# Simple Model for Determining Economic Feasibility of Processing New Oilseeds

**G.C. MUSTAKAS** and **K.D. CARLSON,** Northern Regional Research Center, Science and Education Administration, Agricultural Research, U.S. Department of Agriculture, Peoria, Illinois 61604


## ABSTRACT

A simple model for programming the cost feasibility of processing a new oilseed has been developed that makes use of a programmable calculator. The analysis of cost factors developed in the study provides a realistic measure of the economic feasibility of an oilseed project. By comparing break-even cost-to-make of a new oil with the market price of a competitive oil, a quick indication of the probable success of the project can be estimated. The method is illustrated with a comparison of *Crambe abyssinica* seed oil and high erucic acid rapeseed oil.


## INTRODUCTION

Detailed work on the design of a proposed project for commercial development should include a feasibility survey. The survey examines the technical and physical process factors involved and the existing and potential market conditions for the particular product. Such a preliminary survey gives an estimate on the probable success of the project.

Research to provide the basis for new products and processes from farm crops conducted at the Northern Regional Research Center generally include a cost estimate as an integral part of the investigations. These estimates, similar to ones prepared by industrial firms, are usually quite long and sophisticated and are intended to provide a realistic measure of the economic feasibility of the product or process.

As part of a new crops program to uncover oilseeds containing unique oils suitable for industrial use, frequent cost analyses need to be made in our engineering department.

Recently, we developed an approach for programming the cost feasibility of processing a new oilseed that is exceedingly rapid and simple. Furthermore, the approach can be quickly outlined and put into a programmable calculator that evaluates the interrelationship of variables and determines cost feasibility of the project in a matter of minutes.

## PROGRAMMABLE DESIGN MODEL

Figure 1 shows an outline of the cost analysis that develops the delivered value of the new oil product and then compares it to a competitive oil with an established market price. If the new product oil can be delivered at less than the competitive oil (allowing for a reasonable profit margin), then the new operation is profit oriented and should have an advantage over the competition providing the new product quality can meet the market demands.

The feasibility survey is based on the following relationships:

$$\frac{(S_c + C_r + F_s - M_c)\,100}{2000\,O_y} = \text{C.O.C.} = \text{Cost of crude oil as cent/lb} \quad \text{(I)}$$

where $S_c$ = Farm seed cost, \$/ton seed farm basis
$C_r$ = Crushing or oil extraction cost, \$/ton seed farm basis
$F_s$ = Seed freight, \$/ton seed farm basis
$M_c$ = Meal credit, \$/ton seed farm basis
(calc. as % meal yield X meal market price as \$/ton)
100 is a conversion factor to cent/\$ ton seed farm basis
2000 = lb seed farm basis/ton seed farm basis
$O_y$ = lb crude oil/lb seed farm basis

Equation 2 establishes the cost of the refined oil including freight paid by the oil crusher:

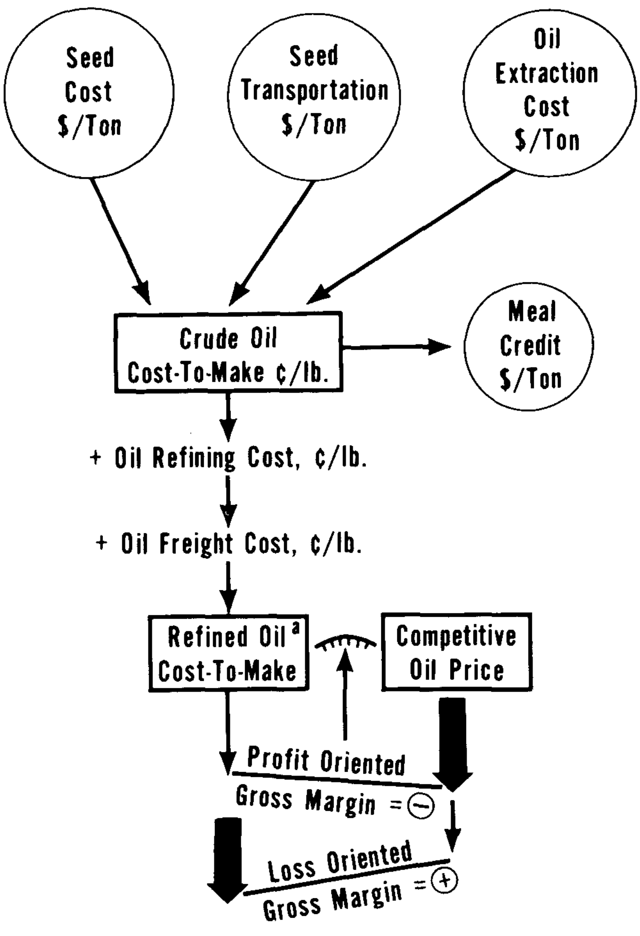
$$\frac{\text{C.O.C.}}{0.95} + R_c + F_o = \text{C.O.R.} = \text{cost of refined oil as cent/lb} \quad \text{(II)}$$

where constant 0.95 = lb refined oil/lb crude oil is based on a 5% refining loss and can be altered according to the following relationship:

$$\text{constant} = \frac{100 - \%\ \text{refining loss}}{100}$$

$R_c$ = Refining cost as cent/lb refined oil
$F_o$ = Freight cost as cent/lb refined oil

Equations 1 and 2 are combined with the price of the competitive oil, $P_{co}$, to give a gross margin, Equation 3.




[a] Exclusive of profits, packaging, and sales costs

FIG. 1. Programmable cost analysis – use of competitive oil pricing as an index.

**Program Code Listing**

| LOC | Code | Key | Comments |
|---|---|---|---|
| 00 | 52 | ( | |
| 01 | 34 | RCL | Seed |
| 02 | 00 | 0 | Cost |
| 03 | 84 | + | |
| 04 | 34 | RCL | Crushing |
| 05 | 01 | 1 | Cost |
| 06 | 84 | + | |
| 07 | 34 | RCL | Seed |
| 08 | 02 | 2 | Freight |
| 09 | 74 | − | |
| 10 | 34 | RCL | Meal |
| 11 | 03 | 3 | Credit |
| 12 | 53 | ) | |
| 13 | 54 | ÷ | |
| 14 | 52 | ( | |
| 15 | 02 | 2 | |
| 16 | 00 | 0 | |
| 17 | 64 | × | |
| 18 | 34 | RCL | Crude oil |
| 19 | 04 | 4 | Yield |
| 20 | 53 | ) | |
| 21 | 94 | = | |
| 22 | 33 | STO | Crude oil cost |
| 23 | 05 | 5 | to make |
| 24 | 41 | R/S | |
| 25 | 34 | RCL | |
| 26 | 05 | 5 | |
| 27 | 54 | ÷ | |
| 28 | 92 | . | |
| 29 | 09 | 9 | |
| 30 | 05 | 5 | |
| 31 | 84 | + | |
| 32 | 34 | RCL | Refining |
| 33 | 06 | 6 | Cost |
| 34 | 84 | + | |
| 35 | 34 | RCL | Oil |
| 36 | 07 | 7 | Freight |
| 37 | 94 | = | |
| 38 | 33 | STO | Refined oil cost |
| 39 | 08 | 8 | to make |
| 40 | 41 | R/S | |
| 41 | 34 | RCL | |
| 42 | 08 | 8 | |
| 43 | 74 | − | |
| 44 | 34 | RCL | Competitive |
| 45 | 09 | 9 | Oil Price |
| 46 | 94 | = | |
| 47 | 41 | R/S | Gross |
| 48 | 42 | RST | Margin |
| 49 | | | |

**Key to Abbreviations**

RCL - Recall from Memory
R/S - Run/Stop
ST - Store in Memory

FIG. 2. Program coding form – oilseed project cost survey.

$$\frac{(S_c + C_r + F_s - M_c)}{20\ O_y\ (0.95)} + R_c + F_o - P_{co} = \text{gross margin} \qquad \text{(III)}$$

*Gross margin* of the new oil product may be above (+) or below (-) the competitive oil and adding in a profit number as cent/lb refined oil will yield a *net margin.*

Memory storage registers for the computer program are as follows:

| Memory register | | Variable |
|---|---|---|
| 0 | $S_c$ | = Farm seed cost, $/ton |
| 1 | $C_r$ | = Crushing cost, $/ton |
| 2 | $F_s$ | = Seed freight, $/ton |
| 3 | $M_c$ | = Meal credit, $/ton |
| 4 | $O_y$ | = Crude oil extraction yield, lb/lb |
| 5 | C.O.C. | = Crude oil cost-to-make, cent/lb |
| 6 | $R_c$ | = Oil refining cost, cent/lb refined oil |
| 7 | $F_o$ | = Refined oil freight, cent/lb refined oil |
| 8 | C.O.R. | = Cost of refined oil to make, delivered, cent/lb |
| 9 | $P_{co}$ | = Market price of competitive oil, cent/lb |

The program coded listing is given in Figure 2.

The calculator used in our work was a Texas Instruments' programmable model-SR-56.

## DISCUSSION

The programmable model was structured to include farm, transportation, oil extraction, and oil-refining costs. Oil extraction may be based on any oil separation method, for example, straight solvent extraction or prepress-solvent extraction – two processes most universally applied in the industry.

### Farm Seed Price

Physical, economic, and governmental factors all play an important role in determining the price a farmer obtains for his crop. Yields, production costs, cultural practices, risk and uncertainty of new crops and returns of a competitive crop all influence the price. Also, timing of a new crop with respect to use of machinery and labor is important and determines whether the new crop is supplementary, complementary, or competitive to existing crops. Diverted acreage policies of Government also can open up opportunities to new crops.

### Crushing or Oil Extraction Costs

Crushing costs can be estimated from annual company reports but will also vary with the tonnage of oilseed being processed. Usually operating costs are given in terms of cents-per-bushel of oilseed crushed, such as 25-50 cents per bushel. For our cost program, this figure is converted to $/ton farm seed.

### Seed Freight

This figure will depend on existing freight rates and will be influenced by bulk volume of the seed and distance to the processor's plant.

### Meal Credits

Meal credit is calculated as the product of the meal value (existing market price) and the percent yield of meal from the oil extraction. For a new seed meal, M, its market value will be determined partly from its protein content relative to a competitive oilseed meal:

$$\text{Market value (M)} = \text{market value(competitive oilseed)} \times \frac{\%\ \text{protein (M)}}{\%\ \text{protein (competitive oilseed)}}$$

Quality factors other than protein content will also affect the meal's value.

### Oil Freight

As with seed freight, this figure will depend on existing freight rates and is expressed in the calculation as cent/lb refined oil.

### Oil Refining Costs

In the oil refining step, costs are affected by factors that increase the refining loss. For example, in refining with caustic soda there is always a considerable amount of neutral oil saponified by the alkali or entrained in the soapstock. This oil is recoverable only as a low grade material and therefore represents a direct monetary loss to the refiner. Also, high refining losses are generally attributed to the presence of phosphatides. The refining cost is estimated from experience or from published data and is expressed as cent/lb of refined oil.

## SAMPLE PROBLEM

### Cost Feasibility of *Crambe abyssinica* – A High Erucic Acid Oilseed

*Crambe abyssinica,* a member of the family Cruciferae, is an oilseed that is agronomically suited to early spring planting in many areas of the United States. Nonedible oil markets would provide outlets for the oil in lubricants, plastics, and chemicals (1-4), and the processed meal would be a protein supplement for beef cattle feeds (5-7). Information on composition of the seed oil and meal (8) and on processes for oil extraction and meal preparation (9-15) have been published or are available from the Northern Regional Research Center. Crambe oil contains 55-60% erucic acid, on the average 17% more erucic acid than im-

TABLE I

Tabulated Results of Crambe Feasibility Study[a]

| Row number | Seed cost[b] | Crushing cost | Seed freight | Meal credit | Price rapeseed oil | Crude oil cost-to-make | Refined oil cost-to make | Gross margin Price differential over rapeseed oil[c] |
|---|---|---|---|---|---|---|---|---|
| | $/ton | $/ton | $/ton | $/ton | ¢/lb | ¢/lb | ¢/lb. | + or - |
| 1 | 100 | 25 | 0 | 66 | 25 | 9.5 | 13.0 | -16.2 |
| 2 | 150 | 25 | 0 | 66 | 25 | 17.6 | 21.5 | -7.7 |
| 3 | 200 | 25 | 0 | 66 | 25 | 25.6 | 30.0 | +0.7 |
| 4 | 100 | 10 | 0 | 66 | 25 | 7.1 | 10.5 | -18.8 |
| 5 | 150 | 10 | 0 | 66 | 25 | 15.2 | 19.0 | -10.3 |
| 6 | 200 | 10 | 0 | 66 | 25 | 23.2 | 27.4 | -1.8 |
| 7 | 250 | 10 | 0 | 66 | 25 | 31.3 | 25.9 | +6.7 |
| 8 | 100 | 35 | 0 | 66 | 25 | 11.1 | 14.7 | -14.5 |
| 9 | 150 | 35 | 0 | 66 | 25 | 19.2 | 23.2 | -6.0 |
| 10 | 200 | 35 | 0 | 66 | 25 | 27.3 | 31.7 | +2.4 |
| 11 | 150 | 10 | 40 | 66 | 25 | 21.6 | 25.8 | -3.5 |
| 12 | 200 | 10 | 40 | 66 | 25 | 29.7 | 34.2 | +5.0 |
| 13 | 200 | 10 | 40 | 66 | 30 | 29.7 | 34.2 | -0.9 |
| 14 | 200 | 10 | 0 | 66 | 25 | 23.2 | 27.4 | -1.8 |
| 15 | 200 | 10 | 0 | 80 | 25 | 21.0 | 25.1 | -4.2 |
| 16 | 200 | 10 | 0 | 100 | 25 | 17.7 | 21.7 | -7.6 |
| 17 | 200 | 30 | 20 | 66 | 25 | 29.7 | 34.2 | +5.0 |
| 18 | 200 | 30 | 20 | 66 | 30 | 29.7 | 34.2 | -0.9 |
| 19 | 200 | 30 | 20 | 66 | 35 | 29.7 | 34.2 | -6.7 |
| 20 | 200 | 30 | 20 | 66 | 40 | 29.7 | 34.2 | -12.6 |

[a]Constant values used for the following in all calculations: oil extraction yield = 0.31 lb/lb, oil refining cost = 2¢/lb, oil freight = 1¢/lb.

[b]Seed cost conversion — 5¢/lb = $100/ton; 7.5¢/lb = $150/ton; 10.0¢/lb = $200/ton; 12.5¢/lb = $250/ton.

[c]+ Figure favorable to rapeseed oil. - Figure favorable to crambe oil.

ported high erucic acid rapeseed oil (47-50%). Stated differently, crambe oil can command a price premium of 1.17 over rapeseed oil, and the gross margin in a comparison of crambe oil and high erucic rapeseed oil then is calculated as in Equation 4.

$$\frac{(S_c + C_r + F_s - M_c)}{20\ O_y\ (0.95)} + R_c + F_o - (1.17)(P_{co}) = \text{Gross margin} \qquad \text{(IV)}$$

Table I gives the cost of crude (Equation I) and refined (Equation 2) crambe oil, and, relative to high erucic acid rapeseed oil, the gross margin (Equation 4) as a function of selected cost inputs.

The eight cost factors (columns 2-9, Table I) are placed into the memory registers of the calculator, which is programmed according to Figure 2, but slightly modified to include the crambe oil/rapeseed oil erucic acid ratio of 1.17. Pressing the R/S key three times in succession gives the data in columns 10, 11, and 12 of Table I. Any of the variables can be changed in the appropriate memory registers and the program then rerun to show the effect of these changes.

Comparison of data in rows 1-10 of Table I shows that changing seed costs in the range from $100 → $250/ton has a profound effect on changing the operation from profit-oriented to loss-oriented. On the other hand, decreases in crushing costs ($35 → $10/ton) have a smaller effect, but do improve the profit picture.

Note that for data compiled in rows 1-10, we assumed that the plant is located in the vicinity of the seed growing area and that there is no seed freight. However, when the plant is located further away and relatively high seed hauling costs ($40/ton) are incurred, the price advantage over rapeseed oil is changed by 6.8cent/lb (row 5 vs. row 11).

The effect of increasing meal byproduct credit from $66 → $100/ton (rows 14-16) is appreciable, increasing the price advantage over rapeseed oil from 1.8 to 7.6cent/lb. Where the competitive price of rapeseed oil increases in the market from 25-40cent/lb (rows 17-20), the opportunities change very rapidly in favor of crambe oil.

In our examples, oil yield ($O_y = 0.31$), refining costs ($R_c = 2$), and oil freight ($F_o = 1$) were kept constant as they are not subject to wide variations. Thus, Equation 4 may be reduced to the form y = ax+b where: y = gross margin; a = 1 ÷ [(20) (0.31) (0.95)] = 0.1698; x = $S_c+F_s+C_r-M_c$; b = 3-1.17 $P_{co}$. Thus, in Figure 3, we parametrically relate gross margin, net cost inputs for crude crambe oil ($S_c+F_s+C_r-M_c$), and four selected rapeseed oil prices ($P_{co}$). (Refined crambe oil costs associated with net cost inputs are shown indexed across the top.) Note e.g., that a net cost input of $154/ton of seed corresponds to a breakeven refined crambe oil cost of ca. 29cent/lb when rapeseed oil is priced at 25cent/lb. This same net cost input would provide margins of ca. 6, 12, and 18cent/lb over rapeseed oil priced at 30, 35, and 40cent/lb, respectively. In another example,

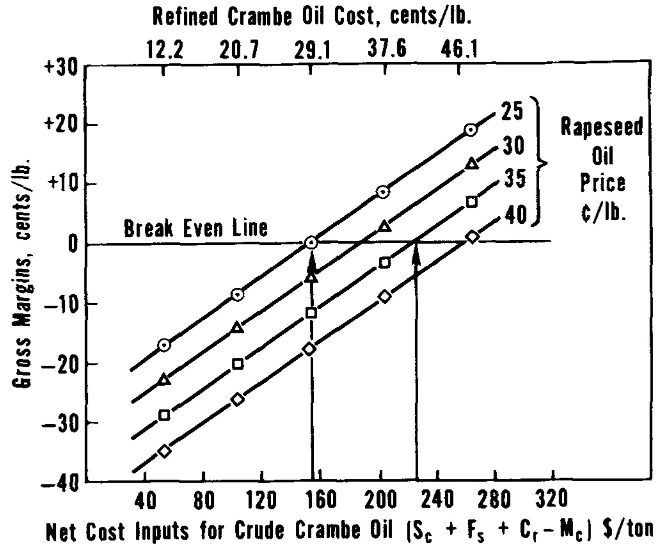



FIG. 3. Parametric plot of gross margin and net cost inputs for crude crambe oil as a function of selected rapeseed oil prices. Equation 4 is reduced to the form y = ax+b (see text) by setting $O_y$ = 0.31, $R_c$ = 2, $F_o$ = 1, while $S_c+F_s+C_r-M_c$ is varied and $P_{co}$ in turn is set equal to 25, 30, 35, and 40.

breakeven net cost inputs can rise to $224/ton of seed if rapeseed oil is 35cent/lb. Rapeseed oil prices have ranged from ca. 18 to 38cent/lb over the last 5 years, during which time limited quantities of crambe oil have been marketed at 18 to 42cent/lb.

## ACKNOWLEDGMENT

G. Kopas, Agricom, International, provided information on cost surveys of crambe.

## REFERENCES

1. Nieschlag, H.J., and I.A. Wolff, JAOCS 48:723 (1971).
2. Carlson, K.D., V.E. Sohns, R.B. Perkins, Jr., and E.L. Huffman, Ind. Eng. Chem., Prod. Res. Dev. 16:95 (1977).
3. Nieschlag, H.J., J.A. Rothfus, V.E. Sohns, and R.B. Perkins, Jr., Ibid. 16:101 (1977).
4. Nieschlag, H.J., G.F. Spencer, R.V. Madrigal, and J.A. Rothfus, Ibid. 16:202 (1977).
5. Lambert, J.L., D.C. Clanton, I.A. Wolff, and G.C. Mustakas, J. Anim. Sci. 31:601 (1970).
6. Perry, T.W., W.H. Tallent, W.M. Beeson, and M.T. Mohler, Ibid. 37:353 (1973).
7. Perry, T.W., W.M. Beeson, W.H. Tallent, and M.T. Mohler, Ibid. 39:248 (1974).
8. Earle, F.R., J.E. Peters, I.A. Wolff, and G.A. White, JAOCS 43:330 (1966).
9. Wolff, I.A., and Q. Jones, The Search for New Crops, "U.S. Yearbook Agric.," 1962, pp. 473-476.
10. Mustakas, G.C., L.D. Kirk, and E.L. Griffin, Jr., JAOCS 45:53 (1968).
11. Kirk, L.D., G.C. Mustakas, and E.L. Griffin, Jr., Ibid. 43:550 (1966).
12. Mustakas, G.C., G. Kopas, and N. Robinson, Ibid. 42:10, 550A, 552A, 554A, 594A (1965).
13. VanEtten, C.H., M.E. Daxenbichler, J.E. Peters, and H.L. Tookey, J. Agric. Food Chem. 14:426 (1966).
14. Mustakas, G.C., L.D. Kirk, E.L. Griffin, Jr., and A.N. Booth, JAOCS 53:12 (1976).
15. Baker, E.C., G.C. Mustakas, and V.E. Sohns, Ibid. 54:387 (1977).

[Received June 28, 1978]