

# Sunflower Oil

## As A

# Fuel Alternative



NORTH DAKOTA  
STATE UNIVERSITY  
SEP 8 - 1980  
SERIALS DEPT.  
LIBRARY

Vern Hofman  
Extension Agricultural Engineer

W. E. Dinusson  
Professor, Animal Science

Don Zimmerman  
Research Chemist, USDA

Delmer L. Helgeson  
Professor, Agricultural Economics

Carl Fanning  
Extension Soils Specialist

## INTRODUCTION

Sunflower oil as a diesel fuel substitute is receiving widespread attention. This publication includes the known information about it. Many questions remain unanswered and research is beginning to answer some of them.

Two types of sunflower seed are available. The most common is the oil type, with about 40 to 42 percent oil by weight. The other type is confectionery and can be subdivided as follows: The larger confectionery seed is directed to the human food market, and contains 25 to 26 percent oil and 23 to 24 percent protein. The smaller confectionery seeds are used for birdseed and contain 22 to 23 percent oil and 22 to 23 percent protein.

## SUNFLOWER OIL AS A FUEL FOR DIESEL ENGINES

The energy content of sunflower oil is approximately 90 percent of the energy of No. 2 diesel fuel and contains about 127,900 BTU/GAL. No. 2 diesel fuel contains 140,000 BTU/GAL and ethyl alcohol contains 84,000 BTU/GAL.

4.3  
1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65  
66  
67  
68  
69  
70  
71  
72  
73  
74  
75  
76  
77  
78  
79  
80  
81  
82  
83  
84  
85  
86  
87  
88  
89  
90  
91  
92  
93  
94  
95  
96  
97  
98  
99  
100  
101  
102  
103  
104  
105  
106  
107  
108  
109  
110  
111  
112  
113  
114  
115  
116  
117  
118  
119  
120  
121  
122  
123  
124  
125  
126  
127  
128  
129  
130  
131  
132  
133  
134  
135  
136  
137  
138  
139  
140  
141  
142  
143  
144  
145  
146  
147  
148  
149  
150  
151  
152  
153  
154  
155  
156  
157  
158  
159  
160  
161  
162  
163  
164  
165  
166  
167  
168  
169  
170  
171  
172  
173  
174  
175  
176  
177  
178  
179  
180  
181  
182  
183  
184  
185  
186  
187  
188  
189  
190  
191  
192  
193  
194  
195  
196  
197  
198  
199  
200  
201  
202  
203  
204  
205  
206  
207  
208  
209  
210  
211  
212  
213  
214  
215  
216  
217  
218  
219  
220  
221  
222  
223  
224  
225  
226  
227  
228  
229  
230  
231  
232  
233  
234  
235  
236  
237  
238  
239  
240  
241  
242  
243  
244  
245  
246  
247  
248  
249  
250  
251  
252  
253  
254  
255  
256  
257  
258  
259  
260  
261  
262  
263  
264  
265  
266  
267  
268  
269  
270  
271  
272  
273  
274  
275  
276  
277  
278  
279  
280  
281  
282  
283  
284  
285  
286  
287  
288  
289  
290  
291  
292  
293  
294  
295  
296  
297  
298  
299  
300  
301  
302  
303  
304  
305  
306  
307  
308  
309  
310  
311  
312  
313  
314  
315  
316  
317  
318  
319  
320  
321  
322  
323  
324  
325  
326  
327  
328  
329  
330  
331  
332  
333  
334  
335  
336  
337  
338  
339  
340  
341  
342  
343  
344  
345  
346  
347  
348  
349  
350  
351  
352  
353  
354  
355  
356  
357  
358  
359  
360  
361  
362  
363  
364  
365  
366  
367  
368  
369  
370  
371  
372  
373  
374  
375  
376  
377  
378  
379  
380  
381  
382  
383  
384  
385  
386  
387  
388  
389  
390  
391  
392  
393  
394  
395  
396  
397  
398  
399  
400  
401  
402  
403  
404  
405  
406  
407  
408  
409  
410  
411  
412  
413  
414  
415  
416  
417  
418  
419  
420  
421  
422  
423  
424  
425  
426  
427  
428  
429  
430  
431  
432  
433  
434  
435  
436  
437  
438  
439  
440  
441  
442  
443  
444  
445  
446  
447  
448  
449  
450  
451  
452  
453  
454  
455  
456  
457  
458  
459  
460  
461  
462  
463  
464  
465  
466  
467  
468  
469  
470  
471  
472  
473  
474  
475  
476  
477  
478  
479  
480  
481  
482  
483  
484  
485  
486  
487  
488  
489  
490  
491  
492  
493  
494  
495  
496  
497  
498  
499  
500  
501  
502  
503  
504  
505  
506  
507  
508  
509  
510  
511  
512  
513  
514  
515  
516  
517  
518  
519  
520  
521  
522  
523  
524  
525  
526  
527  
528  
529  
530  
531  
532  
533  
534  
535  
536  
537  
538  
539  
540  
541  
542  
543  
544  
545  
546  
547  
548  
549  
550  
551  
552  
553  
554  
555  
556  
557  
558  
559  
560  
561  
562  
563  
564  
565  
566  
567  
568  
569  
570  
571  
572  
573  
574  
575  
576  
577  
578  
579  
580  
581  
582  
583  
584  
585  
586  
587  
588  
589  
590  
591  
592  
593  
594  
595  
596  
597  
598  
599  
600  
601  
602  
603  
604  
605  
606  
607  
608  
609  
610  
611  
612  
613  
614  
615  
616  
617  
618  
619  
620  
621  
622  
623  
624  
625  
626  
627  
628  
629  
630  
631  
632  
633  
634  
635  
636  
637  
638  
639  
640  
641  
642  
643  
644  
645  
646  
647  
648  
649  
650  
651  
652  
653  
654  
655  
656  
657  
658  
659  
660  
661  
662  
663  
664  
665  
666  
667  
668  
669  
670  
671  
672  
673  
674  
675  
676  
677  
678  
679  
680  
681  
682  
683  
684  
685  
686  
687  
688  
689  
690  
691  
692  
693  
694  
695  
696  
697  
698  
699  
700  
701  
702  
703  
704  
705  
706  
707  
708  
709  
710  
711  
712  
713  
714  
715  
716  
717  
718  
719  
720  
721  
722  
723  
724  
725  
726  
727  
728  
729  
730  
731  
732  
733  
734  
735  
736  
737  
738  
739  
740  
741  
742  
743  
744  
745  
746  
747  
748  
749  
750  
751  
752  
753  
754  
755  
756  
757  
758  
759  
760  
761  
762  
763  
764  
765  
766  
767  
768  
769  
770  
771  
772  
773  
774  
775  
776  
777  
778  
779  
780  
781  
782  
783  
784  
785  
786  
787  
788  
789  
790  
791  
792  
793  
794  
795  
796  
797  
798  
799  
800  
801  
802  
803  
804  
805  
806  
807  
808  
809  
810  
811  
812  
813  
814  
815  
816  
817  
818  
819  
820  
821  
822  
823  
824  
825  
826  
827  
828  
829  
830  
831  
832  
833  
834  
835  
836  
837  
838  
839  
840  
841  
842  
843  
844  
845  
846  
847  
848  
849  
850  
851  
852  
853  
854  
855  
856  
857  
858  
859  
860  
861  
862  
863  
864  
865  
866  
867  
868  
869  
870  
871  
872  
873  
874  
875  
876  
877  
878  
879  
880  
881  
882  
883  
884  
885  
886  
887  
888  
889  
890  
891  
892  
893  
894  
895  
896  
897  
898  
899  
900  
901  
902  
903  
904  
905  
906  
907  
908  
909  
910  
911  
912  
913  
914  
915  
916  
917  
918  
919  
920  
921  
922  
923  
924  
925  
926  
927  
928  
929  
930  
931  
932  
933  
934  
935  
936  
937  
938  
939  
940  
941  
942  
943  
944  
945  
946  
947  
948  
949  
950  
951  
952  
953  
954  
955  
956  
957  
958  
959  
960  
961  
962  
963  
964  
965  
966  
967  
968  
969  
970  
971  
972  
973  
974  
975  
976  
977  
978  
979  
980  
981  
982  
983  
984  
985  
986  
987  
988  
989  
990  
991  
992  
993  
994  
995  
996  
997  
998  
999  
1000

sunflower oil is slightly heavier than diesel fuel, weighing pounds per gallon. Diesel fuel weighs 7 pounds per gallon. The sunflower oil is thicker than No. 2 diesel fuel and may require thinning. Mixing sunflower oil with ethyl alcohol has been suggested as a way to thin sunflower oil, but sunflower oil will not mix with alcohol. Sunflower oil does mix with diesel fuel.

Engine efficiency or the horsepower produced per gallon ( $\frac{\text{HP-HR}}{\text{GAL}}$ ) is directly related to the energy of the fuel. The higher the energy rating of the fuel, the more horsepower-hours per gallon is produced. It may be more economical to pay \$2.00 or \$2.25 per gallon for sunflower oil than \$1.25 to \$1.50 per gallon for alcohol because the energy content of sunflower oil is higher.

Alcohol presently costs less than sunflower oil, but there are other factors to consider. Since sunflower oil has a higher energy value than alcohol, it should produce more horsepower-hours per gallon.

Preliminary engine tests have been done using crude sunflower oil mixed with No. 2 diesel fuel in varying percentages. A six cylinder, 401 cubic inch turbo-charged farm tractor engine rated at 135 PTO horsepower was run on mixtures of 25 percent sunflower oil and 75 percent No. 2 diesel fuel; 50 percent sunflower oil and 50 percent No. 2 diesel fuel; 75 percent sunflower oil and 25 percent No. 2 diesel fuel. All mixtures were able to fuel the engine and maintained almost full horsepower.

When the 75 percent sunflower oil and 25 percent No. 2 diesel fuel was used, horsepower dropped slightly. This may be because sunflower oil is thicker than diesel fuel and slows the flow through the filters and fuel lines. From preliminary work, it looks as though fuel efficiency is very similar to straight diesel fuel.

13 AENG-5

It has been estimated that a grower could devote about 10 percent of his total acreage to sunflower and replace all his diesel fuel needs. This figure is based on a consumption of approximately 5 gallons of diesel fuel to produce a small grain crop in North Dakota. The following table lists the oil yield in gallons/acre based on various seed yields.

**Oil Yield in Gallons/Acre**

% of Oil Extracted	Seed Yield (lbs/acre)			
	800	1,200	1,600	2,000
60	24.9	37.4	49.9	62.3
80	33.2	49.9	66.5	83.1

If farmers extract sunflower oil on the farm, a degumming process may be needed to help reduce some of the possible problems associated with the fuel filters and injector pump. Sunflower oil has not been tested for its lubricating capacity, varnish and gum content. It is not yet known what effect long term use of sunflower oil might have on engine and fuel system parts.

Producing sunflower oil on the farm is considered by some to be simpler than producing alcohol. Production costs may also be lower.

### SUNFLOWER OIL EXTRACTION PROCESS

Sunflower oil can be obtained by crushing the seed in a screw press operation in which the oil is literally squeezed out of the seed. This process is different from the solvent extraction process used in large commercial oilseed processing plants. The screw press or expeller operation involves the following steps:

- 1. Whole Seed** The seed needs to be cleaned before any further operation. Any stones or metal pieces will damage the expeller. It may also be advantageous to size the seed prior to pressing.
- 2. Dehuller** It may be desirable to remove the hulls to reduce the fiber content and increase the protein content of the meal.
- 3. Roller Mill** Some type of seed breakage may be advisable. Whole seed can be used but efficiencies of oil recovery are lower.
- 4. Cooker** Some means of heating the seed prior to pressing may be needed to obtain the maximum oil recovery.
- 5. Screw press** The press separates the oil from the meal. The meal will still contain some oil, however. The amount will vary from 7 to 15 percent on a dry weight basis.

- 6. Filter** The oil needs to be filtered to remove small seed particles.
- 7. Crude Oil** This oil may need some additional processing to remove phosphatides and waxes. The exact amount remains to be determined.

### COST OF ON-FARM SUNFLOWER OIL EXTRACTION

If sunflower oil is extracted on the farm for fuel, what will it cost? This information is not yet available. There are some economics of scale in screw press extraction and it may be desirable for a group of farmers, a country elevator or a cooperative to process the seed, extract the oil, and dispose of the meal and hulls. Estimates of the cost of producing oil can be determined by taking the market value of sunflower seed, less the value of sunflower oil meal, and dividing the remaining value by the number of gallons of oil produced from a hundred-weight of sunflower. This estimates only the cost of the raw material. Oil cost may vary due to the value of the meal, as the small percentage of oil in the meal tends to decrease the protein content and increase the energy content. The following table lists only the market value of raw sunflower seed less the value of sunflower oil meal at \$100 per ton.

**Estimated Value (\$) of Sunflower Oil Less Processing Cost\***

	Market Value (\$) of Sunflower/CWT				
	\$7.00	\$8.00	\$9.00	\$10.00	\$11.00
Value of Oil/CWT Seed (32 lbs.)	3.60	4.60	5.60	6.60	7.60
Cost per Gallon Sunflower Oil	.88	1.12	1.36	1.61	1.85
Cost per Lb. Sunflower Oil	.11	.14	.17	.21	.24

\*Above chart based on:

Sunflower = 40% oil by weight

Extraction Rate = 80%

Sunflower Oil = 7.7 lbs/Gallon

Sunflower Oil Meal = \$100/Ton or 5¢ /Lb.

100 Lbs. Sunflower Seed → 32 Lbs. Oil → 4.1 Gallons of Oil  
 → 68 Lbs. Sunflower Oil Meal

### ECONOMICS OF SUNFLOWER PRODUCTION

Production practices for sunflower vary by area of the state. Sunflower in eastern North Dakota is grown on land cropped the previous year. In western North Dakota some of the acreage is grown on land in summer fallow the previous year. Weed control is important with sunflower and farmers generally use more herbicide chemical than they do on small grains. The western area, which receives less growing season rainfall, generally requires fewer cultural practices to control weeds. Sunflower also requires a higher cost for insecticides and drying than small grain.

The estimated cost per acre in North Dakota to produce sunflower is \$148.40. Direct or cash cost is \$71.18 and the indirect or fixed cost is \$77.22. The \$148.40 includes a charge for all resources except risk. If the expected yield was 1,500 pounds, a farmer would need 9.89 cents a pound for sunflower to cover all costs except risk.

Sunflower cost compared with wheat and barley show a total cost per acre of \$148.40 for sunflower, \$125.39 for wheat and \$141.14 for barley. Some of the difference in cost between the three crops is the land charge. Sunflower and barley acreage is greater in the eastern area of the state where land prices are higher, while wheat is the main crop over the entire state, resulting in a lower land price.

Good management was assumed in the crop budgets. The fertilizer input was based on the yield goal. Yield goals are above the average yields for the state, yet attainable with

normal weather and growing conditions. Input costs were based on formula or survey data. Current machinery prices were used to determine machinery costs. Fuel prices were estimated at \$1.00 per gallon for both gasoline and fuel. Interest was charged at 11 percent. Overhead costs include a charge for such items as farm share of utilities and auto insurance, farm subscriptions, bank charges, accounting fees, etc. The management charge was arrived at by taking 10 percent of all costs excluding land.

#### FEEDING VALUE OF SUNFLOWER SEED AND MEAL

Preliminary trials indicate that, fed whole to cattle, sunflower seed has an energy value about equal to barley, provided that not over 3 pounds per head are fed daily. Fed whole to swine, the useful energy content is similar to barley when used at less than 10 percent of the ration and is mixed with barley for grinding.

#### 1980 ESTIMATED AVERAGE PRODUCTION COST PER ACRE FOR SUNFLOWER, WHEAT, AND BARLEY, NORTH DAKOTA

Cost Input	Sunflower	Wheat	Barley
<b>Direct Costs</b>			
Seed	\$ 6.40	\$ 8.25	\$ 5.74
Fertilizer	13.36	11.51	16.23
Custom fertilizer application	5.25	1.98	2.26
Herbicide	10.43	5.41	5.77
Custom spraying	3.02	2.11	2.41
Insecticide	4.50		
Drying	4.50		
Fuel & lubricant	8.12	12.56	13.75
Machine repair	4.90	6.55	7.19
Overhead	4.94	4.54	4.93
Interest on operating capital	5.76	4.29	4.48
Total direct costs	\$ 71.18	\$ 57.20	\$ 62.76
<b>Indirect Costs</b>			
Land charge	\$ 39.29	\$ 31.70	\$ 39.02
Machine ownership	18.71	20.78	22.03
Labor	9.37	7.15	7.93
Management	9.85	8.56	9.40
Total indirect costs	\$ 77.22	\$ 68.19	\$ 78.38
<b>Total Production Cost</b>	<b>\$148.40</b>	<b>\$125.39</b>	<b>\$141.14</b>
<b>Expected Yield</b>	15.00 cwt.	34.00 bu.	59.00 bu.
<b>Break-even Price</b>	\$ 9.89 cwt.	3.69 bu.	2.39 bu.

Crude sunflower oil spot market price January 29, 1980, was 26 cents per pound. (Agricultural Marketing Service, Grain and Seed Division, USFA, Minneapolis, Minnesota.)

Refined sunflower oil spot price was 32 cents per pound the same day. (Cargill, Inc., Fargo, North Dakota)

(Crude sunflower oil is defined as oil recovered before it has undergone degumming, neutralizing, deodorizing, winterizing and bleaching processes. Once the oil has been subjected to the above processes, it is defined as refined oil.)

Two types of sunflower oil meals have been available, a 41 percent protein with low fiber (dehulled) and a 28 percent protein with high fiber (not dehulled before extracting oil). At present feed prices, 41 percent sunflower oil meal for swine is worth \$145-150 per ton. Sunflower oil meal is low in lysine and is needed for a balanced ration. For cattle, the value is \$175-180 as a protein supplement. The value of 28 percent meal is something less than \$90 per ton for swine and about \$130-135 for cattle.

No values can be given for moldy or damaged seed.

#### COMPARATIVE COMPOSITION OF SUNFLOWER SEEDS

Type	Oil	Confectionary	Birdseed
Oil, %	41-42	25-26	22-23
Hull, %	21-23	44-45	45-47
Protein, %	18-19	23-24	22-23
Calcium, %	0.2	0.1	0.15
Phosphorus, %	0.58	0.6	0.7
Acid Detergent Fiber, %	15	27	30

#### FERTILIZER VALUE OF SUNFLOWER OIL MEAL

All crop production by-products have value as a soil additive. Incorporation of crop residues aids maintenance of soil tilth, helps prevent soil crusting and aids water infiltration. Difficult to manage sites in a field landscape benefits most. "Gumbo" spots, eroded ridges and erosion prone slopes are preferred locations for application of limited volumes of accumulated crop residues.

It is difficult to assign a value to sunflower oil meal as an aid to soil tilth or plowing ease. However, with decomposition in the soil the plant food content of sunflower oil meal is released and has measurable value as a fertilizer product. Plant nutrient analysis of dehulled and whole seed sunflower oil meal are shown in Table 1.

Current fertilizer prices for nitrogen, phosphorus and potassium are 18, 24 and 12 cents per pound. These nutrient costs were used in the following table to calculate the value of a ton of sunflower meal. Calcium and magnesium were excluded in the calculation. Calcium and magnesium are basic components of agricultural lime. North Dakota soils are high in lime and a commercial market for the product has not developed.

Hauling, handling and application convenience also should be considered in evaluating the fertilizer value of sunflower meal products. Compared with conventional fertilizer materials these are difficult to handle, low analysis products. Conventional fertilizer equipment will require either modification or additional labor during spreading operations to assure the product feeds smoothly. The additional time, labor and equipment costs required to spread these products reduces their value. However, application can be done as a slack season chore, enhancing their value as a management alternative.

The whole seed and dehulled meal used as examples in this cost analysis contain 26 percent and 43 percent protein respectively. These are typical of solvent extraction products. Farm presses that simply squeeze oil from whole seed will leave a residual oil that dilutes the nutrient content of the meal and distorts the dollar value calculations.

TABLE 1  
PLANT NUTRIENT CONTENT OF SUNFLOWER MEAL PRODUCTS (%)

	<u>Nitrogen</u> (N)	<u>Phosphorus</u> (P <sub>2</sub> O <sub>5</sub> )	<u>Potassium</u> (K <sub>2</sub> O)	<u>Calcium</u>	<u>Magnesium</u>
Whole seed sunflower meal	4.3	2.29	1.2	.5	.7
Dehulled sunflower meal	6.9	4.1	3.0	.3	.7

TABLE 2  
Pounds/Ton Plant Nutrient and Relative Value of Sunflower Meal As a Soil Additive

	<u>Whole Seed Meal</u>		<u>Dehulled Seed Meal</u>	
	<u>Lbs./Ton</u>	<u>\$/Ton</u>	<u>Lbs./Ton</u>	<u>\$/Ton</u>
Nitrogen (N)	86	15.48	138	24.84
Phosphorous (P <sub>2</sub> O <sub>5</sub> )	46	11.04	82	19.68
Potassium (K <sub>2</sub> O)	24	2.88	60	7.20
Total		\$29.40		\$51.72