented here. As mentioned above, a major limitation of the economic-engineering approach is the high research cost (French, 1977). After working on this study for some time, we can attest—as economists—to the inordinate, daunting, and unexpected amount of technical engineering detail and time required to complete a study using this approach. For example, we discovered that it is not a simple process to price a screw conveyor used to move material from one stage to another in the plant. To clarify, a screw conveyor consists of several components including a tube, flighting, a trough, a trough cover, spouts, multiple bearings, flanges, etc., each with numerous selections to be specified about the quality and size of the component. All of these components should be priced and totaled to obtain the price estimate of a "screw conveyor." Many stage equipment components are included in the configurations for the model CGB production systems, including, *inter alia*, live bottom bins with variable surge rate sensors, combining augers, mixing augers, bucket elevators, a dryer, a cooler, a bag splitter, electrical wiring, plumbing, a plant control system, etc. The system development and design of such a complex plant stretches the knowledge of non-engineers, like the two senior authors, and even engineers as well. As noted by Black (1955) and reported in French (1977), "As the size and complexity of the operation increases, so does the possibility that the model builder will omit some aspect of cost."

Another potential limitation of the economic-engineering approach at cost analysis is the specification of the model plants. As French (1977) points out, the model plant approach is most appropriate in cases where the researcher is confident of being able to select, *a priori*, the best methods for each of the model plants. In developing the model plant designs, we consulted with agricultural engineers, animal scientists with feed manufacturing expertise, commercial plant designers, and several equipment companies. But even with all of this assistance, on several occasions, independent judgment was used in questions of plant design and equipment use and specification. To the best of our knowledge, we made reasonable, judicial choices that should err on the conservative side. For example, in selecting cooking kettles for the plant, we could have included a large 1,500-gallon kettle to obtain the lowest cost. However, based on discussions with engineering personnel, we chose two 800-gallon kettles at a higher total cost but with the potential of reducing risk in the production process. That is, in a 16-ton-per-hour plant, two kettles showed advantages because if one kettle develops mechanical problems, half of the production line can continue to run. Another advantage is in the case where a bad batch of starch solution is created. Again, only 800 gallons of solution is wasted in a two-kettle plant compared to 1,500 gallons for a single-kettle plant. The point we want to make is that model plant design involves some difficult choices, with the opportunity of second-guessing any design. In the case at hand, there could be better model plants but we feel fairly confident that our design is reasonable and includes the major pieces of equipment for processing CGB feed products with consideration given to economic issues of risk, return, and time and product-flow management.

Yet another possible limitation of using the economic-engineering approach is reliability. Black (1955) and French (1977) maintain that the estimates using the economic-engineering cost approach are "cut adrift from the standard measures of reliability." Given the complexity of designing a model plant and the complex and varied pieces of equipment involved, this certainly appears to be a valid criticism of the approach. French points out that synthetic economic-engineering cost estimates clearly need to be verified against alternative sources of information; however, in the case at hand, there are no CGB feed production plants currently in operation. Therefore, careful review of our results by an engineer-consulting firm seems advisable.

Summary and Future Research

The economic-engineering approach was used to estimate the cost of processing raw CGB and whole cottonseed into a livestock feed product. The extrusion process is based on an experimental processing technique that utilizes a starch solution applied to raw CGB to reduce wear on processing machinery and add value to the feed product. Four model plant systems were developed that range in size from a single-extruder plant processing 4 tons per hour to an four-extruder plant processing 16 tons per hour. Combining varying proportions of CGB and extruded whole cottonseed, the plant system design and process flow allows for production of feed products with varying amounts of fiber (roughage), protein, energy, and fat.

The cost structure of each of the four model plant systems was estimated and a long-run cost curve was developed. The results indicate that economies of size exist for average (per-ton) production cost, with the highest average cost ($58 per ton) for the smallest (single-extruder) plant system and the lowest average cost ($39 per ton) for the largest (four-extruder) plant. The long-run average cost curve turns approximately flat as plant capacity increases to a three-extruder plant size with average cost of $40 per ton and remains relatively constant for larger capacities.

We plan to continue our research effort on CGB extrusion. To complete the feasibility study that was started and is presented here, we need to estimate the feeding value (expected price) of a CGB livestock feed product. This will provide the necessary information to estimate the sales revenue (price x plant output) from a CGB feed production system like the one proposed here and to estimate the return on investment in a CGB feed production plant.

Beyond the feasibility study, additional research is called for to develop a comprehensive analysis of the potential for CGB livestock feed products. Feedlot feeding trials are needed to compare CGB feed products with commonly used roughages such as alfalfa hay and cottonseed hulls. The feeding trials will provide information on how roughages substitute in feedlot rations and whether cattle feedlot performance is affected, in a negative or positive way, with a CGB roughage product. Additional research is called for to evaluate different forms of the product (loose or cubes) and the amount of other additives (protein, energy, fat, etc.) needed to maximize the performance and value of CGB products in a commercial setting. Feedlot operators need to be surveyed to determine their interest in substituting CGB roughage feed for traditional roughages. Yet another area of research concerns the use of extruded CGB feed products in range cattle and dairy cattle rations. An area of concern that places a pall of uncertainty over the entire area of research to develop animal feed products from CGB is the possibility that significant chemical residue may be found in CGB and may reduce, or eliminate, the use of CGB in animal diets. Residue studies are called for to clarify the residue issue.

The results from this research have potential benefits for the cotton and livestock industries and the regional economy of West Texas, if the process is commercialized to produce CGB livestock feed products. The benefits include: higher revenue for cotton producers/ginners; a more digestible/palatable roughage feedstuff for livestock producers; and an environmentally friendly, sustainable, value-added enterprise that creates jobs and increases income for rural communities in cotton producing regions.

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Table 1. Required investment ($1,000's) for building, machinery, and equipment, by asset group and plant size.

	Number of Extruders			
Plant Site Asset Groups	**One**	**Two**	**Three**	**Four**
COBY Building, Electrical, and Plumbing	116	146	166	186
Input Receiving and Preparation[a]	230	232	234	236
COBY Machinery and Equipment[b]	763	1,003	1,239	1,508
Output Product Storage and Loading[c]	230	230	230	230
Operating Inputs[d]	380	579	805	1,043
Total	1,719	2,190	2,674	3,203

[a] Commodity shed, loader, inbound bucket elevators for raw CGB and whole cottonseed, and truck scales.

[b] Includes millwright services plus plant control cost.

[c] Product storage barn, overhead conveyor, and telehandler.

[d] Expenses for three months (excluding depreciation and interest).

Table 2. Annual plant operating cost ($1,000's) and average operating cost ($/ton), by plant size.

	Number of Extruders			
Item	**One**	**Two**	**Three**	**Four**
Labor	286	286	376	466
Raw Inputs	567	1,133	1,700	2,267
Utilities	292	394	512	678
Maintenance and Repair	264	384	504	624
Taxes and Insurance	112	119	127	136
Depreciation	45	54	62	72
Interest, Operating Debt	30	46	64	83
Interest, Fixed Debt	54	64	75	86
Total Operating Cost	1,650	2,480	3,420	4,412
Plant Output (tons/yr)	28,224	56,448	84,672	112,896
Average Operating Cost				
Labor	10.13	5.07	4.44	4.13
Raw Inputs	20.09	20.07	20.08	20.08
Utilities	10.72	7.35	6.41	6.37
Maintenance & Repair	9.35	6.80	5.95	5.53
Taxes and Ins.	3.97	2.11	1.50	1.20
Depreciation	1.59	0.96	0.73	0.64
Interest	2.98	1.95	1.64	1.50
All Components	58.81	44.33	40.77	39.46

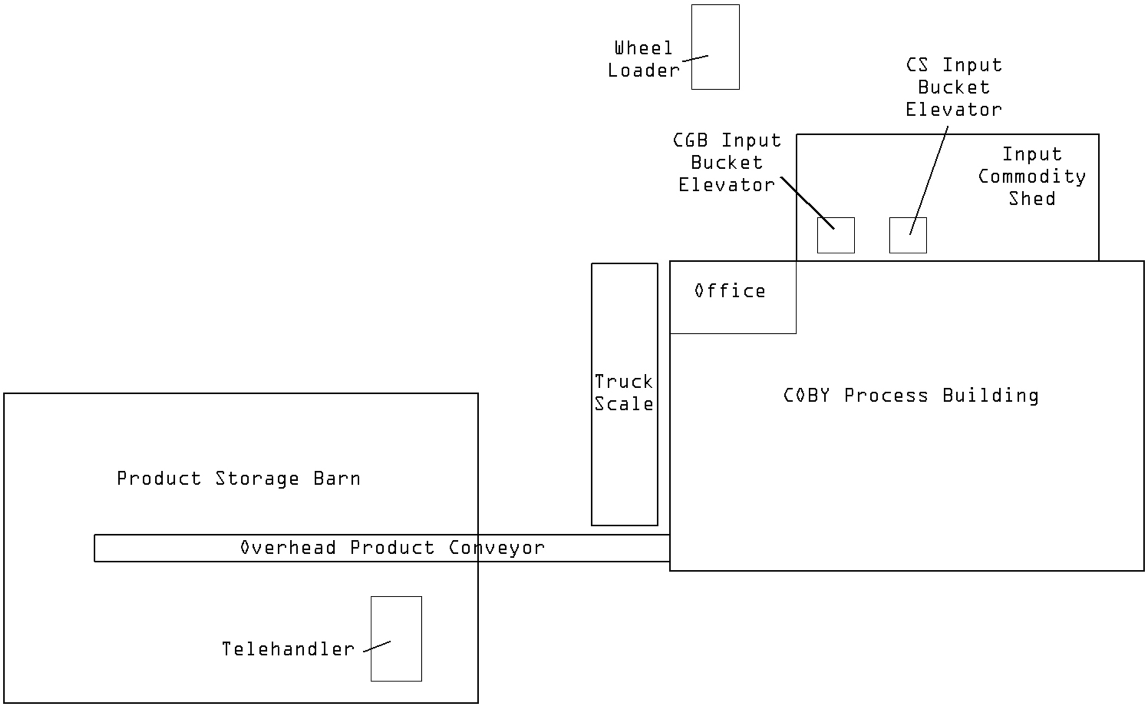

Figure 1. Layout of the CGB feed production plant site.

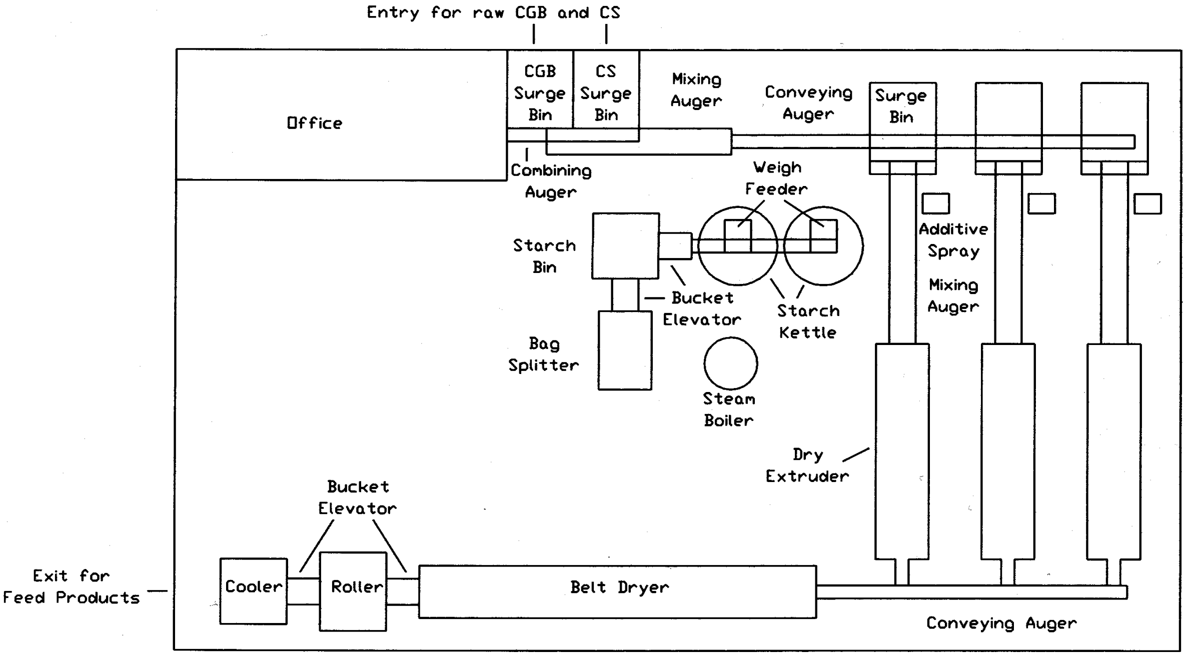

Figure 2. Plant flow diagram of the COBY process building.

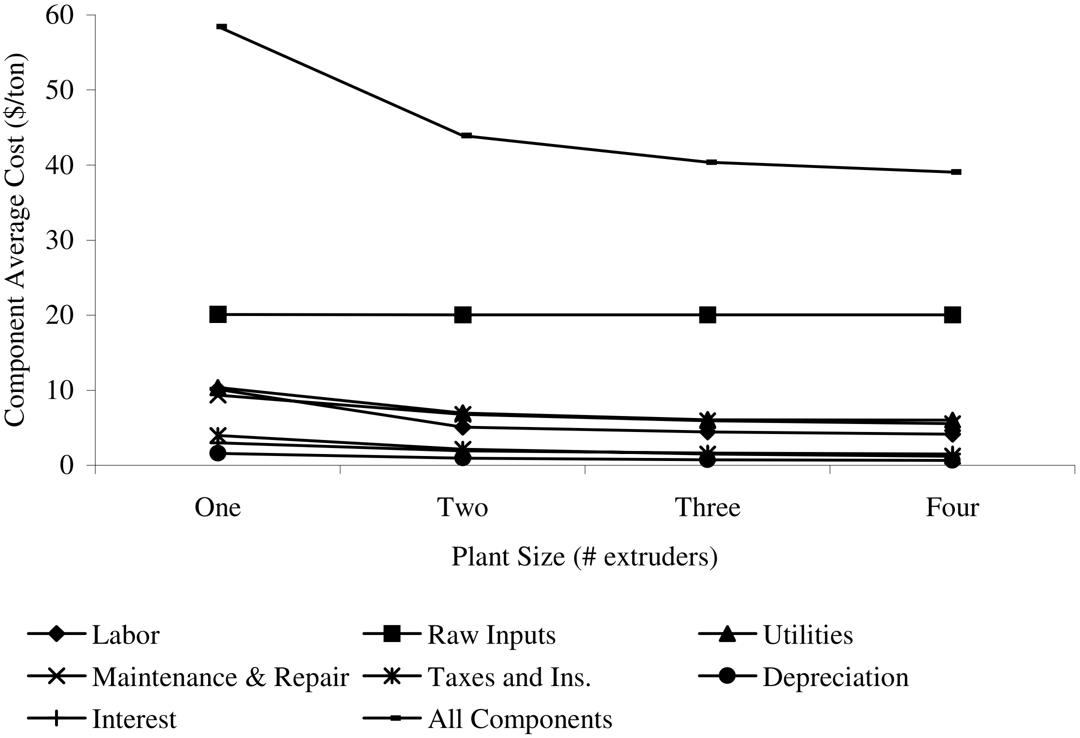

Figure 3. Average cost of production ($/ton) for CGB livestock feed product, by component and for all components.