Planning Agricultural Processing for the South

Butter and Milk Powder Manufacturing Costs

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This publication is one of a series dealing with agricultural processing in the South. Before reading this publication be sure to read Agricultural Processing in the South—1. HOW TO PLAN, which is the first publication in the series and serves as an introduction to all others in the series.

Cover picture courtesy of American Dairy Review

Planning Agricultural Processing for the South

Butter and Milk Powder Manufacturing Costs

Cost of operation is one of the major factors which determine the ability of a processing facility to succeed. The analysis of processing costs provides part of the information which one must have in determining the feasibility of processing. For a description of other considerations involved in the decision to process milk, see *HOW TO PLAN*, the first publication in this series.

The plant under consideration is intended as a standby plant, perhaps operated by a producer group, to receive and process surplus Grade A milk not usable in fluid milk plants. Such surplus is made available unevenly and therefore the plant would be expected to operate at capacity for only a few days during the year.

It is difficult to select an appropriate plant size under such circumstances. The plant capacity chosen is probably as large a size as would be suitable under conditions in the South at a time when the market carries about 20 percent surplus Grade A milk.

Processing milk into butter and powder in the type of operation contemplated involves the following operational stages: milk is delivered to the plant in bulk tank trucks; separators take out the cream, and the cream and skim milk are stored separately; the cream is churned into butter and the butter is stored; the skim milk is condensed, dried, and bagged and the bags of powdered milk are stored. Within the plant, both fluid and condensed milk are moved by pumping through pipes.

The plant size selected has a capacity of 20,000 gallons of whole milk per eight-hour shift. At the standard conversion rate of 8.6 pounds per gallon, this is 172,000 pounds. This size is large enough to offer reasonable processing efficiency when run at capacity. Costs approximate those in larger plants, although larger plants can process more efficiently when run at capacity.

It is assumed that milk will be received in bulk from other distribution plants or from bulk pickup trucks direct from farms. Storage for two days' receipts is provided. It is assumed that the plant can operate for 60 hours weekly without employing a second shift. Operating costs provide for time and a half pay for time over 48 hours.

The plant is flexible because fluid cream and condensed skim may be sold, rather than butter and powder, when market prices are favorable.

Yield Relationships

For the purpose of estimating costs, the schedule of receipts given in Table 1 is assumed. This is approximately the magnitude of receipts of such milk available from Grade A plants in North Carolina in 1961. Average tests of Grade A milk are also given. Yields of powder from the skim milk and buttermilk are estimated by the equation: quantity of nonfat solids equals the butterfat test times 0.3975 plus 7.1703. This equation assumes 2 percent plant loss, 2 percent moisture in the finished powder, and the loss in butter manufacture equal to the gain in the buttermilk.

Cost of Processing

Annual processing costs for the 55.5 million pounds of raw milk flowing into the plant as indicated in Table 1 amount to $326,000 or $0.59 per hundredweight of raw milk. Cost items described in later sections are buildings, equipment, land, utilities, labor and miscellaneous. Table 2 summarizes annual costs and costs per hundredweight.

Table 1. Assumed raw milk receipts and yields of powder and butter

Month	Raw milk receipts (thousand pounds)	Average butterfat test (percent)	Yield of skim and buttermilk powder (percent)	Yield of butter (percent)	Total powder[a] (pounds)	Total butter (pounds)
January	3,664	3.97	8.75	4.75	320,600	174,040
February	2,818	3.93	8.73	4.70	246,011	132,446
March	3,700	3.85	8.70	4.60	321,900	170,200
April	5,879	3.82	8.69	4.56	510,885	268,082
May	7,873	3.77	8.67	4.50	682,589	354,285
June	5,990	3.75	8.66	4.48	518,734	268,352
July	3,417	3.73	8.65	4.45	295,570	152,056
August	3,584	3.69	8.64	4.40	309,658	157,696
September	2,482	3.69	8.64	4.40	214,444	109,208
October	2,920	3.83	8.69	4.58	253,748	133,736
November	4,613	3.87	8.71	4.62	401,792	213,120
December	8,620	3.94	8.74	4.71	753,388	406,002
Total	55,560				4,829,369	2,539,223

[a] *This total includes both skim powder and buttermilk powder although they may be processed and sold separately. Of this amount, the buttermilk powder yield may be calculated by the estimating equation 0.1668 times the fat percentage minus 0.1323.*

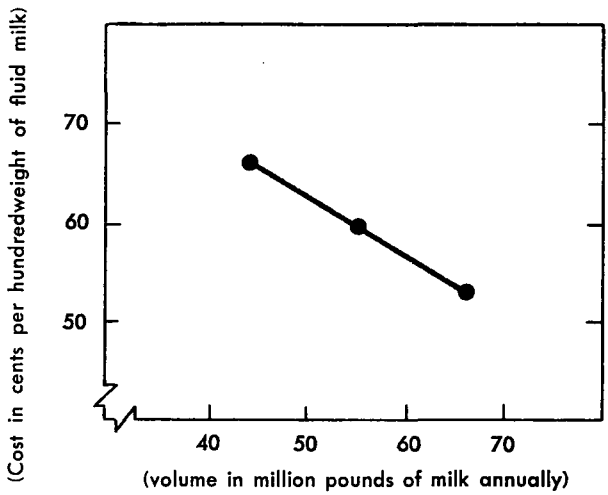
Costs of Operation at Varying Volumes

Since nearly half of the total annual processing costs as computed are independent of volume, one might expect significantly lower costs at higher volumes. Similarly one would expect average processing costs to increase significantly at lower volumes. To illustrate the dependence of cost on volume, available quantities of surplus milk were arbitrarily assumed to increase by 20 percent per month. Plant receipts were increased accordingly

Table 2. Summary of total annual costs for producing butter, nonfat powder and dry buttermilk from 55.5 million pound of milk.

Cost component	Annual Costs	Cost per cwt. of fluid milk
	(dollars)	(dollars)
Building—$218,600 initial cost		
Depreciation (20-year life)	11,000	
Repairs	4,400	
Interest	6,558	
Taxes	2,305	
Insurance	1,760	
Total	26,023	0.047
Equipment—$725,366 initial cost		
Depreciation	63,397	
Repairs (4 percent)	29,015	
Interest (3 percent of initial investment)	21,761	
Taxes (1.2 percent)	8,704	
Insurance (1.0 percent)	7,254	
Total	130,131	0.242
Land—$25,000 initial cost		
Interest	750	
Taxes	300	
Total	1,050	0.002
Utilities		
Electricity	9,260	
Gas	17,091	
Water	500	
Cleaning	3,120	
Total	29,971	0.053
Labor	64,314	0.116
Manager	15,000	0.027
Packaging	45,549	0.082
Office and lab supplies	14,500	0.026
Total annual costs	326,538	0.595

Figure 1. Cost of operating butter-powder plant at three different levels of capacity



and total annual costs were recomputed. Building costs, land costs, equipment costs and manager's salary were assumed to remain at their previous level. Other costs (except labor) were increased by 20 percent. Since labor is usually related to output, it is normally considered a variable cost. However, a check on the daily hours of operation required to process the increased volume indicated that no additional labor would be required to process the larger quantities. Labor crews had been underutilized at the previous volumes. Under these assumptions, total annual processing costs rose to $355,000—an increase of about 8 percent. Average unit processing costs fell to $0.53 per hundredweight of milk.

A similar hypothetical illustration was analyzed in which plant receipts were reduced by 20 percent. In this case, average unit processing costs rose to $0.66 per hundredweight (see Figure 1).

Equipment Costs

Table 3 lists the required equipment and estimates its cost. Key pieces of equipment are the evaporator and dryer. A double effect evaporator powered by two twelve-cylinder heat pumps was selected in preference to a boiler steam type evaporator. Even though the steam equipment requires almost $80,000 less in initial investment, it has the disadvantage of higher operating costs, higher temperatures (affecting powder quality), and longer "warm-up time" prior to operation.

The capacity of the evaporator-dryer unit is 22,000 pounds of fluid skim milk per hour. The dryer is direct fired with natural gas, receiving the condensed milk at 45 percent solids. Heat pumps are also driven by gas. Installation costs are assumed to equal 20 percent of equipment cost and are included in the costs given in Table 3.

Building Costs

The area of the building was estimated at 14,400 square feet. The major areas of the building and their approximate dimensions are the butter making room, 30′ x 40′; butter storage, 40′ x 50′; condensing-drying room, 50′ x 50′; powder storage, 40′ x 60′; compressor room and machine shop, 50′ x 50′; office, 15′ x 30′; receiving room, 50′ x 40′; laboratory, 10′ x 20′; miscellaneous dry storage, 20′ x 20′; and separating and cream storage room, 20′ x 30′.

An itemized list of estimated building costs is given in Table 4. Total building costs are estimated at $220,000, or approximately $14.50 per square foot. Building costs may vary a good deal depending on the desired attractiveness of the building, the slope of the land and many other factors.

Table 3. Equipment list, initial cost and annual depreciation for butter-powder plant

Item and description	Initial cost	Estimated life	Annual depreciation
	(dollars)	(years)	(dollars)
Receiving stage			
Pump to unload trucks	500	15	33
Milk storage tanks, vertical cold wall, 12,000 gal. capacity (4)	48,000	20	2,400
Positive milk pump, 30,000 lbs. per hour variable speed 5½ h.p.	2,500	10	250
Sanitary pipe and fittings	3,200	10	320
Spray ball cleaner for trucks	540	10	54
CIP system	20,000	10	2,000
Sweet water cooling system, 20 h.p. compressor mounted on ice maker	8,000	20	400
1 25 h.p. low pressure boiler	5,000	10	500
	87,740		5,957
Separating stage			
Separators, 10,000 lbs. per hour, cold milk at $9,450 (3)	28,350	15	1,890
Spare separator motor	378	15	25
Schlueter tank 7′ long	2,500	15	167
Chain hoist and truck	550	10	55
Sanitary lines	1,600	10	160
	33,378		2,297
Cream storage stage			
Cream storage tank, 2,000 gal. (2)	12,000	20	600
Pump (2)	800	15	53
Regenerator plant heater for pasteurizing and cooling cream	3,500	10	350
Can filler	1,325	10	133
	17,625		1,136

Table 3 (continued)

Item and description	Initial cost	Estimated life	Annual depreciation
	(dollars)	(years)	(dollars)
Butter operation (7,200 lbs. daily capacity)			
Butter churn, 800 gal. capacity (2)	25,000	10	2,500
Butter boats (2)	2,000	10	200
Buttermilk pump	400	10	40
Buttermilk storage tank (3,000 gal.)	7,000	20	350
Butter packer	10,000	10	1,000
	44,400		4,090
Skim condensing			
Skim storage tanks, 5,000 gal. (5)	42,500	20	2,125
Pump	500	15	33
HTST Pasteurizer, with accessories	15,963	10	1,596
Vacuum pan, 22,000 lbs. milk per hour with accessories	168,465	10	16,847
Sanitary pipe and fittings	7,000	10	700
Plate cooler, for cooling condensed skim	3,500	15	233
Condensed skim storage 3,000 gal. cold wall tanks	12,680	20	634
Pump, 3 h.p. positive, 22,000 lbs. per hour	2,041	15	136
	252,649		22,304
Powder operation			
Surge tank from pan	5,000	15	333
Concentrate preheater, with accessories	4,768	10	477
10 h.p. boiler for redrying powder	4,000	20	200
Spray dryer 2,000 lbs. per hour with powder filler and Y-bagger	110,625	10	11,063
Heat salvage accessories	3,453	10	345
	127,846		12,418
Bulk tank trucks for delivering products (2)	40,000	7	5,555
Total equipment	603,638	Total deprec.	53,757
Installation	116,728	Installation	10,330
Freight	5,000		
	725,366		63,397

Table 4. Estimates of building costs, butter-powder plant

Item	Unit	Number of units required	Cost per unit	Initial cost
			(dollars)	(dollars)
Excavation, including backfill and grading	cubic yd.	325	2.55	8,287
Concrete footings and foundation walls	cubic yd.	108	40.00	4,320
Concrete floor	square ft.	14,400	1.00	14,400
Structural steel	tons	75	280.00	21,000
Masonry				
8" concrete block	square ft.	8,300	.60	4,980
4" concrete block	square ft.	8,600	.50	4,300
2" glazed tile	square ft.	6,170	1.40	8,638
Face brick	square ft.	1,900	1.00	1,900
Roof deck, pre-cost concrete	square ft.	14,400	1.00	14,400
Roofing insulation and sheet metal	allowance	—	—	5,800
Cold storage insulation				
Ceiling	board ft.	3,000	.25	750
Wall	board ft.	9,000	.25	2,250
Doors, refrigerated	—	2	400.00	800
Suspended ceiling (offices and lab)	square ft.	1,000	.40	400
Miscellaneous doors	allowance	—	—	3,500
Windows or glass block	allowance	—	—	2,500
Dairy brick flooring	square ft.	3,500	2.75	9,625
Ceramic tile, floor and wall	square ft.	2,000	1.10	2,200
Vinyl, asbestos floor	square ft.	1,000	.55	550
Heating and ventilating	allowance	—	—	18,000
Plumbing and drainage	allowance	—	—	18,000
Refrigeration	allowance	—	—	7,000
Electrical and power work	allowance	—	—	12,000
Contingencies	allowance	—	—	7,000
Scales, 50-ton capacity	—	1	10,000.00	10,000
Side improvement, paving, landscaping	allowance	—	—	25,000
Architect fees	—	—	—	11,000
Total				218,600

The physical life of the building was estimated for depreciation purposes as twenty years. Annual repairs, interest on the initial investment, insurance and taxes were estimated at rates of 2.0 percent, 3.5 percent, 1.0 percent, and 1.2 percent, respectively, of the initial investment.

Labor Costs

Operating the condensing-drying section of the plant requires five men per shift.

Due to the automatic nature of the equipment, labor requirements are less than for other types of plants. Table 5 indicates an annual labor cost rate of $58,850 for a one-shift operation. Actual annual labor costs under the operating conditions specified are larger during months of peak receipts, since overtime and double shifting are required. Two shifts are required in April, May, June and December when the milk flow approximates that in Table 1. The only positions for which two shifts are required are the raw milk receiver, separator-pasteurizer worker, the evaporator-dryer equipment operator and the powder-bagger. Double shifts in these positions for the four months add $4,664 to the annual labor costs. This assumes that extra labor can be hired during these months for no significant increase in wage rates.

Utility Costs

Natural gas is used to power the heat pumps in the evaporator operation, to heat the precipitation chamber in the drying operation, to operate the small boiler in the powder redrying operation, and to heat the office and laboratory areas of the building. Natural gas requirements and costs for the evaporator and dryer by months for the butter-powder operation are given in Table 6.

Table 5. Labor requirements and costs for typical 8-hour shift, butter-powder plant

Job description	Number of men	Hourly wage	Total annual labor costs
		(dollars)	(dollars)
Receive milk	1	1.40/hour	3,500
Separating and pasteurizing	1	1.40/hour	3,500
Evaporating and drying	1	1.40/hour	3,500
Bagging powder	1	1.40/hour	3,500
Buttermaker	1	2.45/hour	6,150
Assistant buttermaker	1	1.50/hour	4,600
Butter packager and shipping clerk	1	1.40/hour	3,500
Laboratory	1	82.50/week	4,300
Cleaning crew	2	1.40/hour	7,000
Miscellaneous	1	1.40/hour	3,500
Plant superintendent	1	—	8,000
Secretaries	2	325/month	7,800
Total	14	Total	58,850

In some months, daily operation is not feasible due to short supplies of milk. In February, September and October, the months of lightest surplus, it would probably be more economical to evaporate every other day. When feasible, operating every other day would substantially reduce cleaning costs. Gas and electricity requirements would also be slightly reduced with fewer "warming up periods" for the equipment. Estimates of gas and electricity costs are therefore based on every-other-day operation for the equipment during the months mentioned.

Table 6. Gas and electricity costs for a butter-powder plant when no cream or condensed skim is sold

Month	Quantity of skim and buttermilk processed	Hours of operation per month	Gas requirements for evaporator and dryer	Gas costs	Electrical requirements for evaporator and dryer	Electrical costs for evaporator and dryer	Electrical costs for rest of plant
	(1,000 lbs.)		(cu. ft.)	(dollars)	(kwh)	(dollars)	(dollars)
January	3,492	158.7	1,170,412	1,058.33	28,566	471.03	208.56
February	2,683	122.0	899,750	841.80	21,960	418.18	188.50
March	3,519	160.0	1,180,000	1,066.00	28,800	472.90	210.38
April	5,585	253.9	1,872,513	1,620.01	45,702	608.12	281.52
May	7,480	340.0	2,507,500	2,128.00	61,200	732.10	345.36
June	5,685	258.4	1,905,700	1,646.56	46,512	614.60	285.17
July	3,247	147.6	1,088,550	992.84	26,568	455.04	199.44
August	3,393	154.2	1,137,225	1,031.78	27,756	464.55	208.56
September	2,358	107.2	790,600	754.48	19,296	395.46	170.26
October	2,774	126.1	929,987	865.99	22,698	424.08	184.85
November	4,387	199.4	1,470,575	1,298,46	35,892	529.64	237.74
December	8,222	373.7	2,756,038	2,326.83	67,266	780.63	372.72
Total				15,631.08		6,366.33	2,893.06

Sources: Col. 1: Total raw milk receipts minus the butter.
Col. 3: Based on 7,375 cubic feet of gas per hour.
Col. 4: Based on rate schedule in Table 7.
Col. 5: Based on 180 kwh per hour.
Col. 6: Based on rate schedule in Table 8.
Col. 7: Estimated requirements and costs for remainder of plant are adapted from other studies.

The evaporator uses 2,775 cubic feet of gas per hour of operation and the dryer uses 4,600 cubic feet of gas per hour. The heated areas of the building can be heated with an average of 100,000 cubic feet of gas per month, or an additional eighty dollars per month. The 20 horsepower boiler is assumed to require $500 worth of gas per year. Total annual natural gas requirements are thus $17,091 for the entire plant. These cost estimates are based on the rate schedule in Table 7.

Table 7. Rate schedule for natural gas

First	1,000 cu. feet at	$.315 per C
Next	1,000 cu. feet at	.215 per C
Next	8,000 cu. feet at	.165 per C
Next	15,000 cu. feet at	.14 per C
Next	50,000 cu. feet at	.12 per C
Next	125,000 cu. feet at	.11 per C
Next	300,000 cu. feet at	.095 per C
All over	500,000 cu. feet at	.080 per C

Table 8. Rate schedule for electricity

Billing demand[a]	Energy charge
$1.50 per kwh for the first 25 kwh	$.010 for the first 20,000 kwh
$1.20 per kwh for the next 25 kwh	$.008 for the next 50,000 kwh
$1.10 per kwh for the next 50 kwh	$.007 for the next 100,000 kwh
$1.00 per kwh for the rest	$.006 for the next 200,000 kwh
	$.005 for the rest

[a] *Billing demand is a technical term used to describe the number of kilowatts used during a fifteen minute period of peak load.*

Electricity is used to drive the power equipment, and for lighting the building. While the evaporator is operating it requires 80 kilowatt hours per hour. The dryer requires 100 kilowatt hours per hour. Electricity requirements and costs by months are also given in Table 6. Electricity costs are based on the rate schedule in Table 8.

Costs for Office, Shop and Laboratory Equipment and Supplies

Office equipment, such as adding machines, calculators, desks and tables, etc., varies a good deal among plants. The same situation applies to laboratory equipment such as glassware, sterilizer, etc., and shop equipment for minor repairs. Estimates for these costs were adapted from other studies. Total investment in office equipment is estimated at $27,375, investment in laboratory equipment at $15,218 and investment in shop equipment at $13,283. In terms of average annual lifetime costs, these investments total $5,246 for depreciation, $1,676 for interest, $587 for taxes and $447 for insurance. Annual laboratory supplies such as broken glass replacement, test chemicals, etc., are estimated at $1,500 and annual office supplies such as records, stamps, etc., are estimated at $5,000 per year. Total annual miscellaneous costs then are estimated to be $14,500.