The economic feasibility of on-farm feed milling for Arizona poultry ranches

THE ECONOMIC FEASIBILITY OF ON-FARM FEED MILLING FOR ARIZONA POULTRY RANCHES

by

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ABSTRACT

Arizona egg producers are at a comparative disadvantage in the local egg market because feed costs are above California levels. On-farm feed milling was explored as an income-improving alternative. Plants were designed and budgeted for three flock sizes. The objective was to determine the least cost alternative between on-farm feed milling and commercial feed acquisition.

On-farm feed milling was feasible for all model mills since cost per ton was less than the cost of commercial feed. Economies of size existed in on-farm feed milling and cost-savings were greatest for larger volume egg producers requiring greater feed tonnages. The feed mill design for 75,000 birds provided cost-savings over commercial feed acquisition but did not offset the California advantage. Model mills for the 150,000 and 300,000 flock sizes eliminated the competitive disadvantage of Arizona egg producers by reducing feed costs sufficiently to compete with eggs produced in California.

CHAPTER I

INTRODUCTION

Arizona poultry ranches compete with California producers for Arizona markets. California producers have a comparative advantage because of lower production costs (Wilson 1975). As a result, many Arizona egg producers ceased unprofitable operations resulting in a 60 percent decrease in number of layers and egg production from 1970-76. This decrease took place during a period of population growth in Arizona and an increase in egg consumption of 14 percent (1,366,071 to 1,561,875 cases of eggs). Arizona production accounted for 25 percent of the market in 1976 as opposed to 45 percent in 1970. From an economic point of view, poultry ranchers are seeking income-improving alternatives.

The sensitivity of Arizona egg producers' competitive position with respect to changes in feed costs, transportation costs, and population increases through 1990 was assessed through a linear programming transportation model by Wilson (1975). The primary factor affecting the competitive disadvantage of Arizona egg producers was feed costs. Wilson concluded that the competitive disadvantage for Arizona egg producers could be eliminated by producing eggs at feed costs equivalent to California.

This study provides information for poultry ranchers who are currently considering various feed procurement methods for reducing feed costs. Specifically, the economic feasibility of on-farm feed milling relative to commercial feed acquisition is examined. Designs and costs for on-farm feed mills are synthesized from which cost alternatives are ascertained. If feed cost reductions from on-farm feed milling are found, they will be compared to the reductions estimated by Wilson for making Arizona egg producers competitive in the local egg market with California producers.

Review of Literature

The economic feasibility of on-farm feed milling has been discussed in trade journals and U.S.D.A. reports since the 1950's. Trade journals such as Feedstuffs, The Feed Bag, and Wallaces Farmer, e.g., Hagen (1961) and Smith (1960), recorded the growth of on-farm feed milling and published debates regarding its economic feasibility. U.S.D.A. experiment stations researched the system's design and economic feasibility as well as provided planning guides for farmers.

Two limitations inherent in these sources concerned differences between on-farm feed mills. First, valid comparisons of results reported in the literature were problematic because on-farm feed mills varied by design, size, and ration produced. In addition, little of the research dealt specifically with poultry applications. Thus, studies regarding other livestock feed processing systems were used as references. Finally, the similarity of numerous studies in this field made a representative literature review more practical than one that was inclusive.

Growth and Status of On-Farm Feed Milling

On-farm feed milling flourished with the development and improvement of grinding/mixing equipment and feed storage/handling facilities that made it possible to handle large volumes of feed and reduce labor requirements. Moreover, many farms had the opportunity to use high-quality fresh grains from their own supplies.

Illinois economist Ralph Mutti (Hagen 1961) related the adoption rate of on-farm feed milling to larger livestock enterprises and trends to complete rations. Ken McFate, a Missouri agricultural engineer, recognized automated operations as well as cost-savings in feed processing and labor as influential factors ("Costs for Farm Mixing of Feed Outlined" 1965). He also observed that existing mills increased in size because of the greater farm productivity resulting from on-farm feed milling (Hagen 1961).

The status of on-farm feed milling in the Midwest was investigated by Al P. Nelson (1965a). Nelson discovered that the average farm miller did not know his cost for producing a ton of feed since he failed to account for labor, taxes, interest on investment, depreciation, insurance, and power acknowledging only the cost of ingredients. In addition, on-farm millers were large feeders who bought their concentrate from bag dealers or custom mill operators. Some of them would grind and mix for neighbors either by contracting to do the job or by renting out their equipment. He predicted on-farm milling would increase considerably in the future due to the inclination of more educated modern day farmers to experiment.

Debating On-Farm Feed Milling's Economic Feasibility

In 1960, U.S.D.A. economist Carl Vosloh (Smith 1960) stated that large-scale livestock feeders should consider farm processed feeds based upon survey work conducted in North Carolina and Florida. On the other hand, Oakley M. Ray (Smith 1960), Market Research Director for American Feed Manufacturers Association pointed out that surveys favorable to on-farm feed milling have omitted certain costs involved in feed manufacture including credit, production and marketing advice, and the time required for making purchasing and production scheduling decisions. Erwin Wascher (Smith 1960) of Heneggers' and Co. illustrated this viewpoint by citing instances where expensive farm feed mills lied idle because their owners had found that commercial rations actually cost less after analyzing all factors involved. Mutti (Hagen 1961) suggested that values assigned by producers to various cost items such as labor, depreciation, and interest on investment influenced them in determining what method had the lowest cost.

Economic Feasibility

Studies conducted by state agricultural experiment stations determined the cost relationships and break-even points for various sized on-farm feed milling operations and searched for economies of size.

Cost relationships varied by type of milling system (Bloome et al. 1976). Labor was high for portable grinder mixers, mills with portable mixers, and stationary mills with portable mixers. High operating costs were also found for portable grinder mixers and mills with portable mixers.

On the other hand, well-planned automatic electric mills required the least labor and had the lowest operating cost. They also had a long service life but were not always adaptable to existing facilities. Package feed centers, which were also automatic electric mills, had high costs due to overhead storage bins but narrowed significantly the gap of cost per ton of feed produced against other systems as the processed annual volume increased (Bloome and Tubbs 1972). Although there were few options in unit size, they were pre-engineered for reliability and were quickly installed.

Trotter and Hoch's research (1967) was concerned specifically with Pennsylvania poultry farms and compared on-farm feed milling with the purchase of commercial feed. They developed representative systems for six flock sizes based upon data which was obtained from personal interviews with farmers employing the different methods. Incorporated in this was a time and motion study to determine allocation of labor among job elements and the equipment involved in preparing, processing, and storing a ton of feed. Median values were used since they were not influenced by extreme variations. They applied budgeting techniques to attain total system costs and performed protein tests to determine the accuracy of on-farm feed formulation.

Their conclusions were:

1. The economic advantage of on-farm feed milling increased with flock size.
2. The feasibility of on-farm feed milling depended largely on the availability and alternative use for labor. Consequently, when the alternative use for labor was low, on-farm feed milling was

attractive because it provided a higher labor income. Accordingly, when the alternative use for labor was high, commercial feed should be bought.

3. The feasibility of on-farm feed milling was influenced by the availability of capital or credit for fixed and operating costs. Consequently, when the alternative use for capital was low, on-farm feed milling was attractive because it provided higher returns on investment. Accordingly, when the alternative use for capital was high, commercial feed should be bought.
4. If high alternative uses for labor and low alternative uses for capital existed, the purchase of commercial feed resulted in the highest rate of return to the limiting input, labor.

Implementation efficiency was cited as important in determining the feasibility of on-farm feed milling by Degn, Phillips, and Harston (1965). Their work encompassed an analysis of on-farm feed milling for existing plants and an analysis for more ideally designed plants based upon efficient observed cases and adjusted by recommendations from feed plant equipment manufacturers. They found that efficient small plants in Montana were processing feed at a cost almost as low as larger facilities and the most efficient easily competed with commercial sources. Furthermore, small scale on-farm feed mills could be designed that would be more economical than the average of the existing small size mills.

Nelson and Austin (1966) studied how costs could be reduced by changing fixed and variable cost relationships for North Dakota commercial feed plants. They reported the following:

1. Rates of capacity utilization had significant effects on costs per ton of output. For example, average total cost per ton for a 30 ton per eight hour shift mill ranged from $7.71 at 100 percent capacity to $14.27 at 40 percent capacity.
2. Adding second and third shifts to existing plant reduced average total costs in both average fixed and average variable cost components. Thus, lower costs per ton were found when operating a 30 ton mill 16 hours per day than operating a 100 ton mill 8 hours per day.
3. Wide variation in equipment and building costs caused small variation in costs per ton possibly due to improvement in the feed product and lower long run depreciation, maintenance, and other costs.

Further economic implications were presented by Dauzat and Roy (1975) for Louisiana package feed centers versus alternative procurement methods. They mentioned the following:

1. On-farm feed millers may suffer a disadvantage relative to commercial feed processors due to economies in transportation, in favorable hedging opportunities, and quality control of ingredients.

2. Widespread use of on-farm feed mills may represent competition to commercial feed millers and retail feed dealers causing them to reduce markups.
3. On-farm feed millers may lose savings resulting from feed dealers not fully marking up feed prices in proportion to rises in ingredient prices. On the other hand, they may gain savings resulting from feed dealers not fully marking down feed prices in proportion to decreases in ingredient prices.
4. Labor required for ingredient purchases and ration formulation can be substantial although actual labor for milling may appear minimal.
5. The lowest cost per unit of product produced should be the vital factor determining a feed's worth as opposed to the lowest cost per ton of feed obtained. (However, the reason for using this criterion was not clearly explained.)
6. Rations which are technically difficult to mix such as broiler mixes should remain with commercial processors since they are usually complex and costly to mix.
7. On-farm feed mills recover initial investment through depreciation and interest on investment in about seven years.
8. Additional investment in grain storage facilities and higher costs of inventory offset the advantage of purchasing grain at lower prices during harvest time.

Courtney and Siebert (1970) pointed out that factors such as labor and management availability, quality of feed, and the profitability of on-farm feed milling as compared with other forms of investment should be considered before purchasing an on-farm feed mill.

Other factors noted by Degn et al. (1965) were:

1. the amount of unused resources on the farm that could be utilized by feed processing,
2. the distance from farm to commercial plant (as the distance increased so did the feasibility as long as most feed ingredients were found on the farm),
3. the service at the commercial processing plant in the form of waiting time, storage, credit, and nutritional advice,
4. the management ability of the farmer,
5. the continuity of feeding, and
6. the individual farmer's view on future trends regarding economic advantages.

Trotter and Hoch (1967) also considered:

1. availability of ingredients,
2. availability of capital or credit,
3. risks of (a) discontinuing operations before equipment fully amortizes, (b) equipment breakdown, and (c) less available time for managing flock; and
4. access to markets.

Planning Guides

Planning guides by Allen, Sorenson and McCune (1970), Puckett (1964), and the Feed Production School, Inc. (1961) and Feed Production Council (1970) detailed procedures and examples for designing on-farm feed mills. Specifically, they dealt with defining basic processing operations and equipment as well as analyzing process flow, material handling, facility capacity, layout, and standards of operation. Furthermore, Roy and Wiggins (1970) and Vosloh (1976) furnished resource and capital requirements for feed manufacturing at various levels of production. These references guided the design of model on-farm feed mills in this study.

CHAPTER II

EXPERIMENTAL DESIGN

An economic-engineering approach was used to develop mill designs and budgets for Arizona poultry ranchers. Costs of feed produced by the synthesized mills were compared to the cost of commercial feed acquisition. As in any synthesis or budget approach, specific assumptions were made for design specifications, costs, and related prices.

This chapter outlines the assumptions and philosophy of the analysis. It begins with the derivation of production and storage requirements and continues with the provision of sources for developing mill design and on-farm feed milling cost components. An explanation of on-farm feed milling's process flow is then given followed by a listing of costs inherent in using commercial feed. Next, the procedure for making cost comparisons is detailed which includes consideration of total investment, costs associated with ownership, operating costs, ingredient costs, and cost-savings on an average year and Year 1 basis at various levels of capacity utilization. The effects of size and an additional 8 hour work shift are also explored. Finally, the basis for determining the influence of on-farm feed milling on the Arizona egg producer's competitive position in the local egg market is given.

Production Requirements

A layer consumption rate of 100 pounds of feed per bird per year was assumed to determine production requirements of on-farm feed mills for flock sizes representing current and anticipated levels of Arizona egg production (Table 1). Specifically, flock sizes of 75,100, 150,000, and 300,000 birds were investigated at 100 percent capacity utilization. Annual feed requirements (tons) for each flock size were estimated by multiplying the consumption rate by the number of birds in each flock. Daily feed requirements were found by dividing annual requirements by 365 days. Finally, tons of feed produced per milling day were ascertained by assuming an 8 hour operating schedule of 253 days per year (5 days per week less 6 nonoperating days for holidays and one nonoperating day for repairs or an emergency). As a result, on-farm feed mills with approximately 15, 30, and 60 ton production capacity of finished feed per 8 hour day were studied.

Storage Requirements

Storage requirements for ingredients were established for a layer diet prepared by The University of Arizona College of Agriculture based upon production requirements per milling day (Tables 2 and 3). Allowing for 3 percent shrinkage in the milling process, the amount of each ingredient needed per year was calculated depending upon its composition in the layer diet. Daily ingredient requirements were then estimated from which a 14 day storage capacity for ingredients was determined. In addition, finished feed storage was assumed at two milling days production except for the 60 ton mill which had one.

The problem of reserve storage capacity for ingredients and finished feed was considered in the feed mill design. The capacity of this storage depended upon cost/benefit trade-offs. The specifications

Table 1. On-Farm Feed Requirements (tons) by Flock Size for Arizona Poultry Ranchers.

Flock Size	Feed Requirements		
	Feed Needed/Year[a] (tons)	Feed Needed/Day (tons)	Feed Produced per Milling Day[b] (tons)
75,000	3,750	10.2740	14.8221
150,000	7,500	20.5479	29.6443
300,000	15,000	41.0958	59.2886

a. Based upon a consumption rate of 100 pounds per bird per year.

b. Assumes an operating schedule of 253 working days per year (5 days/week less 6 nonoperating days for holidays and one nonoperating day for repairs or an emergency).

Table 2. Layer Diet for Arizona Poultry Ranches.

Layer Diet	
Ingredient	Percent
Ground milo	64.100
Soybean meal (dehulled)	15.850
Meat and bone scraps	5.100
Alfalfa meal (dehy.)	5.100
Calcium carbonate	7.100
Dicalcium phosphate	1.100
Salt	.600
Trace mineral mix (UA)	.200
Vitamin mix (PR-9)	.600
DL-Methionine	.150
TOTAL	100.000

Source: Reid (1976)

Table 3. Storage Requirements for On-Farm Feed Milling on Arizona Poultry Ranches by Daily Tonnage Produced.[a]

Item	Storage Requirements Tons per Day								
	15			30			60		
	Amount Needed Per Year (tons)	Amount Needed Per Day (tons)	14 Day Storage (tons)	Amount Needed Per Year (tons)	Amount Needed Per Day (tons)	14 Day Storage (tons)	Amount Needed Per Year (tons)	Amount Needed Per Day (tons)	14 Day Storage (tons)
Milo	2475.0	6.8	95.2	4950.0	13.6	190.4	9900.0	27.2	380.8
Soybean Meal (dehulled)	609.0	1.7	23.8	1218.0	3.4	47.6	2436.0	6.8	95.2
Meat & Bone Scrap	194.0	.53	7.4	387.0	1.1	15.4	774.0	2.2	30.8
Alfalfa Meal (dehy.)	194.0	.53	7.4	387.0	1.1	15.4	774.0	2.2	30.8
Dicalcium Phosphate	39.0	.11	1.5	78.0	0.22	3.1	156.0	.44	6.2
Calcium Carbonate	271.0	.75	10.5	542.0	1.5	21.0	1084.0	3.0	42.0
Salt	20.0	.06	.8	39.0	.11	1.5	78.0	.22	3.1
Vitamin mix (PR-9)	20.0	.06	.8	39.0	.11	1.5	78.0	.22	3.1
Trace mineral mix (UA)	3.9	.011	.15	7.8	.021	.30	15.6	.042	.59
DL-Methionine	2.0	.006	.08	3.9	.011	.115	7.8	.022	.31
Finished Feed	3750.0	14.8221[b]	29.6443[c]	7500.0	29.6443[b]	59.2885[c]	15000.0	59.2886[b]	118.5772[c]

a. Accounts for 3% shrinkage.

b. Tons of finished feed produced per milling day.

c. 2-Milling Days Storage

provided for "working" storage at approximately 11 days for ingredient delivery and allowed for delays in receiving ingredients or mill breakdown without immediate cessation of feeding operations. Plants were designed without large storage capacities in order to avoid higher fixed costs. Additional storage facilities for ranchers to take advantage of seasonal ingredient price fluctuations and quantity discounts were recognized as an investment decision outside of on-farm feed milling and, thus, not considered in this study. Ingredient storage was specified in "days" because it permitted poultry ranchers to know how many days a flock could suffice with on-farm feed storage while finished feed storage was measured in "milling-days" in order to maintain adequate supply on milling days lost due to repairs or emergencies.

Mill Design and Costs

Physical plants for model on-farm feed mills were then designed using the economic-engineering approach. Planning guides from the U.S.D.A. and American Feed Manufacturers Association explained basic mill operations from which additional plant designs from other feasibility studies were used as input for synthesizing Arizona on-farm feed mills. The Arizona designs were examples of representative plants for their type and size which may not be ideal in every respect; however, efforts were made to ensure relative efficiency in their implementation.

Mr. Mel Gunning (1977), a Phoenix millwright, reviewed the plant designs to make certain that they were workable, efficient, and expandable. Subsequently, costs for building and implementing mills were obtained from equipment dealers and related suppliers. Modifications in design were made at this time to account for adaptation of standard equipment and facilities in the mill instead of adhering to specifications that demanded custom-made items at higher prices (Appendix A). Yet, actual mill situations would probably require slight modification from these specifications due to the unique physical, feed, and financial requirements of each ranch.

Feed Ingredient Prices

The problem of forecasting feed ingredient prices to determine on-farm feed milling's total cost were not considered in this study because prices vary seasonally as well as from year to year. Rather, February 23, 1977 ingredient prices as paid by Arizona Feeds, a Tucson-based commercial feed processor, were used because they were relatively current Arizona quotations. As a result, these prices may differ from those paid by Arizona poultry ranchers due to volume purchases, hedging, and ranch location. Nevertheless, they provided a useful estimate which ranchers could easily substitute for once their individual ingredient prices are known.

Process Flow

The mills designed in this study were automatic electric and comprised three centers of operation: (1) receiving, (2) processing, and (3) mixing (Figure 1). Receiving entailed dumping bulk ingredients into a truck receiving hopper that conveyed the ingredients by gravity to a bucket elevator for storage in ingredient tanks. In this case, milo and soybean meal were the only bulk ingredients stored. All other ingredients were sacked and kept outside the mill building. Forklifts

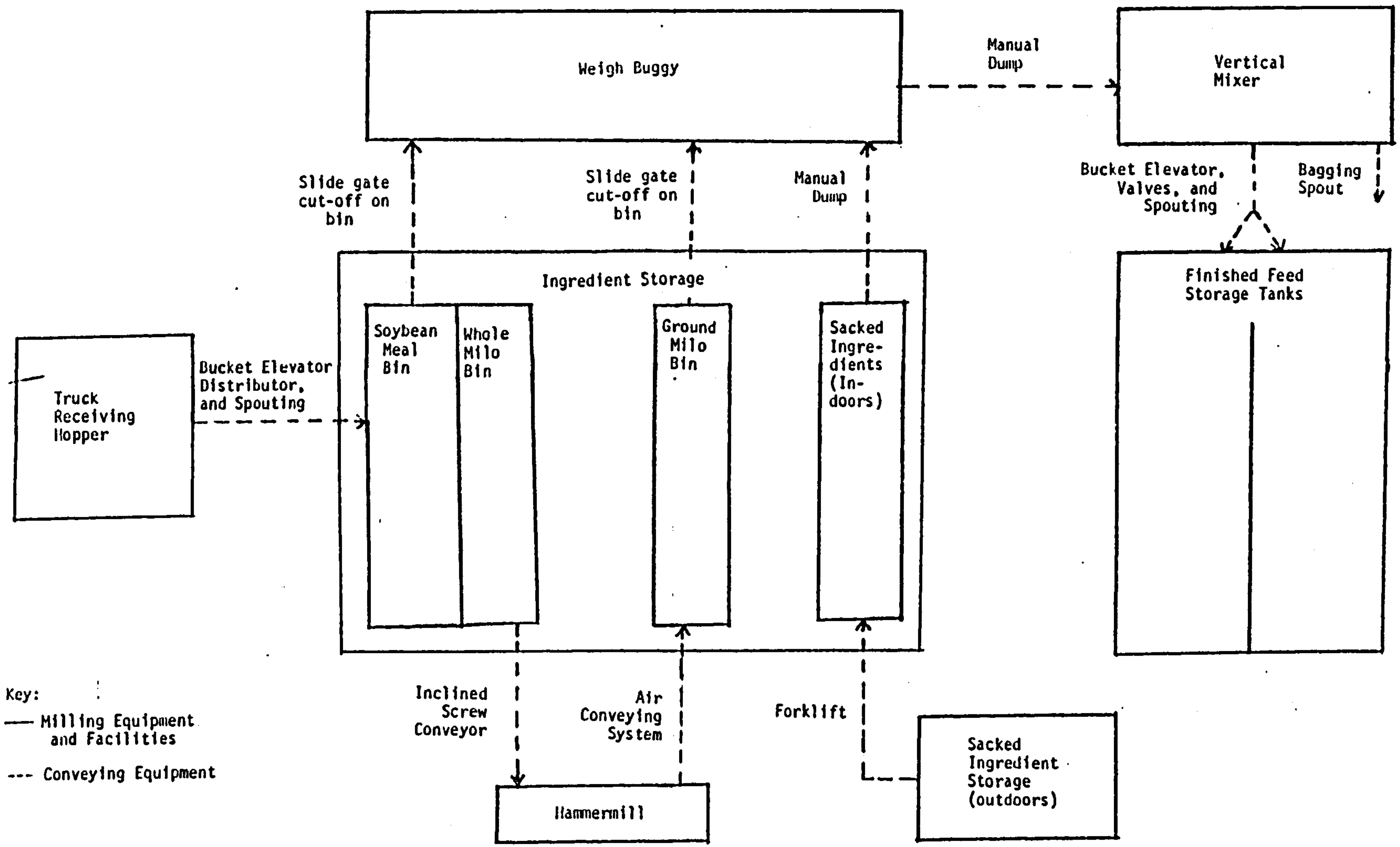

Figure 1. Process Flow for 30 Ton per 8 Hour Day On-Farm Feed Mill

were used to transfer sacked feed ingredients into the mill building when needed.

Processing involved grinding of grain into a digestable form. In this case, milo moved through discharge screw conveyors to the hammermill for grinding. At completion, milo was brought to a ground grain storage bin by either a screw or pneumatic conveyor, depending upon which was more efficient for the particular sized mill.

Mixing included combining all ingredients into a single feed ration and conveying it to a mill storage facility. Ingredients were unloaded in their proper proportions into a weigh buggy and then deposited into a vertical mixer. Next, mixed feed was discharged into a second bucket elevator and taken to finished feed storage.

No consideration was given to pelletizing feed. However, a bagging spout was included on the mixer because it provided an opportunity for storing feed at a relatively low cost in case of an emergency as well as providing the means to sell sacked feed.

Commercial Feed

Total costs for purchasing commercial feed equivalent to that produced on-farm were obtained from Arizona Feeds, Tucson (Table 4). Their prices were assumed representative of feed costs currently encurred by Arizona poultry ranchers although Arizona Feeds was not the only source of poultry feed for the state. Included in them were charges for feed, delivery, and state tax. Volume discounts were not considered because they were believed to vary among feed producers and ranchers.

Table 4. Total Costs per Ton of Commercial Feed Formula by Flock Size.

Cost Components	Cost per Ton Flock Size		
	75,000 (dollars)	150,000 (dollars)	300,000 (dollars)
Commercial feed formula	$148.78	$148.78	$148.78
Delivery charge[a]	6.50	6.50	6.50
Tax[b]	.58	.58	.58
TOTAL	155.86	155.86	155.86

a. Assumed a 30-mile one-way haul from commercial plant to poultry ranch.

b. Tax -- 3/8 of one percent.

Procedure for the Analysis

Average annual costs were used to determine the economic feasibility of on-farm feed milling on Arizona poultry ranches based upon cost comparisons analysis with commercial feed acquisition. Production costs were also computed for Year 1 to permit poultry ranchers to assess the initial financial requirements of operating an on-farm feed mill.

The criterion used for evaluating on-farm feed milling was cost per ton of feed because of its traditional application in the literature. Accordingly, the qualitative equivalency between on-farm processed feed and commercial feed was assumed. No basis was found for using cost per unit of product over cost per ton of feed as suggested by Dauzat and Roy (1975).

Total investment was calculated for each model mill and used for estimating annual production costs. Subsequently, annual depreciation, interest on investment, insurance, taxes, and costs for electricity and repairs were determined based upon assumptions and sources given in Tables 6 and 17. However, further explanation of annual depreciation follows to cite effects of different derivation techniques on total cost.

Annual investment in equipment and facilities were computed using the traditional method of averaging initial investment and salvage value. However, Selley (1977) pointed out that this method understates the interest on investment and, therefore, annual cost of mill operation. The basic reason for the underestimate is that the time value of funds is overlooked in the traditional method. For example, higher interest costs would result from more frequent replacement of equipment or facilities whereas interest costs would remain constant when estimated using the traditional method.

Costs to determine the magnitude of the underestimate of interest in using the traditional method and changes in interest costs that evolve from use of the net present value method were determined. Specifically, interest costs for the mill were calculated using the present value method with an 8.5 percent interest rate. Then, the interest rate required to provide the same interest cost using the depreciation method was computed (Appendix B). Although interest costs were underestimated by 26 and 33 percent for assets having useful lifetimes of 17 and 25 years, respectively, in no case were the conclusions of this study altered by use of the depreciation method versus the net present value method.

Subtracting on-farm feed milling's annual production cost per ton from commercial feed's cost per ton yielded the maximum ingredient cost per ton for on-farm feed milling economic feasibility. Consequently, ingredients costing more than this dollar amount per ton ensured a loss from on-farm feed milling while ingredients costing less indicated cost-savings.

Cost of ingredients per ton of finished feed was computed by adding the products of the total cost per hundredweight for each ingredient and its proportion in the layer diet and multiplying that sum by twenty (since 20 cwt = 1 ton). Summing finished feed's ingredient cost per ton and the production cost per ton yielded on-farm feed milling total cost per ton.

Cost-savings or losses per ton were derived by subtracting the cost per ton of on-farm feed milling from commercial feed. Time to repay the on-farm feed milling initial investment was estimated by dividing the initial mill investment by depreciation and interest on investment (Dauzat and Roy 1975). Furthermore, a payout period was predicted that included cost-savings for repayment of the initial investment.

Cost reductions per ton of on-farm milled feed due to increases in daily tonnage produced were investigated to determine the existence and degree of economies of size. Furthermore, relationships among cost items for on-farm feed milling were traced through a percentage distribution of production costs.

Effects of less than 100 percent capacity utilization of on-farm feed milling total cost per ton were examined to find at what utilization rates, if any, on-farm feed milling cost more than using commercial feed. This is extremely important to Arizona poultry ranchers since flock sizes, and hence, feed requirements can vary considerably over time. Fixed cost per ton was adjusted proportionally for decreases in feed production and equipment depreciation. Equipment depreciation decreased proportionally to capacity utilization since less usage extended equipment lifetimes. Variable cost per ton was reduced 10 percent less than output due to inherent fixed characteristics: for example, electrical power usage where mill facilities must be lighted during mill operations regardless of the amount of finished feed produced (Austin and Nelson 1966). Labor costs were also reduced in this process making the mill operator's job part-time although the mill operator would be probably assigned other farm duties so that he would not seek employment elsewhere. Total costs per ton were then determined for 80, 60, and 40 percent capacity utilizations.

Relationships between fixed and variable costs were also changed to study the effects of adding a second 8 hour work shift to Arizona on-farm feed mills. Operating mills at 100 percent capacity with two 8 hour work shifts was explored as a lower cost alternative to investing in larger plants that produced the same amount of feed.

Finally, Wilson's claim (1975) that feed costs were the primary factor affecting the competitive disadvantage of Arizona egg producers with respect to California producers prompted investigating on-farm feed milling as a means of offsetting this disadvantage. Thus, percent reductions in feed costs associated with on-farm feed milling were compared to the percent reductions estimated by Wilson (1975) to produce eggs at feed costs equivalent to California.

CHAPTER III

RESULTS OF THE ANALYSIS

Costs of on-farm feed milling and commercial feed acquisition are compared in this chapter. In addition, costs associated with on-farm feed milling are detailed. Calculations of initial investment for the 15, 30, and 60 ton per 8 hour day mills are made which become the foundation for determining costs on an average annual and Year 1 basis. The following variables are estimated: production costs, production cost per ton, maximum ingredient cost per ton for on-farm feed milling economic feasibility, ingredient cost per ton, cost-savings, total cost, total cost per ton, and time required to repay the initial investment. Economies of size, cost component relationships, capacity utilization at levels less than 100 percent, and capital versus labor intensive mills are discussed. Finally, the cost of on-farm processed feed is compared to cost reductions necessary to become competitive with California egg producers as determined by Wilson (1975).

Average Annual Costs Associated with On-Farm Feed Milling

On-farm feed milling provided feed at less cost than commercial acquisition on an average annual basis. It resulted in cost-savings and repayed the initial investment during the useful lifetime of the investment. A useful life of 25 years for facilities and 17 years for equipment was assumed.

Initial investments for 15, 30, and 60 ton per 8 hour day on-farm feed mills on Arizona poultry ranches were $85,683, $95,905, and $105,671, respectively (Table 5). Total production costs for the average year amounted to $29,692, $33,199, and $38,720 (Table 6). Consequently, average annual production costs per ton were $7.92, $4.43, and $2.58 (Table 6).

The total cost of commercial feed was estimated at $155.86 per ton which made the average annual maximum ingredient costs for on-farm feed milling feasibility $147.94, $151.43, and $153.28 per ton, respectively, for the 15, 30, and 60 ton mills (Table 7). Since ingredient cost per ton of finished feed was $137 (Table 8), cost-savings were apparent for the on-farm feed milling alternative.

Total average annual costs per ton for on-farm feed milling were $144.92, $141.43, and $139.58 (Table 9) which provided average annual cost-savings per ton of $10.94, $14.43, and $16.28 (Table 10). The required time to repay the initial investment for each mill was 10.72, 10.79, and 10.76 years (Table 11). However, inclusion of cost-savings to repay initial investment reduced the time required to 1.75, .82, and .42 years.

Average Annual Cost Relationships for On-Farm Feed Milling

Economies of Size

Economies of size existed for on-farm feed milling because cost-savings were greatest for larger volume egg producers requiring greater feed tonnages (Table 12). Average annual cost reductions per ton of

Table 5. Initial Investment for On-Farm Feed Milling on Arizona Poultry Ranches by Daily Tonnage Produced.

Investment Components	Initial Investment Tons per Day		
	15	30	60
Bulk ingredients:			
Receiving system[a]	$ 6,774	$ 6,774	$ 6,774
Storage tanks[b]	7,131	8,350	9,461
Hammermill	2,004	3,264	4,592
Pneumatic conveyor	--	1,188	1,188
Screw conveyor	800	--	--
Feed mixing system complete	3,195	3,195	3,843
Bucket elevator, valves, spouting, finished feed storage tanks	6,087	7,916	7,916
Building	13,650	13,650	13,650
Wiring	5,850	7,150	11,050
Fork lift	16,800	16,800	16,800
Freight[c]	2,599	3,069	3,377
Erection[d]	19,493	23,015	25,331
Sales Tax[e]	1,300	1,534	1,689
TOTAL	$85,683	$95,905	$105,671

a. Includes truck receiving hopper, bucket elevator, distributor and spouting.

b. Includes discharge screw conveyors.

c. Freight -- 10 percent on initial investment minus mill building, wiring, forklift, erection and sales tax (Sanderson 1977).

d. Erection -- 75 percent on initial investment minus mill building, wiring, forklift, freight and sales tax (Sanderson 1977).

e. Sales tax -- 5 percent on initial investment minus mill building, wiring, forklift, erection and freight (Sanderson 1977).

Table 5. Initial Investment for On-Farm Feed Milling on Arizona Poultry Ranches by Daily Tonnage Produced.

Investment Components	Initial Investment Tons per Day		
	15	30	60
Bulk ingredients:			
Receiving system[a]	$ 6,774	$ 6,774	$ 6,774
Storage tanks[b]	7,131	8,350	9,461
Hammermill	2,004	3,264	4,592
Pneumatic conveyor	--	1,188	1,188
Screw conveyor	800	--	--
Feed mixing system complete	3,195	3,195	3,843
Bucket elevator, valves, spouting, finished feed storage tanks	6,087	7,916	7,916
Building	13,650	13,650	13,650
Wiring	5,850	7,150	11,050
Fork lift	16,800	16,800	16,800
Freight[c]	2,599	3,069	3,377
Erection[d]	19,493	23,015	25,331
Sales Tax[e]	1,300	1,534	1,689
TOTAL	$85,683	$95,905	$105,671

a. Includes truck receiving hopper, bucket elevator, distributor and spouting.

b. Includes discharge screw conveyors.

c. Freight -- 10 percent on initial investment minus mill building, wiring, forklift, erection and sales tax (Sanderson 1977).

d. Erection -- 75 percent on initial investment minus mill building, wiring, forklift, freight and sales tax (Sanderson 1977).

e. Sales tax -- 5 percent on initial investment minus mill building, wiring, forklift, erection and freight (Sanderson 1977).

Table 6. Average Annual Production Costs for On-Farm Feed Milling on Arizona Poultry Ranches by Daily Tonnage Produced.

Cost Components	Average Annual Production Costs Tons per Day		
	15	30	60
Fixed Costs			
Investment			
Depreciation			
Facilities[a]	$ 1,325	$ 1,592	$ 1,700
Equipment[b]	2,840	3,019	3,405
TOTAL	4,165	4,611	5,105
Interest on investment[c]	3,824	4,280	4,716
Insurance[d]	425	463	487
Taxes[e]	926	1,036	1,141
TOTAL	9,340	10,390	11,449
Total fixed costs	9,340	10,390	11,449
Average fixed cost per ton	2.49	1.39	.76
Variable Costs			
Labor			
Wage[f]	$ 8,320	$ 8,320	$ 8,320
FICA[g], Workmen's Compensation[h], and benefits[i]	2,579	2,579	2,579
TOTAL	10,899	10,899	10,899
Repairs[j]	4,713	5,275	5,812
Electrical[k]	4,740	6,635	10,560
Total variable costs	20,352	22,809	27,271
Average variable cost per ton	5.43	3.04	1.82
Total production costs	$29,692	$33,199	$38,720
Average annual production cost per ton	7.92	4.43	2.58

a. Depreciation — 25 years straight line depreciation (Vosloh 1976), 5 percent salvage value (matches IRS allowance).

b. Depreciation -- 17 years straight line depreciation (Vosloh 1976), 5 percent salvage value (matches IRS allowance).

c. Interest on investment -- 8-1/2 percent on one-half initial investment and salvage value (matches interest on long-term safe investment in today's money market assuming the availability of equity for financing).

Table 6. (continued)

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d. Insurance -- one-half initial investment multiplied by the proportion of insurance for Year I to initial investment; includes liability on products and premises, fire and vandalism.

e. Taxes -- one-half initial investment multiplied by the proportion of taxes for Year I to initial investment.

f. Labor -- one man at $4.00 per hour, 40 hours per week (Poppy 1977).

g. FICA -- 5.85 percent of salary (Natl. Coun. on Comp. Ins. 1976).

h. Workmen's compensation -- 10.15 percent of salary (National Council on Compensation Insurance 1976).

i. Fringe benefits -- 15.00 percent of salary (Hathorn 1977); includes hospitalization, pre-paid insurance, vacation pay, and health benefits.

j. Repairs -- 5-1/2 percent on initial investment (Vosloh 1976).

k. Electrical -- Estimate from Tucson Gas and Electric, including general service rate and tax (Rate 10 Schedule).

Table 7. Average Annual Maximum Ingredient Costs for On-Farm Feed Milling Feasibility on Arizona Poultry Ranches by Daily Tonnage Produced.

	Cost per Ton Tons per Day		
	15	30	60
Commercial feed formula cost	$155.86	$155.86	$155.86
On-farm feed milling average annual production costs	7.92	4.43	2.58
Maximum ingredient cost for on-farm feed milling feasibility	$147.94	$151.43	$153.28

Table 8. Feed Ingredient Prices for On-Farm Feed Milling on Arizona Poultry Ranches — February 23, 1977.

Ingredient	Price ($ per cwt)	Tax[a] ($)	Total Cost ($ per cwt)	Ingredient as a Percent of Layer Diet (percent)	Ingredient Cost per cwt of Finished Feed (dollars)
Milo	4.82	.02	4.84	.6410	3.10
Soybean meal (dehulled)	12.52	.05	12.57	.1585	1.99
Meat and bone scrap	12.50	.05	12.55	.0510	.64
Alfalfa meal (dehy.)	5.75	.02	5.77	.0510	.29
Dicalcium phosphate	11.05	.04	11.09	.0110	.12
Calcium carbonate	.55	.00	.55	.0710	.04
Salt	.93	.00	.93	.0060	.01
Vitamin mix (PR-9)	35.73	.13	35.86	.0020	.07
DL-Methionine	95.00	.36	95.36	.0060	.57
Trace mineral mix (VA)	15.00	.06	15.06	.0015	.02
On-farm finished feed	6.85				

Total ingredient cost per one cwt of finished feed:	$ 6.85
Since 20 cwt = 1 ton	x 20
Thus, ingredient cost per ton of finished feed	$137.00

a. Tax equals 3/8 of one percent.

Table 9. Average Annual Cost per Ton for On-Farm Feed Milling on Arizona Poultry Ranches by Daily Tonnage Produced.

Cost Components	Cost per Ton Tons per Day		
	15	30	60
Ingredient cost	$137.00	$137.00	$137.00
Average annual production cost	7.92	4.43	2.58
TOTAL	$144.92	$141.43	$139.58

Table 10. Average Annual Cost-Savings per Ton for On-Farm Feed Milling on Arizona Poultry Ranches by Daily Tonnage Produced.

Cost Components	Cost-Savings per Ton Tons per Day		
	15	30	60
Commercial feed formula cost	$155.86	$155.86	$155.86
On-farm feed milling cost	144.92	141.43	139.58
COST-SAVINGS PER TON	$ 10.94	14.43	16.28

Table 11. Time to Repay On-Farm Feed Milling Initial Investment on an Average Annual Basis on Arizona Poultry Ranches by Daily Tonnage Produced.

Payout	Time to Repay Initial Investment on an Average Annual Basis Tons per Day		
	15	30	60
	years		
Including cost-savings	1.75	.82	.42
Not including cost-savings	10.72	10.79	10.76

Table 12. Average Annual Cost Reductions per Ton of Feed Due to Increases in Daily Tonnage Produced.

Tons per Day	Cost per Ton		Difference
15	$144.92		
			$3.49
30	141.43		
			1.85
60	139.58		
		TOTAL	$5.34

feed due to daily production increases from 15 to 30 and 30 to 60 tons were $3.49 and $1.85 per ton. Economies of size, therefore, influenced on-farm feed milling average annual production costs by a total cost reduction of $5.34 per ton.

Cost Component Relationships

The identification of major cost components is important in feasibility decisions. In this study, labor costs were highest as a proportion of average annual production costs at all levels of feed production (Table 13). Labor costs decreased, however, from 36.7 to 28.1 percent of average annual production costs as physical plant increased from 15 ton to 60 ton capacity since the labor requirement and cost of one man to operate the mill remained constant regardless of mill size. Consequently, labor costs were semi-variable in that they increased for additional production on existing mill facilities in the form of additional work shifts but not as plant investment increased.

Electrical costs were the next largest expense of average annual production costs at all levels of feed production and increased from 16.0 to 27.3 percent as physical plant increased from 15 ton to 60 ton capacity due to actual increases in expenditure. All other cost items remained relatively stable as a proportion of average annual production costs when physical plant increased.

Capacity Utilization

The profitability of operating feed mills at 80, 60, and 40 percent of designed capacity was synthesized to account for variability in flock size. Average annual total costs per ton for on-farm feed milling

Table 13. Percentage Distribution of Average Annual Production Costs Among Cost Items for On-Farm Feed Milling on Arizona Poultry Ranches by Daily Tonnage Produced.

Cost Components	Percentage Distribution of Average Annual Production Costs Tons per Day		
	15	30	60
	- - - - - - - - percent - - - - - - -		
Fixed Costs			
Investment			
Depreciation			
Facilities	4.5	4.8	4.4
Equipment	9.6	9.1	8.8
TOTAL	14.1	13.9	13.2
Interest on Investment	12.9	12.9	12.2
Insurance	1.4	1.4	1.3
Taxes	3.1	3.1	2.9
TOTAL	31.5	31.3	29.6
Total fixed costs	31.5	31.3	29.6
Variable Costs			
Labor			
Wage	28.0	25.0	21.4
FICA, Workmen's Compensation, and Benefits	8.7	7.8	6.7
TOTAL	36.7	32.8	28.1
Repairs	15.8	15.9	15.0
Electrical	16.0	20.0	27.3
Total variable costs	68.5	68.7	70.4
Total Production Costs	100.0	100.0	100.0

remained below the cost for commercial feed at each level of capacity utilization for the model mills (Table 14). The highest average total cost per ton was $149.30 at 40 percent capacity of the 15 ton mill which still provided a cost-saving of $6.56 per ton.

Capital Versus Labor Intensive Mills

Costs were compared to determine the least cost alternative between building a larger capacity mill or adding an 8 hour work shift on 15 and 30 ton per 8 hour day mills for producing twice as much feed per day (Table 15). Investment in larger plant capacity resulted in ranchers encurring lower costs than using two 8 hour shifts on 15 and 30 ton mills. Specifically, one 8 hour shift on the 30 ton mill cost $141.43 per ton, $2.62 less than two 8 hour shifts on the 15 ton mill; one 8 hour shift on the 60 ton mill cost $139.58 per ton, $1.36 less than two 8 hour shifts on the 30 ton mill. The cost per ton difference was attributed to the labor intensive mills' increased fixed cost from accelerated depreciation and a twofold increase of variable cost which resulted from the doubling of each variable cost component. Furthermore, there were no increases in variable cost for larger capacity mills.

Elimination of Arizona Competitive Disadvantage

Percent reductions in feed costs resulting from the use of 15, 30, and 60 tons per 8 hour day on-farm feed mills were 7.0, 9.3, and 10.5 percent during the average year (Table 16). These cost reductions, except for production at the 15 ton level, exceeded the 7.8 percent cost reduction necessary to become competitive with California egg producers as determined by Wilson (1975).

Table 14. Average Annual Cost per Ton for On-Farm Feed Milling on Arizona Poultry Ranches at Various Capacity Levels by Daily Tonnage Produced.

Capacity Level (%) Tons per 8-hour Day	Fixed Cost[a]	Average Fixed Cost per Ton	Variable Cost[b]	Average Variable Cost per Ton	Total Production Cost	Average Production Cost per Ton	Ingredient Cost per Ton	Average Total Cost per Ton	Commercial Feed
15 Ton:									
100% (3,750)[c] [75,000][d]	$9,340	$2.49	$20,352	$5.43	$29,692	$ 7.92	$137	$144.92	$155.86
80% (3,000) [60,000]	8,867	2.96	18,317	6.10	27,184	9.06	137	146.06	155.86
60% (2,250) [45,000]	8,529	3.79	14,247	6.33	22,776	10.12	137	147.12	155.86
40% (1,500) [30,000]	8,275	5.52	10,176	6.78	18,451	12.30	137	149.30	155.86
30 Ton									
100% (7,500) [150,000]	10,390	1.39	22,809	3.04	33,199	4.43	137	141.43	155.86
80% (6,000) [120,000]	9,887	1.65	20,528	3.42	30,415	5.07	137	142.07	155.86
60% (4,500) [90,000]	9,527	2.12	15,966	3.55	25,493	5.67	137	142.67	155.86
40% (3,000) [60,000]	9,258	3.09	11,405	3.80	20,663	6.89	137	143.89	155.86
60 Ton									
100%(15,000) [300,000]	11,449	.76	27,271	1.82	38,720	2.58	137	139.58	155.86
80%(12,000) [240,000]	10,882	.91	24,544	2.04	35,426	2.95	137	139.95	155.86
60% (9,000) [180,000]	10,476	1.17	19,090	2.12	29,566	3.29	137	140.29	155.86
40% (6,000) [120,000]	10,172	1.70	13,636	2.27	23,808	3.97	137	140.97	155.86

a. Fixed costs were reduced at lower capacity levels due to decreases in depreciation. Depreciation of equipment for 80, 60, and 40 percent capacity was based upon lifetimes of 20.4, 23.8, and 27.2 years.

b. Variable costs were reduced 10% less than output at decreasing capacity levels due to certain costs in the variable classification depicting "fixed" characteristics such as electricity (i.e., a fixed amount of electricity will be needed to light the mill building). This adjustment was adopted from Austin and Nelson (1966).

c. Tons of finished feed produced by capacity level.

d. Number of layers fed at various capacity levels by daily tonnage produced.

Table 15. Average Annual Production Costs at 100% Capacity, One and Two 8 Hour Shifts, for On-Farm Feed Milling on Arizona Poultry Ranches by Daily Tonnage Produced (8 Hour Shift).

Cost Components	Average Annual Production Costs Tons per Day					
	15		30		60	
	1 Shift	2 Shifts	1 Shift	2 Shifts	1 Shift	2 Shifts
Fixed Costs						
Investment:						
Depreciation						
Facilities	$1,325	$1,325	$1,592	$1,592	$1,700	$1,700
Equipment[a]	2,840	5,680	3,019	6,038	3,405	6,810
Interest on investment	3,824	3,824	4,280	4,280	4,716	4,716
Insurance	425	425	463	463	487	487
Taxes	926	926	1,036	1,036	1,141	1,141
Total fixed cost	9,340	12,180	10,390	13,409	11,449	14,854
Average fixed cost per ton	2.49	1.62	1.39	.89	.76	.50
Variable Costs						
Labor[b]						
Wage	$8,320	$16,640	$8,320	$16,640	$8,320	$16,640
FICA, Workmen's Compensation, and Benefits	2,579	5,158	2,579	5,158	2,579	5,158
Total	10,899	21,798	10,899	21,798	10,899	21,798
Repairs[b]	4,713	9,426	5,275	10,550	5,812	11,624
Electrical[b]	4,740	9,480	6,635	13,270	10,560	21,120
Total variable cost	20,352	40,704	22,809	45,618	27,271	54,542
Average variable cost per ton	5.43	5.43	3.04	3.04	1.82	1.82
Total production cost	29,692	52,884	33,199	59,027	38,720	69,396

Table 15. (continued)

Cost Components	Average Annual Production Costs Tons per Day					
	15		30		60	
	1 Shift	2 Shifts	1 Shift	2 Shifts	1 Shift	2 Shifts
Average production cost per ton	$ 7.92	$ 7.05	$ 4.43	$ 3.94	$ 2.58	$ 2.31
Ingredient cost per ton	137.00	137.00	137.00	137.00	137.00	137.00
Average total cost per ton	144.92	144.05	141.43	140.94	139.58	139.31
Commercial feed formula	155.86	155.86	155.86	155.86	155.86	155.86

a. Depreciation of equipment for 2 shift mill was based upon a lifetime of 8.5 years.

b. Repairs, labor and electricity were assumed to increase proportionally with usage.

Table 16. Average Percent Reduction in Feed Costs for On-Farm Feed Milling on Arizona Poultry Ranches Versus Required Percent Reductions to Eliminate California Production from the Arizona Egg Market by Daily Tonnage Produced.

Item	Reduction in Feed Costs Tons per Day		
	15	30	60
Percent reduction in Arizona feed costs required to eliminate California production from the Arizona market (Wilson 1975)	7.8%	7.8%	7.8%
Percent reduction in Arizona feed costs resulting from on-farm feed milling at 100% capacity	7.0%	9.3%	10.5%

Year 1 Costs Associated with On-Farm Feed Milling

Production costs for Year 1 were computed to ascertain the poultry rancher's initial cash flow so that an assessment of the capital available versus the initial financial requirements of operating an on-farm feed mill could be made by individual ranchers. However, it appeared that capital availability would not be a problem since the cost per ton of on-farm processed feed remained below the cost per ton of commercial feed.

Year 1 annual production costs were higher than the average year due to higher than average annual fixed costs (Table 17). This was attributed to the investment being worth more in its first year of operation than in the average year which resulted in higher costs for interest on investment, insurance and taxes. Thus, total Year 1 production costs were $34,866, $38,977, and $45,065 having production costs per ton of $9.30, $5.20, and $3.00. Maximum ingredient costs for on-farm feed milling feasibility were lower at $146.56, $149.66 and $152.86 per ton (Table 18), but still provided cost-savings since ingredient cost per ton of finished feed was $137.00. Total Year 1 production costs per ton were higher at $146.30, $142.20, and $140.00 (Table 19) which provided lower cost-savings per ton of $9.56, $13.66, and $15.86 (Table 20).

The payout periods if Year 1 depreciation and interest on investment were constant throughout the mill's useful lifetime were 7.25, 7.28, and 7.27 years and 1.88, .86, and .43 years when cost-savings was included (Table 21). Consequently, the actual payout periods for the mills lie between the Year 1 and average year estimates because: (1)

Table 17. Year 1 Production Costs for On-Farm Feed Milling on Arizona Poultry Ranches by Daily Tonnage Produced.

Cost Components	Year I Production Costs Tons per Day		
	15	30	60
Fixed Costs			
Investment			
Depreciation			
Facilities[a]	$1,325	$1,592	$1,700
Equipment[b]	2,840	3,019	3,405
Total	4,165	4,611	5,105
Interest on investment[c]	7,648	8,560	9,432
Insurance[d]	850	925	975
Taxes[e]	1,851	2,072	2,282
Total	14,514	16,168	17,794
Total Fixed Costs	14,514	16,168	17,794
Average fixed cost per ton	3.87	2.16	1.19
Variable Costs			
Labor			
Wage[f]	$8,320	$8,320	$8,320
FICA[g], Workmen's Compensation[h], and benefits	2,579	2,579	2,579
Total	10,899	10,899	10,899
Repairs[j]	4,713	5,275	5,812
Electrical[k]	4,740	6,635	10,560
Total variable costs	20,352	22,809	27,271
Average variable cost per ton	5.43	3.04	1.82
Total production costs	$34,866	$38,977	$45,065
Year I production cost per ton	9.30	5.20	3.00

a. Depreciation -- 25 years straight line depreciation (Vosloh 1976), 5 percent salvage value (matches IRS allowance).

b. Depreciation -- 17 years straight line depreciation (Vosloh 1976), 5 percent salvage value (matches IRS allowance).

c. Interest on Investment -- 8-1/2 percent on initial investment and salvage value (matches interest on long-term safe investment in today's money market assuming the availability of equity for financing).

Table 17. (continued)

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d. Insurance -- Estimate from McGhee (1977); includes liability on products and premises, fire and vandalism.

e. Taxes -- Estimate from Dalton (1977).

f. Labor -- one man at $4.00 per hour, 40 hours per week (Poppy 1977)

g. FICA -- 5.85 percent of salary (National Council on Compensation Insurance 1976).

h. Workmen's Compensation -- 10.15 percent of salary (National Council on Compensation Insurance 1976).

i. Fringe benefits -- 15 percent of salary (Hathorn 1977); includes hospitalization, prepaid insurance, vacation pay, and health benefits.

j. Repairs -- 5-1/2 percent on initial investment (Vosloh 1976).

k. Electrical -- Estimate from Tucson Gas and Electric, including general service rate and tax (Rate 10 Schedule).

Table 18. Year 1 Maximum Ingredient Costs for On-Farm Feed Milling Feasibility on Arizona Poultry Ranches by Daily Tonnage Produced.

Item	Cost per Ton Tons per Day 15	 30	 60
Commercial feed formula cost	$155.86	$155.86	$155.86
On-farm feed milling Year I production costs	9.30	6.20	3.00
Maximum ingredient costs for on-farm feed milling feasibility	$146.56	$149.66	$152.86

Table 19. Year 1 Cost per Ton for On-Farm Feed Milling on Arizona Poultry Ranches by Daily Tonnage Produced.

Cost Components	Cost per Ton Tons per Day 15	 30	 60
Ingredient cost	$137.00	$137.00	$137.00
Year 1 production cost	9.30	5.20	3.00
TOTAL	$146.30	$142.20	$140.00

Table 20. Year 1 Cost-Savings per Ton for On-Farm Feed Milling on Arizona Poultry Ranches by Daily Tonnage Produced.

Item	Cost-Savings per Ton Tons per Day		
	15	30	60
Commercial feed formula	$155.86	$155.86	$155.86
On-farm feed milling	146.30	142.20	140.00
Cost-savings per ton	$ 9.56	$ 13.66	$ 15.86

Table 21. Time to Repay On-Farm Feed Milling Initial Investment on a Year 1 Basis on Arizona Poultry Ranches by Daily Tonnage Produced.

Payout	Time to Repay Year 1 Initial Investment on a Year 1 Basis Tons per Day		
	15	30	60
	- - - - - - - - years - - - - - - - -		
Including cost-savings	1.88	.86	.43
Not including cost-savings	7.25	7.28	7.27

the payout period based on the average year overstates the actual since more depreciation and interest are payed out before the average year, and (2) the payout period based on Year 1 understates the actual since less depreciation and interest on investment are payed out after the first year.

Year 1 Cost Relationships for On-Farm Feed Milling

Economies of Size

As expected, economies of size were larger for on-farm feed milling during Year 1 than on an average annual basis due to Year 1's higher production costs (Table 22). Year 1 cost reductions per ton of feed due to daily production increases from 15 to 30 and 30 to 60 tons were $4.10 and $2.20 per ton; therefore, total cost reductions from economies of size were $6.30 per ton.

Cost Component Relationships

Increases in interest on investment, the second largest expense, reduced variable costs as a proportion of total production costs for the model mills (Table 23). Labor costs remained highest as a proportion of total production costs but at a lower level of 31.3 to 24.2 percent as physical plant increased from 15 to 60 ton capacity. Electrical costs followed interest on investment as the next major expense ranging from 13.6 to 23.4 percent of total production costs.

Table 22. Year 1 Cost Reductions per Ton of Feed Due to Increases in Daily Tonnage Produced.

Tons per Day	Cost per Ton		Difference
15	$146.30		
			$4.10
30	142.20		
			2.20
60	140.00		
		TOTAL	$6.30

Table 23. Percentage Distribution of Year 1 Production Costs Among Cost Items for On-Farm Feed Milling on Arizona Poultry Ranches by Daily Tonnage Produced.

Cost Components	Percentage Distribution of Year I Production Costs Tons per Day		
	15	30	60
	- - - - - - - percent - - - - - - -		
Fixed Costs			
Investment			
Depreciation			
Facilities	3.8	4.1	3.8
Equipment	8.1	7.7	7.6
Interest on investment	21.9	22.0	20.9
Insurance	2.4	2.4	2.2
Taxes	5.3	5.3	5.1
Total	41.6	41.5	39.5
Total Fixed Costs	41.6	41.5	39.5
Variable Costs			
Labor			
Wage	23.9	21.3	18.5
FICA, Workmen's Compensation and Benefits	7.4	6.6	5.7
Total	31.3	28.0	24.2
Repairs	13.5	13.5	12.9
Electrical	13.6	17.0	23.4
Total Variable Costs	58.4	58.5	60.5
Total Production Costs	100.0	100.0	100.0

Capacity Utilization and Capital Versus Labor Intensive Mills

Year 1 total costs per ton for on-farm feed milling remained below the cost for commercial feed at each level of capacity utilization for the designed mills (Table 24). Furthermore, larger mill capacity provided lower costs per ton when producing 30 and 60 tons of feed per day than adding an 8 hour work shift on 15 and 30 ton per 8 hour day mills (Table 25).

Elimination of Arizona Competitive Disadvantage

Finally, the relative reductions in feed cost for Year 1 were 6.1, 8.8, and 10.2 percent for the 15, 30, and 60 ton mills (Table 26). These cost reductions, with the exception of the 15 ton level, exceeded the 7.8 percent cost reduction necessary to become competitive with California egg producers as determined by Wilson (1975).

Table 24. Year 1 Cost per Ton for On-Farm Feed Milling on Arizona Poultry Ranches at Various Capacity Levels by Daily Tonnage Produced.

Capacity Level (%) Tons per Day	Fixed Cost[a]	Average Fixed Cost per Ton	Variable Cost[b]	Average Variable Cost per Ton	Total Production Cost	Year I Production Cost per Ton	Ingredient Cost per Ton	Year I Total Cost per Ton	Commercial Feed
15 Ton:									
100% (3,750)[c] [75,000][d]	$14,514	$3.87	$20,352	$5.43	$34,866	$ 9.30	$137	$146.30	$155.86
80% (3,000) [60,000]	14,041	4.68	18,317	6.11	32,358	10.79	137	147.79	155.86
60% (2,250) [45,000]	13,703	6.09	14,247	6.33	27,950	12.42	137	149.42	155.86
40% (1,500) [30,000]	13,449	8.97	10,176	6.78	23,625	15.75	137	152.75	155.86
30 Ton:									
100% (7,500) [150,000]	16,168	2.16	22,809	3.04	38,977	5.20	137	142.20	155.86
80% (6,000) [120,000]	15,665	2.61	20,528	3.42	36,193	6.03	137	143.03	155.86
60% (4,500) [90,000]	15,305	3.40	15,966	3.55	31,271	6.95	137	143.95	155.86
40% (3,000) [60,000]	15,036	5.01	11,405	3.80	26,441	8.81	137	145.81	155.86
60 Ton:									
100%(15,000) [300,000]	17,794	1.19	27,271	1.82	45,065	3.00	137	140.00	155.86
80%(12,000) [240,000]	17,227	1.44	24,544	2.04	41,771	3.48	137	140.48	155.86
60% (9,000) [180,000]	16,821	1.87	19,090	2.12	35,911	3.99	137	140.99	155.86
40% (6,000) [120,000]	16,517	2.75	13,636	2.27	30,153	5.02	137	142.02	155.86

a. Fixed costs were reduced at lower capacity levels due to decreases in depreciation. Depreciation of equipment for 80, 60, and 40 percent capacity was based upon lifetimes of 20.4, 23.8, and 27.2 years.

b. Variable costs were reduced 10% less than output at decreasing capacity levels due to certain costs in the variable classification depicting "fixed" characteristics such as electricity (i.e., a fixed amount of electricity will be needed to light the mill building). This adjustment was adopted from Austin and Nelson (1966).

c. Tons of finished feed produced by capacity level.

d. Number of layers fed at various capacity levels by daily tonnage produced.

Table 25. Year 1 Production Costs at 100% Capacity, One and Two 8 Hour Shifts, for On-Farm Feed Milling on Arizona Poultry Ranches by Daily Tonnage Produced (8 Hour Shift).

Cost Components	Average Annual Production Costs Tons per Day					
	15		30		60	
	1 Shift	2 Shifts	1 Shift	2 Shifts	1 Shift	2 Shifts
Fixed Costs						
Investment:						
Depreciation						
Facilities	$1,325	$1,325	$1,592	$1,592	$1,700	$1,700
Equipment[a]	2,840	5,680	3,019	6,038	3,405	6,810
Interest on investment	7,648	7,648	8,560	8,560	9,432	9,432
Insurance	850	850	925	925	975	975
Taxes	1,851	1,851	2,072	2,072	2,282	2,282
Total fixed cost	14,514	17,354	16,168	19,187	17,794	21,199
Year I fixed cost per ton	3.87	2.31	2.16	1.28	1.19	.71
Variable Costs						
Labor[b]						
Wage	8,320	16,640	8,320	16,640	8,320	16,640
FICA, Workmen's Compensation and Benefits	2,579	5,158	2,579	5,158	2,579	5,158
Total	10,899	21,798	10,899	21,798	10,899	21,798
Repairs[b]	4,713	9,426	5,275	10,550	5,812	11,624
Electrical[b]	4,740	9,480	6,635	13,270	10,560	21,120
Total variable cost	20,352	40,704	22,809	45,618	27,271	54,542
Year I variable cost per ton	5.43	5.43	3.04	3.04	1.82	1.82

Table 25. (continued)

Cost Components	Average Annual Production Costs Tons per Day					
	15		30		60	
	1 Shift	2 Shifts	1 Shift	2 Shifts	1 Shift	2 Shifts
Total production cost	$34,866	$58,058	$38,977	$64,805	$45,065	$75,741
Year I production cost per ton	9.30	7.74	5.20	4.32	3.00	2.52
Ingredient cost per ton	137	137	137	137	137	137
Year I total cost per ton	146.30	144.74	142.20	141.32	140.00	139.52
Commercial feed formula	155.86	155.86	155.86	155.86	155.86	155.86

a. Depreciation of equipment for 2 shift mill is based upon a lifetime of 8.5 years.

b. Repairs, labor, and electricity were assumed to increase proportionally with usage.

Table 26. Year 1 Percent Reduction in Feed Costs for On-Farm Feed Milling on Arizona Poultry Ranches Versus Required Percent Reductions to Eliminate California Production from the Arizona Egg Market by Daily Tonnage Produced.

Item	Reduction in Feed Costs Tons per Day		
	15	30	60
	- - - - - - - percent - - - - - -		
Percent reduction in Arizona feed costs required to eliminate California production from the Arizona market (Wilson 1975)	7.8%	7.8%	7.8%
Percent reduction in Arizona feed costs resulting from on-farm feed milling at 100% capacity	6.1%	8.8%	10.2%

CHAPTER IV

SUMMARY AND CONCLUSIONS

The purpose of this study was to determine the economic feasibility of on-farm feed milling for Arizona poultry ranchers. Specifically, costs were estimated for on-farm feed milling versus commercial feed acquisition.

An economic-engineering approach was used to develop model designs and costs for on-farm feed mills at flock sizes of 75,000, 150,000 and 300,000 birds. As in any synthesis or budgeting approach, assumptions were inherent in their representation. The results provided input for poultry ranchers deciding among alternatives to reduce feed costs which according to Wilson (1975) would improve their competitive position in the Arizona egg market. Furthermore, this study supplied a method for ranchers to assess individual situations by substituting their own mill requirements and related prices into the feasibility framework.

Feasibility of on-farm feed milling existed in all model mills since cost per ton was less than cost per ton of commercial feed. The largest mill at 60 tons per 8 hour day yielded the lowest cost per ton, and thereby the highest cost-savings when compared against commercial feed.

Changes in relationships between fixed and variable costs per ton through capacity utilization or substituting additional labor for plant investment did not affect on-farm feed milling feasibility. Cost-savings were present for all mills as capacity utilization decreased to 40 percent. Additional labor requirements in the form of a second 8 hour work shift also provided cost-savings; yet these cost-savings were less than cost-savings from larger capacity mills. Thus, it was apparent that additional plant investment was the lower cost alternative as long as the additional capacity can be utilized.

The magnitude of reductions in feed costs against commercial feed provided Arizona egg producers with a better competitive position in the Arizona egg market. On-farm feed milling, except for production at the 15 ton per day level, allowed Arizona egg producers to produce eggs at feed costs less than California which would eliminate their competitive disadvantage.

Finally, farmers should now consider other factors that are necessary to the implementation of on-farm feed milling in Arizona. Most important are (1) labor and management availability, (2) ingredient availability, (3) capital or credit availability, (4) importance of services provided by commercial processing plant such as storage, credit, and nutritional advice, (5) feed quality, (6) profitability of an on-farm feed milling versus other forms of investment, (7) risks of discontinuing operations before equipment fully amortizes, equipment breakdown, and less available time for managing flock, and (8) access to markets.

Thus, the conclusions of this study are as follows:

1. On-farm feed milling is a feasible feed procurement alternative based upon cost comparisons to commercial feed

acquisition for Arizona poultry flock sizes of 75,000, 150,000, and 300,000 birds.

2. Flock sizes may decrease to 40 percent of capacity without influencing the feasibility of on-farm feed milling.
3. The choice of additional labor or plant investment to produce twice the amount of feed of an 8 hour per day mill does not influence the feasibility of on-farm feed milling at these flock sizes. However, larger capacity mills have greater cost-savings which makes them the lower cost alternative.
4. Economies of size were present for on-farm feed milling. No diseconomies of size were found for the production levels examined in this study.
5. On-farm feed milling, except at a flock size of 75,000 birds, eliminated the competitive disadvantage of Arizona egg producers according to Wilson (1975) by reducing feed costs to less than his estimate of feed costs in California.

APPENDIX A

PHYSICAL PLANT AND ESTIMATED COSTS FOR ON-FARM FEED MILLING ON ARIZONA POULTRY RANCHES

Table A-1. Physical Plant and Estimated Costs for 15 Ton per 8 Hour Day On-Farm Feed Mills on Arizona Poultry Ranches.

Item	Price
A. Facilities	
I. Mill Building — 20' x 40' x 20'; metal structure, tin siding, concrete floor; includes erection, materials, freight, and sales tax	$13,650
II. Ingredient Storage Bins — Outside type with hopper bottom, each with slide gate cut-off and ladder	
1 - 26.8 ton for soybean meal	1,567[a]
1 - 31.1 ton for ground milo	1,652[a]
III. Bulk Tanks -- Steel bulk tank on concrete pads; side-draw hoppered bottoms and ladder	
1 - 73.6 ton for whole milo	3,082[a]
IV. Bulk Tank -- Square overhead type, 60° corner draw hoppers, 18" sq. discharges, structural steel supports fabricated for bolted field erection and 18" rack and pinion gate	1,789[a]
1 - 30 ton for finished feed	
B. Equipment	
I. Receiving Center	
(a) Truck receiving hopper -- 4' x 10' x 4' including grate	484
(b) Bucket elevator: (1) 75 ft. high; 1500 bu./hr. capacity; service platform & ladder; self-adjusting boot cleanout	3,667
(2) 5 h.p. motor with drives	448
(c) Distributor — Turnhead type	
(1) 6 ducts; 10" diameter with manual remote control; 45° slope	645
(2) 1/4" diameter cable, 140 ft. long	10

Table A-1. Costs for 15 Ton (continued)

Item	Price
(d) Spouting:	
(1) Flanged; 14 gauge; 8" diameter; approximately 270 ft	$1,364
(2) 3-square 2 round adapters	84
(3) 6-Flangs	72
II. Processing Center	
(a) Screw conveyor, inclined: from whole milo tank to hammermill	
(1) 9" diameter; 10' long; 14 gauge; U trough	276
(2) 1 1/2 h.p. motor with magnetic starter and push button	137
(3) 1 belt drive sheave	387
(4) Discharge inlet	30
(b) Hammermill	
(1) Gravity discharge type, complete with base extension, coupling, and coupling guard for direct drive motor	1,259
(2) 10 h.p. motor	278
(3) Ammeter	96
(4) Magnet	271
(5) Starter	100
(c) Screw Conveyor, horizontal: from hammermill to bucket elevator	
(1) 9" diameter; 10' long; 14 gauge; U trough	276
(2) 2 h.p. motor with magnetic starter and push button	137
(3) 1 belt drive sheave	387
III. Mixing Center	
(a) Weigh buggy -- 1/2 ton capacity	672
(b) Vertical mixer:	

Table A-1. Costs for 15 Ton (continued)

Item	Price
(1) 100 cubic ft. capacity mixer (2 tons) and drive	$2,000
(2) 7 1/2 h.p. motor	230
(3) Bagging Spout	86
(4) V Belt Guard	197
(c) Discharge pipe -- 3 ft. long	10
(d) Bucket elevator:	
(1) 75 ft. high; 1500 bu./hr. capacity; service platform and ladder; self-adjusting boot cleanout	3,667
(2) 5 h.p. motor with drives	448
(e) Valves -- 2 way square valve; round opening; 12 gauge; 8" diameter; flanged.	143
(f) Spout: 1 - 8 ft. long; 14 gauge; 8" diameter	40
C. Miscellaneous Costs	
Freight @ 10% of investment minus mill building	2,599
Erection @ 75% of investment minus mill building	19,493
Sales Tax @ 5% of investment minus mill building	1,300
Wiring (with 30% contingency fund); includes installation and sales tax	5,850
Forklift -- 4,000 lb. load capacity; includes sales tax	16,800
TOTAL COST	$85,683

a. Reflects use of a .75 multiplier on original list price which provides a more accurate estimate of cost to the poultry rancher after negotiating price with storage facility dealers and allowing for dealer discounts (Lunt 1977).

Table A-2. Physical Plant and Estimated Costs for 30 Ton per 8 Hour Day On-Farm Feed Mills on Arizona Poultry Ranches.

Item	Price
A. Facilities	
I. Mill Building -- 20' x 40' x 20'; metal structure, tin siding, concrete floor; includes erection, materials, freight, and sales tax	$13,650
II. Ingredient Storage Bins -- Outside type with hopper bottom, each with slide gate cut-off and ladder	
1 - 51.1 ton for soybean meal	2,586[a]
1 - 66.1 ton for ground milo	2,912[a]
III. Flat-Bottom Tank (including ladder) -- 5,470 Bu. for whole milo	2,022[a]
IV. Bulk Tanks -- Square overhead type, 60° corner draw hoppers, 18" sq. discharges, structural steel supports fabricated for bolted field erection and 18" rack and pinion gate	
2 - 30 ton for finished feed	3,578[a]
B. Equipment	
I. Receiving Center	
(a) Truck receiving hopper -- 4' x 10' x 4' including grate	484
(b) Bucket elevator:	
(1) 75 ft. high; 1500 bu./hr. capacity; service platform and ladder; self-adjusting boot cleanout	3,667
(2) 5 h.p. motor with drives	448
(c) Distributor -- Turnhead type	
(1) 6 ducts; 10" diameter with manual remote control; 45° slope	645
(2) 1/4" diameter cable, 140 ft. long	10

Table A-2. Costs for 30 Ton (continued)

Item	Price
(d) Spouting	
(1) Flanged; 14 gauge; 8" diameter; approximately 270 ft.	$1,364
(2) 3 - Square 2 round adapters	84
(3) 6 - Flangs	72
II. Processing Center	
(a) Screw conveyor, inclined: from whole milo tank to hammermill	
(1) 9" diameter; 10' long; 14 gauge; U trough	276
(2) 2 h.p. variable speed gear motor with magnetic starter and push button	137
(3) 1 belt drive sheave	387
(4) Discharge inlet	30
(b) Hammermill	
(1) Gravity discharge type, complete with base extension, coupling, and coupling guard for direct drive motor	2,330
(2) 20 h.p. motor	467
(3) Ammeter	96
(4) Magnet	271
(5) Starter	100
(c) Air conveying system: from hammermill to bucket elevator (which transports ground milo to ground grain bin)	
(1) Air release fan, collector and pipe	908
(2) V belt and adjustable base	140
(3) 3 h.p. motor	140
III. Mixing Center	
(a) Weigh buggy -- 1/2 ton capacity	672
(b) Vertical Mixer	

Table A-2. Costs for 30 Ton (continued)

Item	Price
(1) 100 Cubic ft. capacity mixer (2-ton) and drive	$2,000
(2) 7 1/2 h.p. motor	230
(3) Bagging Spout	86
(4) V belt guard	197
(c) Discharge pipe -- 3 ft. long	10
(d) Bucket elevator:	
(1) 75 ft. high; 1500 bu./hr. capacity; service platform and ladder; self-adjusting boot cleanout	3,667
(2) 5 h.p. motor with drives	448
(e) Valves -- 3 way valve; 12 gauge, 8" diameter; flanged	143
(f) Spouting: 2 - 8 ft. long; 14 gauge; 8" diameter	80
C. Miscellaneous Costs	
Freight @ 10% of investment minus mill building	3,069
Erection @ 75% of investment minus mill building	23,015
Sales tax @ 5% of investment minus mill building	1,534
Wiring (with 30% contingency fund); includes installation and sales tax	7,150
Fork lift -- 4,000 lb. load capacity; includes sales tax	16,800
TOTAL COST	$95,905

a. Reflects use of .75 multiplier on original list price which provides a more accurate estimate of cost to the poultry rancher after negotiating price with storage facility dealers and allowing for dealer discounts (Lunt 1977).

Table A-3. Physical Plant and Estimated Costs for 60 Ton per 8 Hour Day On-Farm Feed Mills on Arizona Poultry Ranches.

Item	Price
A. Facilities	
I. Mill Building -- 20' x 40' x 20'; metal structure, tin siding, concrete floor; includes erection, materials, freight, and sales tax	$13,650
II. Flat Bottom Tanks (includes ladder)	
(a) 4,150 bu. for soybean meal	1,647[a]
(b) 4,750 bu. for ground milo	1,778[a]
(c) 12,000 bu. for whole milo	3,546[a]
III. Bulk Tanks -- Square overhead type, 60° corner draw-hoppers, 18" sq. discharges, structural steel supports fabricated for bolted field erection and 18" rack and pinion gate	
2 - 30 ton for finished feed	3,578[a]
B. Equipment	
I. Receiving Center	
(a) Truck receiving hopper -- 4' x 10' x 4' including grate	484
(b) Bucket elevator:	
(1) 75 ft. high; 1500 bu./hr. capacity; service platform and ladder; self-adjusting boot cleanout	3,667
(2) 5 h.p. motor with drives	448
(c) Distributor -- Turnhead type	
(1) 6 ducts; 10" diameter with manual remote control; 45° slope	645
(2) 1/4" diameter cable, 140 ft. long	10
(d) Spouting:	

Table A-3. Costs for 60 Ton (continued)

Item	Price
(1) Flanged; 14 gauge; 8" diameter; approximately 270 ft.	$1,364
(2) 3 - Square 2 round adapters	84
(3) 6 - Flangs	72
II. Processing Center	
(a) Screw conveyors, inclined: from whole milo tank to hammermill from soybean meal tank to weigh buggy from ground milo tank to weigh buggy	
(1) 3 - 9" diameter; 10 ft. long; 14 gauge; U trough	828
(2) 3 - 2 h.p. variable speed gear motors with magnetic starter and push button	411
(3) 3 - 1 belt drive sheaves	1,161
(4) 3 - Discharge inlets	90
(b) Hammermill	
(1) Gravity discharge type, complete with base extension, coupling, and coupling guard for direct drive motor	3,314
(2) 40 h.p. motor	666
(3) Ammeter	96
(4) Magnet	316
(5) Starter	200
(c) Air conveying system: from hammermill to ground grain bin	
(1) Air release fan, collector and pipe	908
(2) V belt and adjustable base	140
(3) 3 h.p. motor	140
III. Mixing Center	
(a) Weigh buggy -- 1/2 ton capacity	672

Table A-3. Costs for 60 Ton (continued)

Item	Price
(b) Vertical Mixer	
(1) 160 cu. ft. capacity twin spiral mixer	$2,600
(2) 10 h.p. motor	278
(3) Bagging spout	86
(4) V belt guard	197
(c) Discharge Pipe -- 3 ft. long	10
(d) Bucket elevator:	
(1) 75 ft. high; 1500 bu./hr. capacity; service platform and ladder; self-adjusting boot cleanout	3,667
(2) 5 h.p. motor with drives	448
(e) Valves -- 3 way valve; 12 gauge; 8" diameter; flanged	143
(f) Spouting: 2 - 8 ft. long; 14 gauge; 8" diameter	80
C. Miscellaneous Costs	
Freight @ 10% of investment minus mill building	3,377
Erection @ 75% of investment minus mill building	25,331
Sales tax @ 5% of investment minus mill building	1,689
Wiring (with 30% contingency fund); includes installation and sales tax	11,050
Fork lift — 4,000 lb. load capacity; includes sales tax	16,800
TOTAL COST	$105,671

a. Reflects use of a .75 multiplier on original list price which provides a more accurate estimate of cost to the poultry rancher after negotiating price with storage facility dealers and allowing for dealer discounts (Lunt 1977).

APPENDIX B

FORMULA FOR INTEREST RATES USING THE TRADITIONAL DEPRECIATION METHOD WHERE INTEREST CHARGES ARE EQUIVALENT TO NET PRESENT VALUE METHOD

Present Value Method

Assuming an interest rate (i), the present value (PV) of an annual return (R) received in each of n periods and a salvage value realized at time n is:

$$(1)\quad PV = \frac{R}{i}\left(1 - \frac{1}{(1+i)^n}\right) + \frac{SV}{(1+i)^n}$$

Solving for R in (1) and substituting I for PV results in the annual return that an investment of an amount I would require assuming an interest rate of i, salvage value of S, and useful life of n.

$$(2)\quad R = \frac{iI(1+i)^n}{(1+i)^n-1} - \frac{i(S)}{(1+i)^n-1}$$

Traditional Depreciation Method

Using the traditional depreciation method, the annual cost (C) of an investment (I) with interest rate (i) and salvage value (S) depreciated over n periods equals the depreciation plus interest charge:

$$(3)\quad C = \frac{I-S}{n} + i\left(\frac{I+S}{2}\right)$$

where $\frac{(I-S)}{n}$ = Straight line annual depreciation

$\frac{(I+S)}{2}$ = Average annual investment

Solving (3) for the interest rate (i) yields:

$$(4) \quad i = \frac{2(C - \frac{I-S}{n})}{I+S}$$

Assuming an investment of I with a useful life of n, salvage value of s, and an interest rate of i, (2) can be used to solve for the equivalent annual return, R. That R can then be substituted for C in (4) to solve for the interest rate that would have to be used with the traditional depreciation method to have the same average annual costs as with the present value method. The substitution of R for C is justified by recognizing that the cost C is in fact a required return R.

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