Economics of On-Farm Processing of Sunflower Oil

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ABSTRACT

Sunflower oil is being researched as an extender or substitute for diesel fuel. Sunflower seed contains ca. 40% oil. Each Btu used to produce the seed and process oil will return ca. 5.78 Btu. The price relationship per Btu of diesel to sunflower oil was 1:4.00 in 1979. This ratio declined to 1:1.80 in 1981. The on-farm processing cost for 4800 gal varied from $2.82 to $4.33 per gallon for the three press sizes analyzed. Operating these presses 300 days annually reduced cost per gallon from $1.74 to $2.99.

INTRODUCTION

Reduced diesel fuel supplies in the early 1970s and United States' dependence on imports for fossil fuel supplies has led researchers to investigate possible alternatives for liquid fuels. Vegetable oils are particularly attractive as they are a renewable resource with possible use as a fuel extender or substitute of diesel fuel. Diesel tractors will run on vegetable oils, but certain coking and viscosity problems need further research. Engineers indicate that most of the problems can be corrected without any major changes in the diesel engine.

In North Dakota, the vegetable oil attraction is sunflower. One economic factor is the relative importance of farm sector production in North Dakota. In 1979 sunflower was among the top three in gross returns (Fig. 1). Wheat was first with $934 million, cattle second with $525 million, and sunflower third with $317 million.

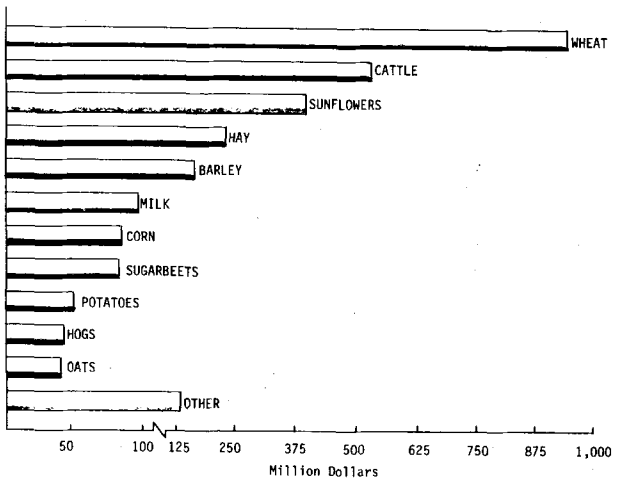

FIG. 1. Relative importance of farm sector production, North Dakota, 1979.

SUNFLOWER PRODUCTION

Oil-type sunflower was first grown commercially in the United States in about 1966. North Dakota and Minnesota grew 95,800 acres of oil-type sunflower in 1967 and 4,640,000 acres in 1979, a 48-fold increase. South Dakota started reporting sunflower acreage in 1973. The three states reported 5,257,000 acres planted to oil-type sunflower in 1979 (Fig. 2), ca. 98.6% of the reported US acreage. About 75% of the supply of whole sunflower seed in the five-year period 1977-81 was exported, the balance moving to the domestic crushing market (1).

North Dakota oil-type sunflower production has resulted in the potential of over one million short tons of sunflower oil annually during the 1978-81 period (Fig. 3). Minnesota

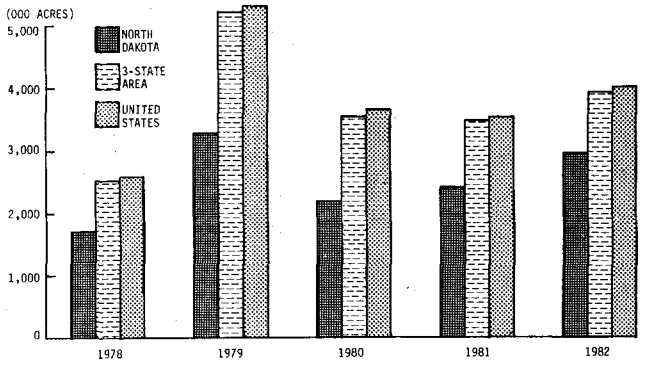

FIG. 2. Planted acres of oil sunflower, North Dakota, tri-state and United States.

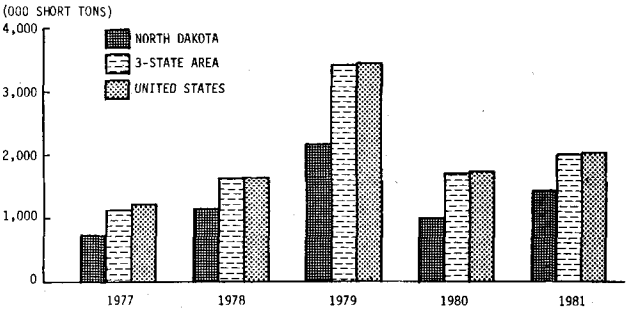

FIG. 3. Production of oil sunflower, North Dakota, tri-state and United States.

production holds at about one-half million short tons and South Dakota has been close to one-quarter million short tons of oil. The United States' potential production of oil would average about two million short tons annually. The highest sunflower planted acreage and oil production occurred in 1979 with 3.5 million short tons of oil.

Sunflower has the highest oil content (40%) of the oil crops grown in the United States (Table I). Rapeseed and safflower also have a high oilseed content but acreage is small. Oilseed produced per acre puts peanuts in first place, producing 93 gal/acre, sunflower, 61; soybeans, 42; and cottonseed, 11.

There were 86 million acres of the four major oilseed crops grown in 1981 (Table II). This acreage would produce 71 million short tons of seed, which, if it were all processed

TABLE I

Composition of Commercial Oilseeds: Oil, Meal and Other Products

Oilseed	Average composition		
	Oil	Oil meal	Hulls
		%	
Sunflower	40	40	18
Soybeans	18	73	7
Cottonseed	17	46	35
Peanuts	31	42	25
Rapeseed	35	47	16
Safflower	36	21	41

TABLE II

Oil Crops: Harvested Acres, Total Production in Short Tons, Percentage Oil, and Gallons of Oil, United States, 1981

Oil crop	Harvested acres[a]	Production in short tons[a]	Percent oil	Gallons oil
	(1,000)			(1,000)
Sunflower	3,811	2,243	40	233,112
Soybeans	66,688	60,913	18	2,847,907
Cottonseed	13,820	6,254	17	276,146
Peanuts	1,488	1,974	31	158,985
Total	85,807	71,384		3,516,150
Diesel fuel equivalent[b]				3,262,987

[a]Reference 2.

[b]A gallon of No. 2 diesel fuel contains 140,000 Btu and a gallon of sunflower oil has 130,000 Btu. Vegetable oil gallons were adjusted by .92857 to make the energy content the same.

TABLE III

Sunflower Acreage Required to Produce Sunflower Oil to Substitute for Diesel Fuel at Varying Rates

Area	Rate of substitution			
	10%	25%	50%	100%
			acreage	
North Dakota	231,048	577,619	1,155,239	2,310,477
Tri-state	692,505	1,731,263	3,462,525	6,925,049
United States	6,078,691	15,196,728	30,393,456	60,786,911
Percent of US cropland	1.3	3.4	6.7	13.4

to oil, produce ca. 3.5 million short tons of vegetable oil, equivalent to 3.3 million short tons of diesel fuel. The four major oilseed crops used 19% of the total 1981 US cropland acreage.

Diesel fuel consumed in US agricultural production is estimated at 3308 million gal, with consumption in the tri-state area (North Dakota, Minnesota, South Dakota) estimated at 378 million gal and in North Dakota at 126 million (3). The acreage of sunflower required to produce oil at 10, 25, 50 and 100% substitution rates is shown in Table III. At a 10% substitution rate it would require 6 million acres of sunflower in the United States or 1.3% of the total cropland. A 25% substitution rate would require 15 million acres of sunflower, or 3.5% of the cropland. If sunflower oil were substituted for all the diesel fuel, 61 million acres of cropland would be required, or 13% of total US cropland (453 million acres) for fuel production.

The acreage in Table III was estimated by using the five-year average sunflower yield for each of the areas. The processing efficiency was estimated to be 94%, which is a mix of commercial, intermediate-size plants, and small on-farm processing units.

How competititve is sunflower with other crops? Assuming above-average management, all costs (including ownership, labor, management, a charge for land) and using a five-year average price, sunflower ranked higher than the small grain crops and flax (Table IV). Small grains, flax and summer fallow land are sunflower's principal competitors for acreage in North Dakota. West central and western North Dakota are the areas where sunflower is a good competitor for acreage. How well it competes each year depends on the variable price relationships.

There was a low level of carryover stocks of sunflower seed (304,000 tons) going into the 1981-82 marketing year

TABLE IV

Estimated Crop Costs and Returns Per Acre, East Central North Dakota

Cost and return item	Hours wheat	Barley	Oats	Flax	Soybeans	Corn grain	Sunflower	Dry beans
	bushels						cwt	
Yield per acre	35.8	58.3	69.2	14.8	25.0	70.0	14.4	15.00
Price per unit[a]	3.21	2.16	1.28	6.06	6.31	2.42	10.15	19.30
Gross income	114.92	125.93	88.58	89.69	157.75	169.40	146.16	289.50
Direct cost[b]	59.62	59.00	49.69	49.63	65.39	84.69	75.02	83.56
Return over direct cost	55.30	66.93	38.89	40.06	92.36	84.71	71.14	205.94
Indirect cost[b,c]	68.23	65.74	64.71	60.52	79.04	77.45	67.77	80.86
Return to risk	(12.93)	1.19	(25.82)	(20.46)	13.32	7.26	3.37	125.08
Rank	6	5	8	7	2	3	4	1

[a]1977-81 averaage price received by North Dakota farmers.

[b]1980-82 average estimated production cost for east central North Dakota: References 4-6.

[c]Includes costs for machinery ownership, labor, land charge and management.

(Table V). Demand for whole seeds was sufficiently strong to absorb most of the supply. At the end of the 1981-82 marketing year, a carryover of 120,000 tons is expected. Domestic crushing was expected to be down 280,000 tons from the previous year. The reason for this is that crushing margins are off and plants have temporarily reduced their crushing. Exports continue to be the major demand for sunflower seed.

ECONOMICS OF ON-FARM PROCESSING OF SUNFLOWER OIL

Costs were estimated for processing a volume of sunflower oil sufficient to provide the fuel requirements for an average-size North Dakota farm (8). An average-size farm, based on 1978 data, consists of 1038 acres, comprising 737 acres (71%) in cropland, 245 acres (24%) in pasture and 56 acres (5%) taken up by the farmstead, roads and miscellaneous land usage. Such a farm is estimated to use 4800 gallons of diesel fuel annually, assuming diesel engines were used for all field, harvest and livestock operations (Table VI).

TABLE V

Sunflower Seed Supply and Disappearance[a]

	Marketing year	
	1980-81	1981-82
	(1,000 metric tons)	
Supply		
Beginning stocks	980	304
Production	1748	2098
Imports	28	28
Total supply	2756	2430
Disappearance		
Crush	780	500
Exports	1505	1650
Seed, other	167	160
Total disappearance	2452	2310
Ending stocks	304	120

[a]Reference 7.

Three sizes of small on-farm presses were used for the economic analysis: a small press which crushes 0.35 ton per day (producing 3.73 gal of oil per hour), an intermediate size press which is capable of crushing 1.67 tons of seed per day and produces 19.3 gal of oil per hour, and a large press which can crush 5.0 ton/day of whole sunflower seed and produces 57.79 gal/hr of oil. The processing of 4800 gal of sunflower oil would not require additional labor beyond the individual operator. The time required to process 4800 gal would be ca. 160, 31 and 10 nine-hr days, respectively, for the three presses. This assumes the presses operate 8 hr/day plus an additional hour for starting and shutting the press down. These plants were manually operated with cost provision for fully automated operation.

Estimated equipment costs ranged from $17,685 for the small press to $28,405 for the large press (Table VII). Estimated building investment costs ranged from $11,250 for the two smaller presses to $13,000 for the large press. Buildings, in each instance, were uninsulated steel structures. If heat was desired for cold weather operation, an additional cost allowance would be needed for insulation and a heat source.

The investment in equipment and buildings per ton of whole sunflower seed processed for 4800 gal of oil is $514 for the small press, $610 for the intermediate press and $799 for the large press. The investment cost on a per-ton processed basis is high because these presses, particularly the two larger presses, are operated at low capacity to produce the 4800 gal. If each press were operated at full capacity, 300 days per year, the investment per ton would be reduced to $276 for the small press, $63 for the intermediate press and $28 for the larger press.

Total estimated processing costs per gallon of crude sunflower oil were $4.33 for the 0.35 ton/day press, $2.82 for the 1.67 ton/day press and $2.87 for the 5.0 ton/day press (Table VIII). These costs include a charge for all resources used in processing sunflower seed.

As an alternative in analyzing the cost structure, it was assumed that some farmers may already have a building suitable to house the press and a zero opportunity cost was considered for the operator's labor. By deleting building depreciation and the labor charge, the resulting cost per gallon of crude sunflower oil is $2.57 for the small press,

TABLE VI

Estimated Diesel Fuel Requirements for an Average-Sized North Dakota Farm, 1978

Farm organization[a]	Acres	Number	Gal/unit[b,c]	Total gallons of diesel fuel usage
Wheat	247	–	4.57	1129
Barley	61	–	4.73	289
Sunflower	42	–	7.76	326
Oats	28	–	5.52	155
Other row crops	29	–	10.32	299
Flaxseed	6	–	5.82	35
Summer fallow	207	–	5.70	1180
All hay	77	–	2.34	180
Pasture	40	–	1.60	64
Livestock				
Beef cows	–	48	3.27	157
Sheep	–	5	1.60	8
Hogs	–	8	2.63	21
Miscellaneous				957
Totals	737	61		4800

[a]Reference 9. (Farms with sales of $2,500 or more were used).
[b]Reference 10.
[c]Reference 11.

TABLE VII

Investment in Equipment and Building for Three Sizes of On-Farm Processing Presses for Sunflower Seed Oil Extraction, North Dakata, 1981

	Size of press		
	0.35 ton/day	1.67 ton/day	5.0 ton/day
		dollars	
Equipment			
Seed cleaner	1,030	1,030	1,170
Hopper bin	1,760	1,760	2,600
Press	7,165	7,955	14,745
Oil settling tank	230	270	370
Oil filter	3,735	5,620	5,755
Oil storage tank[a]	2,600	2,600	2,600
Augers and motors	1,165	1,165	1,165
Total equipment investment	17,685	20,400	28,405
Building	11,250[b]	11,250[b]	13,100[c]
Total investment in equipment and building	28,935	31,650	41,505

[a]5000 gal capacity, a one-year supply for the average farm.

[b]Steel building ca. 1200 sq ft not insulated. The meal storage requires more space given the high oil content, meal should not exceed 5 ft in depth while in storage.

[c]Steel building ca. 1400 sq ft not insulated.

TABLE VIII

Estimated Costs for Processing 4800 gal of Sunflower Oil on the Farm, North Dakota, 1981

Cost item	Size of press		
	0.35 ton/day	1.67 ton/day	5.0 ton/day
Variable costs			
Equipment repair[a]	$ 1,585	$ 360	$ 193
Building repair[b]	225	225	262
Electricity @ $0.04/kW hr[c]	189	85	85
Sunflower seed – $10.42/cwt[d]	11,743	10,819	10,819
Total variable cost	$13,742	$11,489	$11,359
Fixed costs			
Equipment amortized for 15 years[e]	$ 2,289	$ 2,640	$ 3,676
Building amortized for 25 years[f]	1,229	1,229	1,431
Insurance on equipment and building[g]	174	190	249
Management, owner operator labor @ $5.00/hr	7,200	1,400	470
Total fixed cost	$10,892	$ 5,459	$ 5,826
Total processing cost	$24,634	$16,948	$ 17,185
Tons of meal produced	37.87	33.43	33.43
Credit of meal @ $101.70/ton[h]	$ 3,851	$ 3,400	$ 3,400
Total cost to process 4800 gal of sunflower oil	$20,783	$13,548	$13,785
Cost/gal of sunflower oil	4.33	2.82	2.87
Cost/gal not including labor and building costs	2.57	2.27	2.48
Processing efficiency[i]	82%	89%	89%

[a]The annual repair cost was prorated by the time the machine was used: 53% of the small press, 10% of the medium press and 3.5% for the large press. The annual equipment repair costs were charged on a percentage basis of new cost as follows: press 27%, filter 21%, other equipment 4%.

[b]Steel building repair charged at 2% of new cost.

[c]1981 commercial utility rate.

[d]1976-80 average price received by farmers.

[e]Depreciation and interest on equipment were amortized over 15 years at 10% interest paid quarterly. The 10% interest was the average paid for Baa industrial bonds for 1975-79.

[f]Depreciation and interest on the building were amortized over 25 years at 10% interest paid quarterly.

[g]$6.00/$1000 charged on equipment and building.

[h]January-March 1981 average spot market price, Minneapolis, MN.

[i]Percent of oil removed.

$2.27 for the intermediate press and $2.48 for the large press (Table VIII).

Total time required to process 4800 gal was 1440 hr for the small press, 280 hr for the intermediate size press and 93 hr for the large press. The processing efficiency, percentage of oil obtained from the seed, was 82% for the 0.35 ton/day press and 89% for the 1.67 and 5.0 ton/day presses.

What would the cost structure be if each of the presses were operated 300 days annually? The presses operating 300 days annually will produce 9000, 46,272 and 138,696 gallons of crude sunflower oil, respectively, for the three press sizes. This is equivalent to enough oil for 1.87 average-size North Dakota farms for the small press, 9.64 farms for the intermediate size and 28.90 farms for the large press.

The estimated costs for the three presses operating 300 nine-hr days (8 hr for the press and 1 hr to start and stop the press at the beginning and end of the day) is $3.94/gal for the small press, $2.03 for the intermediate press and $1.74 for the large press (Table IX). The reduction in cost per gallon when moving from producing 4800 gal to operating 300 days is $0.40 for the small press, $0.79 for the intermediate press and $1.13 for the large press.

A byproduct of processing sunflower seed is the meal. The small press operating 300 days will produce 71 tons of meal, the intermediate press 322 tons and the large press 966 tons. Credit was given for the meal produced at $101.70/ton in the cost analysis.

The number of animal units that can be supported from the small on-farm presses depends on the type of ration a farmer is feeding. If alfalfa hay is included in the ration, the amount of protein supplement needed is very little or none. If the ration is corn silage and/or native hay, then two or three pounds of meal per animal unit could be used. The animal units that can be supported using rations containing 1, 2 and 3 pounds of sunflower meal per day are shown in Table X. The feeding period was 180 days. The small press producing 4,800 gal of crude sunflower oil will produce enough meal for 122-367 animal units, depending on the rate of feeding. The small press operating full time (300 days) could support from 263 to 789 animal units. The large press operating full time would support 3578-10,733 animal units (Table X).

The price relationship of fossil fuels and soybean oil for the 11-year period 1970-1980 is shown in Figure 4 (histor-

TABLE IX

Estimated Costs for Processing 300 Nine-Hour Days by Three Sizes of Presses, North Dakota, 1981

Cost item	Size of press		
	0.35 ton/day	1.67 ton/day	5.0 ton/day
Variable costs			
Equipment repair[a]	$ 2,990	$ 3,601	$ 5,507
Building repair[b]	225	225	262
Electricity @ $0.04/kW hr[c]	165	822	2,446
Hired labor @ $5.00/hr	6,300	12,100	13,030
Sunflower seed @ $10.42/cwt[d]	22,007	104,283	312,600
Total variable cost	$31,687	$121,031	$333,845
Fixed costs			
Equipment amortized for 15 years[e]	$ 2,289	$ 2,640	$ 3,676
Building amortized for 25 years[f]	1,229	1,229	1,431
Insurance on equipment and building[g]	174	190	249
Management, owner operator labor @ $5.00/hr	7,200	1,400	470
Total fixed cost	$10,892	$ 5,459	$ 5,826
Total processing cost	$42,579	$126,490	$339,671
Credit for meal @ $101.70/ton[h]	$ 7,217	$ 32,774	$ 98,242
Total processing cost	$35,362	$ 93,716	$241,429
Total gal of sunflower oil processed	9,000	46,272	$138,696
Total tons of meal	70.96	322.26	966.00
Cost/gal of sunflower oil	$ 3.93	$ 2.03	$ 1.74
Cost/gal not including labor and building costs	$ 2.99	$ 1.97	$ 1.73
Processing efficiency[i]	82%	89%	89%

[a]The annual equipment repair costs were charged on a percentage basis of new cost as follows: press 27%, filter 21%, other equipment 4%.

[b]Steel building repair charged at 2% of new cost.

[c]1981 commercial utility rate.

[d]1976-80 average price received by farmers.

[e]Depreciation and interest on equipment were amortized over 15 years at 10% interest paid quarterly. The 10% interest was the average paid for Baa industrial bonds for 1975-79.

[f]Depreciation and interest on the building were amortized over 25 years at 10% interest paid quarterly.

[g]$6.00/$1000 charged on equipment and building.

[h]January-March 1981 average spot market price, Minneapolis, MN.

[i]Percent of oil removed.

TABLE X

Number of Animal Units Required to Consume the Sunflower Meal Produced by the On-Farm Presses Using Various Feeding Rates

Tons of meal produced	Number of animal units lb/day of sun meal[a] 1	2	3
33[b]	367	183	122
38[c]	422	211	141
71[d]	789	394	263
322[e]	3,578	1,789	1,193
966[f]	10,733	5,367	3,578

[a]Sunflower meal supplement was fed for 180 days.

[b]Meal production from the 1.67 and 5.0 ton/day presses producing 4800 gal of sunflower oil.

[c]Meal production from the 0.35 ton/day press producing 4800 gal of sunflower oil.

[d]Meal production from the 0.35 ton/day press operating 300 days.

[e]Meal production from the 1.67 ton/day press operating 300 days.

[f]Meal production from the 5.00 ton/day press operating 300 days.

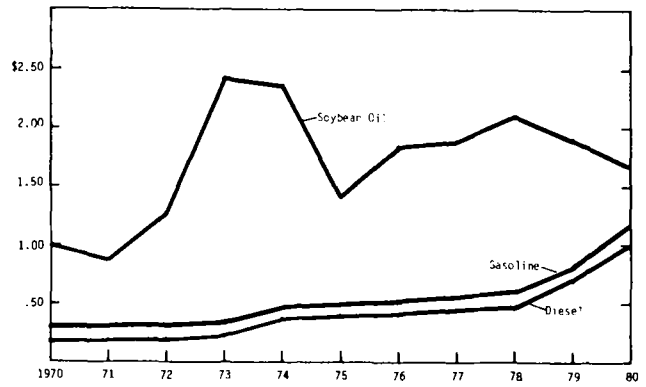

FIG. 4. Prices of fossil fuels and soybean oil, 1970-80.

ical published price data were not available for sunflower oil). High variability in the price of crude soybean oil existed during the 1970s. Fossil fuel prices during the last three years have been increasing, whereas crude soybean oil prices have decreased.

Using 8-month statistics for 1979 for sunflower oil and No. 2 diesel fuel, the cost/price ratio per Btu was 4.00, meaning the crude sunflower oil price was four times higher on a Btu basis compared to No. 2 bulk diesel fuel. The cost/price ratio shifted downward to 2.15 for 1980 and 1.80 for 1981.

The prospects for the cost/price ratio to equalize and actually reverse is difficult to predict. Such factors as the level of US crude oil import dependence, conservation practices, increased domestic oil production, increased agricultural production, processing costs and increased yields per acre of sunflower are all linked in such a forecast. Substitutes for diesel will be produced when the diesel fuel price rises to a level equal to or above the cost of producing substitutes. Despite the limited time range, the evidence does suggest these two sources of energy are moving closer together. This indicates crude sunflower oil as an alternative energy source has moved closer competitively with bulk diesel prices when compared to the recent 32-month period.

Another important relationship when evaluating an alternative energy source is to consider the energy inputs required to produce and process an alternative energy material. The conversion for sunflower oil, using current production and processing estimates, results in an input-output of almost 6:1, meaning that for each Btu used to produce and process sunflower oil, 6 Btu are returned (Table XI). The intermediate-size on-farm press was used to estimate the processing energy requirements. If energy derived from only the oil is used, 2.88 Btu are returned for every Btu used in production and processing. These ratios have an excellent potential for increasing with future prospects for genetic improvements and advances in cultural practices that will increase yields per acre.

TABLE XI

Energy Inputs and Outputs for an Acre of Sunflower Yielding 1450 lb/acre, North Dakota

Item	Btu/acre
Energy input	
Production – 20.1 gal/acre @ 140,000 Btu/gal	2,814,000
Oil extraction[a] – 65.3 gal/acre requiring 1720 Btu/gal	112,316
Total	2,926,316
Energy output	
Oil – 65.3 gal/acre @ 130,000 Btu/gal	8,489,000
Meal – 947 lb/acre @ 8900 Btu/lb	8,428,000
Total	16,917,000
Ratio of $\frac{\text{output}}{\text{input}} = \frac{16,917,000}{2,926,316} = 5.78:1$	

[a]Small intermediate on-farm press was assumed.

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