# Symposium

Papers from the symposium on

## Vegetable Oils as Diesel Fuels

presented at the 73rd AOCS Annual Meeting
held in Toronto, Canada, May 2-6, 1982

# Vegetable Oils as Diesel Fuels: Overview

**E.H. PRYDE**, Organizer and Chairman, Northern Regional Research Center, Agricultural Research Service, US Department of Agriculture, Peoria, IL 61604

Vegetable oils apparently have good potential as alternative fuels for maintaining crop production during periods of fuel shortages. Among the advantages of vegetable oils as fuel are: their physical nature as liquids and, hence, their portability; their heat content (88% of diesel oil); their ready availability and the fact that they are renewable resources. In reality, vegetable oil fuels used in US farm tractors introduce a number of problems, the origins of which can be traced back to their high viscosity, low volatility, and the reactivity of the unsaturated hydrocarbon chains.

In short-term engine performance tests of less than 10 hr duration, the vegetable oils perform quite well. The problems show up only after the engine has been operating on the vegetable oil for longer periods of time and are far more pronounced in direct-injection engines than in the less efficient engines having precombustion chambers (indirect injection). The problems include:

–coking and trumpet formation on the injectors to such an extent that fuel atomization does not occur properly or is even prevented as a result of plugged orifices;
–carbon deposits;
–oil ring sticking; and
–thickening and gelling of the lubricating oil as a result of contamination with vegetable oil.

In addition to the question of technical feasibility, the following symposium and poster session papers address questions of on-farm production, economic feasibility, oil availability, land availability, energy efficiency and vegetable oil modification.

On-farm recovery of oil from sunflower seed appears feasible (Backer, Jacobsen and Olson), and this probably is true also for other oilseeds of high oil content. The economics of on-farm recovery of sunflower oil are not favorable at the moment, but the energy output/input ratio for this oil is very favorable (Helgeson and Schaffner). Use of a 25/75 blend of sunflower oil in diesel oil in a standard 200-hr screening procedure indicated that long-term use of such a mixture would not be feasible in a direct-injection engine (Ziejewski and Kaufman). With a different type of direct-injection engine, the same test procedure indicated that a 33/67 but not a 50/50 blend of soybean oil in diesel might be tolerated for emergency use (Adams, Peters, Rand, Schroer and Ziemke). The differences in engines but probably not in the vegetable oils might account for apparent discrepancies between these two results.

A third oilseed, winter rape (*Brassica napus L.*), when blended in the proportion 30/70 in diesel oil, was used to power an indirect-injection engine for 850 hr with no adverse effects noted (Peterson, Auld and Korus). On-farm recovery was demonstrated also for this oilseed. Either high- or low-erucic rapeseed oils can be recovered satisfactorily in a screwpress, and the oils show little difference in performance between small or large engines in short-term tests, but there is a major problem with viscosity, particularly in cold weather (Strayer, Blake and Craig).

Cottonseed and sunflower oils need to be at least degummed for fuel use, as shown in short-term performance tests with an engine having a precombustion chamber, but even at that state of refinement, they are unsuitable for runs of more than 40 hr when used as the straight, unblended fuel (Engler, Johnson, LePori and Yarbrough).

Although vegetable oils apparently can be tolerated in direct-injection engines only as dilute blends in diesel oil, there is accumulating evidence worldwide that the simple esters can function as a diesel fuel by themselves because of improved viscosity and volatility properties compared to the triglyceride. Ethyl esters of monounsaturated or short-chain fatty acids should make good alternative fuels as demonstrated in short-term tests with a single-cylinder, direct-injection engine (Klopfenstein and Walker). Most of the ester fuels tested had higher thermal efficiencies than did No. 2 diesel fuel. An intriguing concept is the conversion of used frying oil to simple esters (Nye, Williamson, Deshpande, Schroder, Snively, Yurkewich and French).

Either acidic or basic catalysts could be used for the transesterification, but best results were obtained with potassium hydroxide.

Good progress has been made in answering some of the questions posed earlier, but definitive answers for all of the problems are not yet available, and there is need for continuing testing of modified fuels and evaluation of engine design factors.

# Farm-Scale Recovery and Filtration Characteristics of Sunflower Oil for Use in Diesel Engines[1]

**L.F. BACKER, L. JACOBSEN** and **J.C. OLSON**, Agricultural Engineering Department, North Dakota State University, Fargo, ND 58105

## ABSTRACT

The "Hander," new Type 52 oil expeller was evaluated to determine its performance in expressing sunflower oil for use in diesel engines. Strain gauges were mounted on the barrel of the expeller and were used to give a relative indication of barrel pressure. Relative barrel pressure was then used as the independent variable in determining performance. Filterability of four commercial sunflower oils and blends of these oils with No. 2 diesel fuel were determined at various temperatures and pressures. Oil extraction efficiency ranged from ca. 56% to 84% at low and high relative barrel pressures, respectively. The greatest oil extraction rate was 12.3 kg/hr at a feed rate of 40 kg/hr with an extraction efficiency of ca. 80%. Dewaxed sunflower oils and blends filtered much better than nondewaxed oils and their blends. Increasing temperature, pressure and percentage of diesel fuel in the blends increased filterability of dewaxed sunflower oil.

## INTRODUCTION

America's view on energy availability and costs is very different today to that a decade ago. Today, almost 45% of our total energy is derived from oil and 40% of this is imported. The majority of this oil comes from an international oil pool controlled by OPEC. It is now clear that the United States must solve its energy problem at home. Various alternative liquid fuels are being considered, with much attention being given to vegetable oils.

The diesel engine application is widespread in agriculture, and increasing numbers and used in automobiles and trucks. Various researchers have demonstrated that sunflower oil has potential as an alternative fuel for diesel engines (1).

The practicality of an alternative farm fuel is dependent on the amount of land required to produce the crop. The average sunflower yield in the United States is 1390 kg/ha. The oil content of the seed is ca. 40%, which can all be recovered in a commercial solvent extraction operation to get 604 L/ha of sunflower oil. The on-farm fuel required to produce one hectare of sunflower or small grain in North Dakota ranges from 56 to 84 L. Under these conditions, one hectare of sunflower could produce enough fuel to grow 7-11 hectares of small grain or sunflower (2). Further, it may be possible for the farmer to reduce costs compared to commercial processing by recovering the oil from the seeds with a screw expeller and then processing the oil as necessary. There are two major differences between commercial processing and on-farm processing. In the latter, the hulls are not removed and solvent extraction is not utilized. The meal will be high in fiber content and will contain 12-18% oil on a dry weight basis, and efficiency of oil recovery will be less than in a commercial process.

[1]Work on this project is supported by North Dakota Agricultural Experiment Station Project 1439.

After recovery, sunflower oil is clarified through one or more processes to remove most of the solids (primarily small seed particles). The large solids can usually be screened off or settled out. Before the oil can be considered for use as a fuel, the fines must be removed. This can be accomplished by using one or more of several processes including settling, screening (stationary or vibrating), centrifuge, filter press or vacuum filtration. For on-farm processing, gravity settling followed by the use of a filtration system appears quite attractive. Gravity settling requires very little capital investment and virtually no operating expense.

It was recognized that filtration would be required or at least be desirable in several locations in the total fuel supply system, i.e., prior to delivery to the storage tanks, or prior to delivery to the engine fuel supply tank, or prior to the injection pump in the fuel system of the diesel engine. The pressure differential across the filter would range from relatively low to relatively high values. Oil temperatures at the time of filtration would also vary from low to high. Additionally, sunflower oil samples from various sources were quite different in visual appearance and turbidity, which would affect the filtration characteristics of the oils.

The objective of this research was to evaluate the performance of an on-farm type screw expeller for recovering sunflower oil for use in diesel engines. A further objective was to determine filtration rates of some commercially available sunflower oils and blends of these oils with diesel fuel at various temperatures and pressures.

## EXPERIMENTAL PROCEDURES

### Sunflower Oil Recovery

Capacity of an oil extraction unit may be given in terms of the mass of seed or in terms of mass or volume of oil produced per unit of time. Oil recovery efficiency is the ratio of the oil produced to the total oil content of the seed.

The unit under study was the "Hander" oil expeller, New Type 52, made by CeCoCo of Osaka, Japan, rated at ca. 50 kg/hr of dehulled sunflower seed, and powered by a 2.2 kW electric motor. This unit is similar in form to all oilseed screw presses (3). It is simply a screw conveyor with decreasing volumetric displacement from the feed inlet end to the point of discharge of the press cake, which revolves within a drained barrel. The decreasing volume of the screw applies increasing pressure to the seeds as they move through the length of the barrel, causing the oil to be "squeezed" from the seed and expelled through the barrel. Additionally, the screw fits into a tapered ring at the discharge point of the press cake. The screw can be adjusted axially relative to this ring to change the pressure applied to the seeds. Varying the applied pressure will influence the feed rate, oil capacity,