

Feasibility of a Producer-Owned Winter Canola Processing Venture

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Abstract: The feasibility of a winter canola processing facility with further processing into biodiesel or food grade refined oil was investigated. The rate and location of canola adoption was projected using field level records on over 130,000 wheat farms. The results indicated acceptable rates of return for two alternative mechanical oil extraction systems. Further integration into biodiesel or food grade oil increased returns slightly while doubling the total project costs. Returns were sensitive to canola seed price and canola oil price. The study concluded that a \$0.105/lb canola price would provide adequate crushing returns and sufficient incentives for canola adoption.

Key words: crop adoption, extruder/expeller, feasibility, meal quality, oil extraction, refining

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FEASIBILITY OF A PRODUCER-OWNED WINTER CANOLA PROCESSING VENTURE

Background

Each year over 6 million acres of hard red winter wheat is planted in Oklahoma, making it the state's major cash crop. Oklahoma's typical precipitation pattern favors the production of winter crops. However, returns to wheat production have been stagnant. Additionally, the continuous wheat cropping system has led to disease and weed pressures. The combination of agronomical and economic concerns with continuous winter wheat has led to interest in winter canola as a rotational crop.

Winter canola production has a number of advantages for Southern Plains wheat producers. The growth cycle matches the region's traditional precipitation patterns. Canola is a broadleaf while wheat is a grassy plant, a distinction that allows producers to economically control both grassy and broadleaf weeds on canola/wheat rotation acres. Herbicide resistant varieties of canola are also available, providing more options for problem weeds. A canola/wheat rotation can also break insect and disease cycles, and the deep tap roots of canola tend to break up the hardpan in wheat fields. For these reasons, agronomists expect a 5-10% increase in wheat yields following canola. Even ignoring the synergist effects, winter canola production appears to offer higher returns (relative to winter wheat) and canola prices are uncorrelated with wheat prices.

Oklahoma canola production has increased from a few thousand acres in 2004 to over 50,000 acres planted for the 2006 harvest season. The absence of processing facilities is a major impediment to widespread canola adoption. The majority of Oklahoma canola is currently transported to North Dakota for processing, with transportation costs eroding almost 30% of the value. This situation led a group of producers to investigate a producer-owned canola processing

venture which would purchase canola seed from the participating producers, and add value by extracting the oil component of the crop and marketing oil and meal feed. A multi-disciplinary team at Oklahoma State University was asked to assist in assessing the feasibility of a producer-owned canola-processing venture. Because of the “chicken and egg” nature of canola production and processing, this assessment involved unique challenges.

Study Design

Investigating the feasibility of canola processing involved several complications. In addition to the market, investment, and production issues typically considered in a feasibility assessment, investigating canola processing feasibility necessitated forecasting the adoption process of winter canola. Projections on canola adoption help to determine the optimal plant size and location and to forecast the adequacy of raw material supply during the initial years. Alternative technologies, including solvent-based (hexane) extraction and mechanical extraction systems including expellers and extruder-expeller systems, were considered along with further processing alternatives, i.e. refining food grade oil or producing biodiesel.

Objectives

The overall objective was to assess the feasibility of a producer-owned winter canola processing facility, with and without further processing into food grade refined oil or biodiesel .

Specific objectives were to:

- Project the rate and location of Oklahoma canola adoption and the minimum price level required to stimulate adoption;
- Identify alternative processing technologies and their technical and economic efficiencies;
- Estimate capital and operating costs for oil extraction, refining and biodiesel production;
- Determine the market potential for raw and refined oil, biodiesel and meal feeds; and

- Project the return on investment and capital requirements of a producer-owned winter canola processing venture and sensitivity to various risk factors.

Raw Material Supply

The viability of a canola processing venture obviously depends upon a reliable source of raw material. Raw material acquisition risks can be mitigated, to an extent, by organizing the processing business as a farmer-owned cooperative with delivery commitments. However, canola adoption is still an important issue since it impacts the availability of member investors. Because winter canola is envisioned as a rotational crop with winter wheat, projected canola production would be expected to be related to wheat acreage. Canola production could be estimated by assuming that some arbitrary percentage of wheat acres rotated into canola. However, a simplistic projection would ignore the economic factors, including canola price, which would influence producer's decisions to adopt a wheat/canola rotation. Canola price assumptions and the locations of canola production are key variables influencing the profitability of canola processing.

In order to more accurately project the location of potential canola acreage and identify the price level necessary for adoption, canola adoption was examined on a field-by-field basis. Yield and location information for over 130,000 individual wheat fields were obtained from USDA/FSA data for the 1995-2004 period. Field level costs of production and return estimates for both wheat and canola were calculated using USDA/ERS and Oklahoma State cost of production data. While farm level yield data on canola in Oklahoma is limited, a five year history of experiment station variety test yields is available. The variety test yield data was used to estimate the correlation between canola and wheat yields. The data indicated that, on a per-

pound basis, canola yielded approximately 85% that of winter wheat varieties grown in the same variety plot locations.

The field-by-field time series of actual wheat yield data was used to estimate a time-series of canola yields for the same fields. The yield and cost of production information was used to forecast the relative profitability of wheat versus winter canola for each field and to forecast canola adoption at various canola prices. The analysis determined that at canola prices above \$0.095/lb the returns to a wheat/canola rotation exceeded the returns to continuous wheat on many fields. After identifying the fields where projected canola returns exceeded wheat returns it was necessary to project the time-path of canola adoption.

Historically, farmers have not immediately adopted new technologies or more profitable alternative crops. For example, the comprehensive adoption of hybrid corn required almost 14 years. More recently, herbicide resistant soybeans, often cited as an example of rapid adoption, achieved a 44% adoption rate three years after commercial introduction (Babcock, Duffy and Wisner). Oklahoma wheat producers will not immediately shift acreage to canola even if the returns from canola production exceed that of wheat. The time path of an acreage shift is an important consideration in determining whether the supply of canola will be sufficient to support a new processing operation.

The time path of canola adoption was modeled by adding a series of constraints to the model that selected which fields would adopt canola. The constraints did not allow more than 10% of the wheat acres belonging to a single producer to shift into canola production in a given year. The total shift of wheat acres for each producer was also limited to 50%, the level required for a total shift to wheat/canola rotation. This reflected the fact that producers were not expected to adopt continuous canola. The model also did not allow more than 10% of the wheat acreage

in any particular county to shift into winter canola in a given year. Using these constraints and the wheat versus canola return projections, a geographically linked database of projected canola adoption for a five year time frame was generated.

Eight possible processing plant locations were identified based on existing wheat production and grain storage infrastructure. The adequacy of canola supply was examined for each plant location procurement region. Four of the locations were projected to have significant canola adoption (more than 100,000 acres within a 50 mile radius). These locations were used in calculating raw material and final product transportation costs in the feasibility model.

Table 1: Projected Shift from Wheat to Canola Production for Selected Procurement Areas Under Various Yield Assumptions

	<u>Under Various Canola Yield Assumptions</u>		
	Canola Yield= Historical Wheat Yield	Projected Acreage Shift	
		Canola Yield = 2,250 lbs/acre	Canola Yield = 2,500 lbs/acre
Garfield & Surrounding Counties	32,182	327,512	329,961
Custer & Surrounding Counties	25,448	463,100	468,780
Major & Surrounding Counties	21,313	321,523	324,193
Jackson & Surrounding Counties	1,023	137,931	138,670
	Percentage of Supply Required for 300 ton/day Plant		
Garfield & Surrounding Counties	33%	336%	338%
Custer & Surrounding Counties	26%	475%	481%
Major & Surrounding Counties	22%	330%	333%
Jackson & Surrounding Counties	1%	141%	142%

Canola price = \$.095/lb.

Processing Technologies

The main objective of oilseed processing is to extract oil from the seed. Oil is the most valuable product, however the oilseed meal is another source of revenue to support the processing operation. Ideally, the process extracts as high a portion of the seed's oil content as possible and provides a good quality meal that contains as few anti-nutritional elements as possible. Oilseed extraction technologies include solvent (hexane) and mechanical extraction.

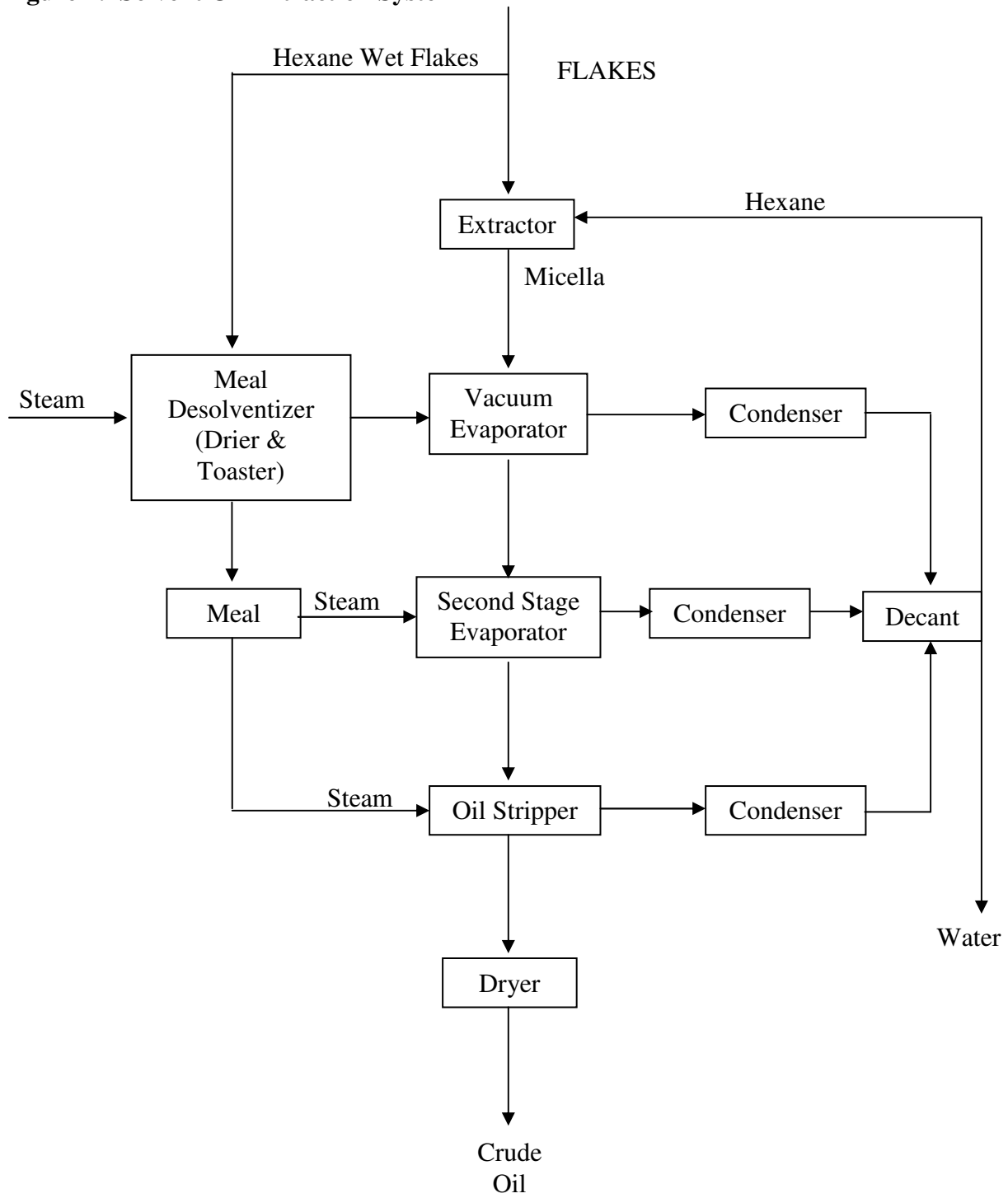
Solvent Extraction

A flow chart of a typical solvent extraction system is provided in Figure 1. Solvent extraction removes a high proportion (up to 99%) of the oil. Solvent extraction is generally economically attractive only when large quantities of seed can be processed since significant economies of scale exist. A typical U.S. solvent extraction soybean plant has a daily capacity of 2500-3000 tons/day (27-30M bushels/year). Constructing and operating solvent extraction with a petroleum distillates such as hexane raise occupational safety and environmental issues.

Solvents used for oilseed extraction are extremely flammable. Therefore, the equipment that extracts the oil and removes the solvent must be airtight and leak proof, and all motors and electrical switches, lights, etc. must be specially designed as vapor-explosion-proof (Class I-D). No matches, no smoking, and no cutting torches, welder's grinders, or other heat-producing or spark-producing devices can be permitted where such solvents are used. Careless exposure to sources of fire or sparks (including engines of trucks driven too close to extraction plants) have caused disastrous explosions.

The EPA now categorizes hexane as a HAP (hazardous air pollutant). It is included on the list of 189 toxic chemicals. It is controlled under the TRI (toxic release inventory) of the U.S. EPA. Refer to Inform, Vol. 9, No.7, July 1998:p 708. Modern state of the art facilities have a maximum guaranteed loss of 0.15%, with practical operations at 0.1%. Even at this guaranteed loss of 0.15%, a moderate-sized 100,000 bushel per day facility will lose 6,000 pounds of hexane per day to the environment (atmospheric leaks from distillation, decanting, open vessels, and the meal). Because of both these environmental and safety issues it has become virtually impossible to site a new hexane plant in some locations in the United States.

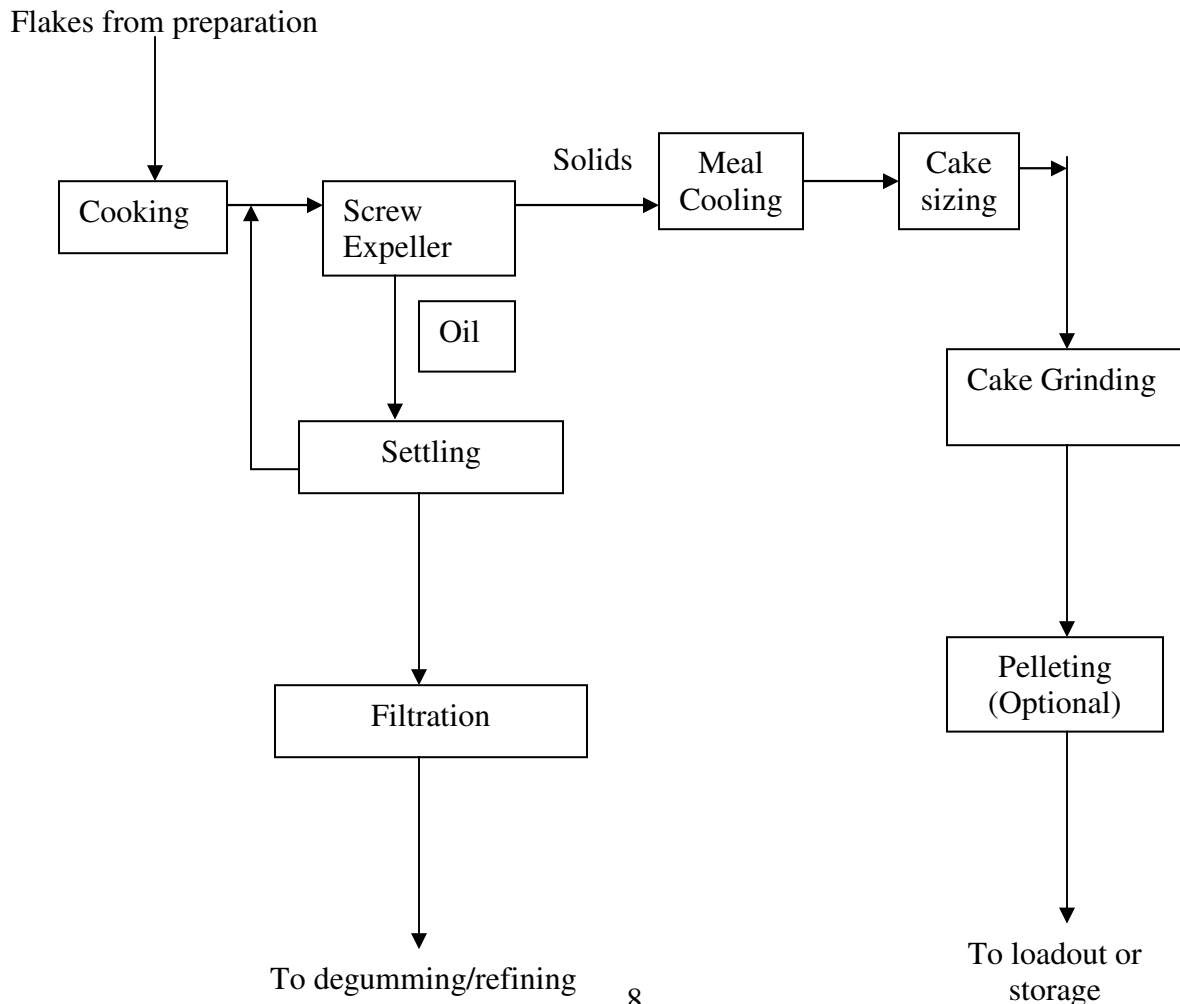
Figure 1: Solvent Oil Extraction System



Mechanical Extraction

Preheated steam expellers are a type of mechanical extraction in which cracked seeds are heated with steam and then processed in a continuous screw press to force the oil from the seed. Preheated steam expeller systems have higher oil extraction efficiency relative to the older style single expeller (also called a cold press). The primary function of the steam is to increase throughput and to reduce the wear on the screw press. The steam pre-treatment also assists in deactivating enzymes and can improve the protein quality and texture of the meal, relative to that of a mechanical cold press. Preheated steam expellers are typically used in intermediate sized facilities processing from 300-1,000 ton/day (3M-10M bushels/year). A flow chart of a pre-treated steam expeller system is provided in Figure 2.

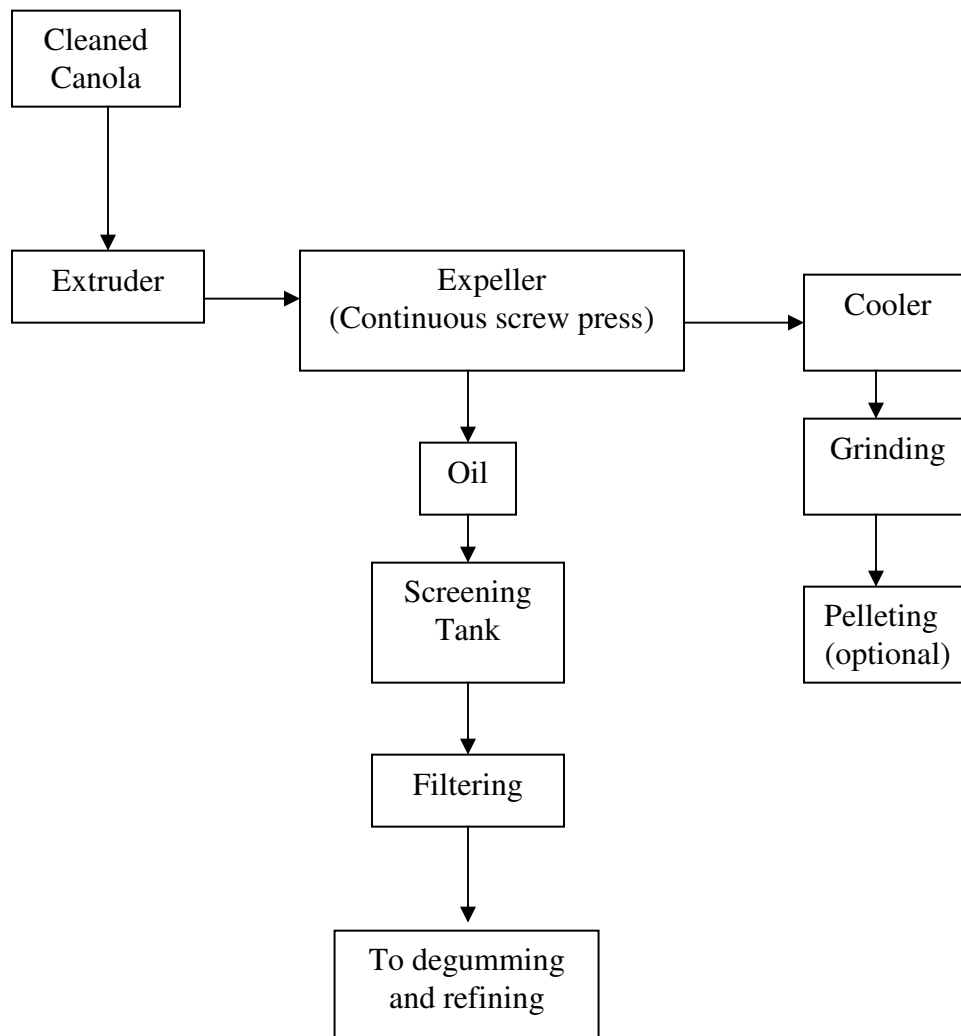
Figure 2: Pre-treated Steam Expeller



Extruder/Expeller

Extruder/expellers compress the oilseed to very high pressure using friction as a source of heat to raise the temperature to approximately 135 ° C. The heat deactivates the enzymes and destroys micro-organisms. The compressed material then expands rapidly as it leaves the extruder. The expansion ruptures the starch cell structure, facilitating the release of the oil. After leaving the extruder the oilseed is immediately processed in a screw press. The extrusion step increases oil yield relative to a cold pressing system. In addition, the temperature and dwell time can be manipulated to improve the digestibility and quality of the meal. The meal from this system generally has a higher level of bypass protein, a desired property in dairy cattle rations.

Figure 3: Extruder/Expelling Processing Flowchart



Because of the scale economies and environmental and worker safety issues involved with solvent extraction it was determined that the proposed Oklahoma canola processing operation should concentrate on mechanical extraction technologies. A detailed equipment list and cost estimate was obtained from the leading oilseed crushing manufacturers for both pre-treated steam and extruder/expeller systems both with capacities of 330 tons/day (300 metric tones/day). Operating costs were estimated using information provided by the equipment manufacturers, expert opinions from oilseed specialists at Oklahoma State University's Food and Agricultural Products Center, and other sources. Utility cost estimates were based on connected horsepower and boiler throughputs. Maintenance cost estimates incorporated information obtained from the manufacturers concerning the cost and operating life of the major wear items in the expellers and extruders.

Oil Purification and Further Refining

The oil directly recovered from the canola seeds, whether through solvent extraction or mechanical expelling, is "crude" and contains impurities, such as lecithin, free fatty acids, and undesirable color and odor. These impurities are removed in a series of processes that yield "refined" oil. These processes include de-gumming, physical or chemical refining, bleaching and deodorizing. De-gumming, refining, and bleaching can be achieved by a number of processes. The following descriptions focus on common processes used for canola.

De-gumming

Crude oil from the extraction process is usually de-gummed before being sold as raw oil or transferred to the further refining process (Figure 9). De-gumming removes phosphatides which tend to separate from the oil and form a sludge during storage. The phosphatide content of oil varies but is typically around 1.25%, which equates to a phosphorus content of 500 ppm.

Canola oil can be de-gummed by adding an acid such as citric or phosphoric acid, followed by a water wash and vacuum drying process. Acid de-gumming reduces phosphorus to 5-50 ppm.

Physical Refining and Bleaching

In physical refining the free fatty acids are eliminated through steam distillation. Acid-water de-gummed oil with a phosphorus content below 50 ppm is treated with phosphoric acid. It is then treated with an acid-activated bleaching clay which absorbs the precipitated phosphatides and chlorophyll. The remaining oil contains trace quantities of soap. Washing the oil with hot water and eliminating the wash water from the bottom after adequate settling or by-passing it through a centrifuge remove the traces of soap. Washing is repeated three or four times in a batch operation for maximum removal of the soap from the oil.

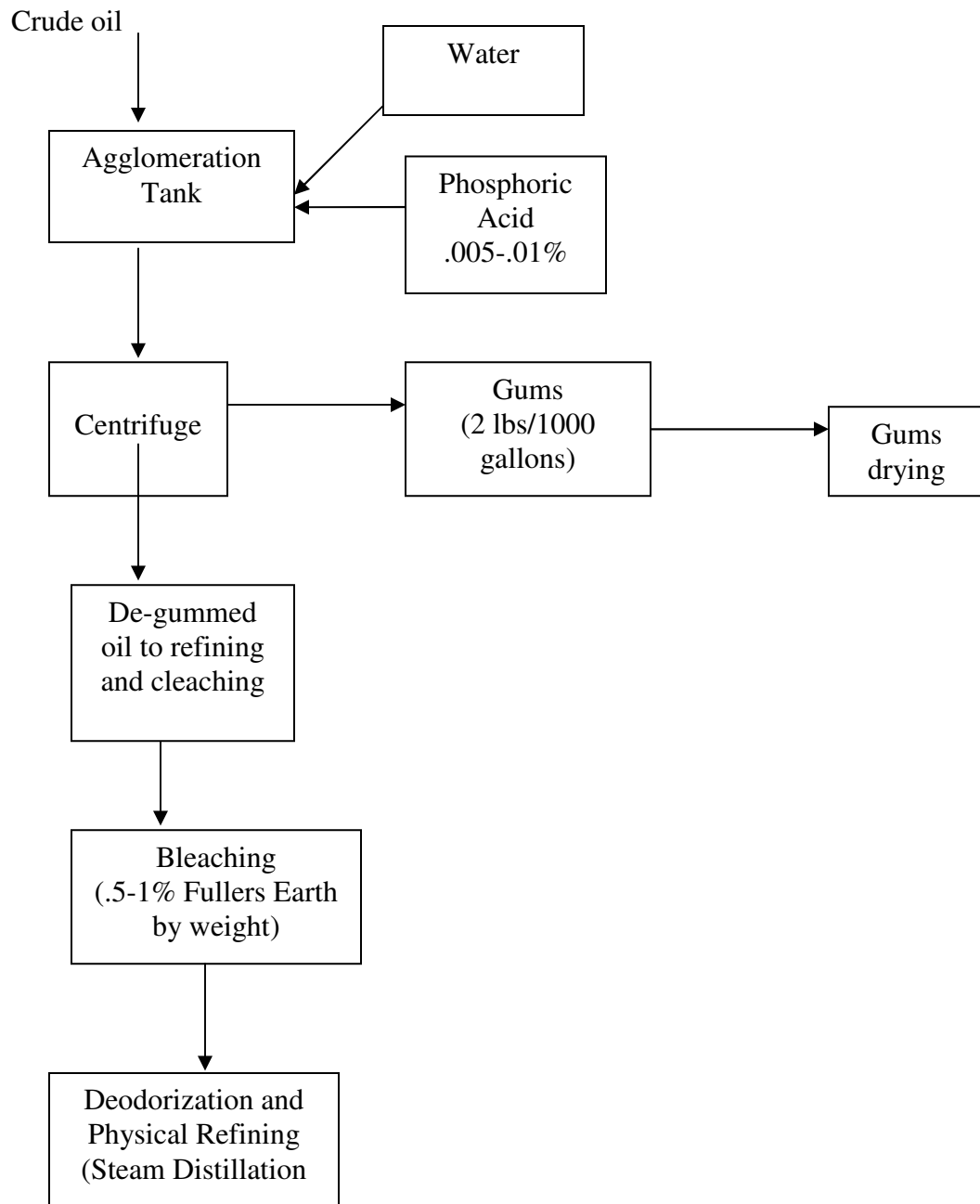
Absorptive Bleaching

The bleaching process removes color, odor, other impurities and residual soap. Alkali refined oil still retains most of the chlorophyll compounds. Chlorophyll removal is one of the most important aspects of the refining and bleaching process. Chlorophyll serves as a catalyst for the oxidation process and gives an undesirable green color to the oil. Absorptive bleaching can be accomplished by treated de-gummed oil with phosphoric or citric acid. Approximately 1% of a bleaching clay as Fuller's earth is then used to absorb the precipitated phosphatides and chlorophyll. The slurry is then pumped into a vacuum system and heated to 104 - 166 ° C. The slurry which contains the bleaching clay and the absorbed compounds is then filtered, cooled and pumped to a holding tank. After the slurry has been removed the oil is heated and the free fatty acids are removed by steam distillation as part of the deodorization process.

Deodorization

The purpose of deodorizing oil is to eliminate undesirable odors and remaining free fatty acids. Deodorization involves a steam stripping process wherein good-quality steam, generated from de-aerated and properly treated feed water, is injected into the neutralized and bleached oil under low absolute pressure and high temperature to vaporize the odoriferous compounds. When physical refining is used all of the free fatty acids must also be removed during the deodorization process. The same basic process is used but the oil must be to be heated beyond the temperature required for deodorization.

Figure 4: De-gumming and Physical Refining Process



Biodiesel Production

Biodiesel can be produced by chemically combining several types of natural oils or fats with an alcohol to form alkyl esters of fatty acids. Fatty acid alkyl esters that meet stringent transportation fuel quality standards are generally known as biodiesel. Biodiesel can be used in pure form (B-100) or blended with petroleum diesel. Blends as low as 2% (B-2) have been demonstrated to be sufficient to create lubrication advantages, while blends up to 20% (B-20) can be used in most diesel engines without modification. Biodiesel has an oxygen content of approximately 11% (by weight). This oxygen in biodiesel improves combustion and therefore reduces hydrocarbon, carbon monoxide, and particulate emissions, but tends to increase nitrogen oxide emissions (Wyatt et. al). Biodiesel has better lubrication properties (lubricity) than current low-sulfur (500 ppm sulfur by weight) petroleum diesel. This lubricity advantage is expected to become more important with the ultra-low-sulfur petroleum diesel requirements (15 ppm sulfur by weight) for 2006. A 1% or 2% volumetric blend of biodiesel in low-sulfur petroleum diesel improves lubricity substantially. This lubricity advantage should boost biodiesel demand as a fuel additive.

B-20 mixtures of biodiesel typically raise the cold weather properties by 2° to 10° F relative to #2 diesel. Biodiesel has higher cloud and pour points compared to conventional diesel. The cloud point is the temperature at which wax first becomes visible when the fuel is cooled. The pour point is the temperature at which the amount of wax out of solution is sufficient to gel the fuel, thus it is the lowest temperature at which the fuel can flow. The solvent property of biodiesel can cause other fuel-system problems. Biodiesel may be incompatible with the seals used in the fuel systems of older vehicles and machinery, necessitating the replacement of those parts if biodiesel blends are used.

In June 2004, EPA finalized the Clean Diesel Trucks and Buses Rule, and the Clean Off-Road Diesel Rule, with more stringent standards for new diesel engines and fuels. The rules require the use of lower sulfur fuels beginning in 2006 for highway diesel fuel, and 2007 for off-road diesel fuel. In June 2006 refiners must meet a 15 parts per million (ppm) standards for at least 80% of the highway diesel fuel produced, with a 500 ppm cap on the remaining 20% of their production. By 2010, all highway diesel fuel must meet a 15 ppm cap. Off-road diesel fuel can currently contain up to 3,000 ppm sulfur. This will be reduced to 500 ppm in 2007 and 15 ppm in 2010. As the sulfur content of diesel is reduced the lubricity of the fuel is also decreased. Biodiesel can be used as an additive to improve lubricity. A .5% blend of biodiesel will increase lubricity by 30%. The new low-sulfur regulations will create/increase demand for lubricity additives. If biodiesel is found to be the lowest cost additive, U.S. biodiesel demand should expand substantially.

The most common production process for biodiesel is base catalyzed transesterification, a relatively simple process which has a conversion yield of around 98%. Crude vegetable oil contains triglycerides which are glycerine molecules three long chain fatty acids attached. (Vegetable oils vary in the nature of the fatty acids which can in turn affect the characteristics of the biodiesel.) In the transesterification process, the triglyceride is reacted with alcohol (usually methanol or ethanol) in the presence of a catalyst which is usually a strong alkaline like potassium hydroxide or sodium hydroxide. The alcohol reacts with the fatty acids to form the mono-alkyl ester, or biodiesel and crude glycerol.

Production Process

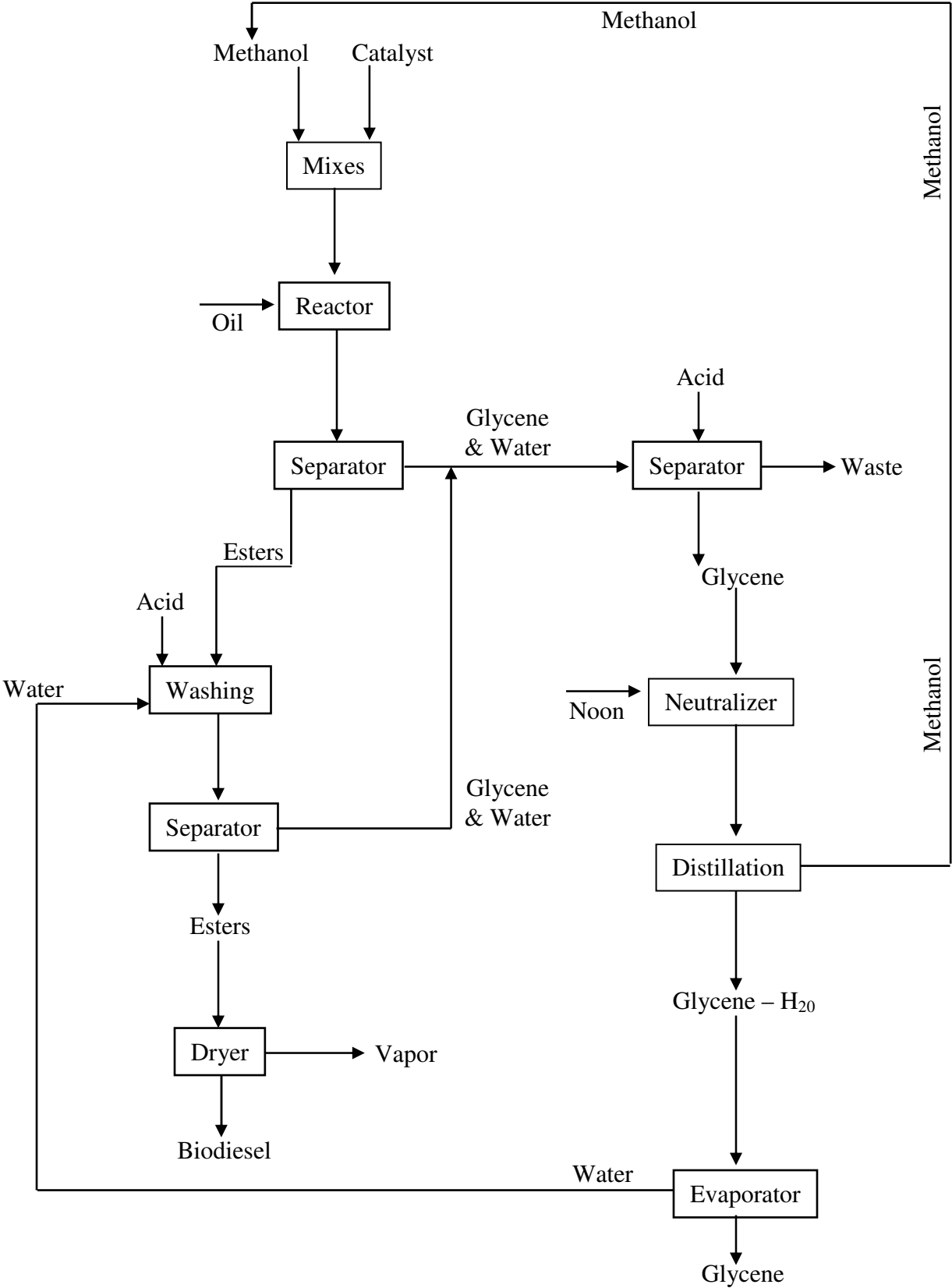
The biodiesel production process (Figure 4) begins by mixing alcohol and a catalyst which is typically sodium hydroxide (caustic soda) or potassium hydroxide (potash). The

alcohol and catalyst are mixed or agitated and then transferred to a closed reaction vessel where the oil is added. After these initial steps the system is totally closed to the atmosphere to prevent the loss of alcohol. The reaction mix is kept just above the boiling point of the alcohol (around 160 °F) to speed up the reaction and the process is closed to the atmosphere to prevent the loss of alcohol.

The reaction produces two basic products: glycerin and biodiesel. Each has a substantial amount of the excess methanol that was used in the reaction. Glycerin has a higher density than biodiesel and can be gravity-separated by simply drawing off the bottom of the settling vessel. A centrifuge can be used to separate the glycerin and biodiesel more rapidly. The biodiesel is purified by washing gently with warm water to remove residual catalyst or soaps, dried, and sent to storage. Prior to use as a commercial fuel, the finished biodiesel must be analyzed using sophisticated analytical equipment to ensure it meets any required specifications.

The glycerin separation contains unused catalyst and soaps. Mineral acids are used to neutralize the glycerin before it is routed to the evaporator where water and alcohol are removed. These steps yield an 80-88% pure glycerin that can be sold as crude glycerin. The glycerin can also be distilled to 99% or higher purity and sold into the cosmetic and pharmaceutical markets.

Figure 5: Biodiesel Production Process



Equipment lists and cost quotations for “turn-key” systems for biodiesel production and food grade refining systems were obtained from a manufacturer. The further processing systems had an annual capacity of 10 million gallons/year which was a fairly close match to the protected oil yield from the crush operation of 8.6 million gallons/year. Operating costs for the biodiesel and food grade refining systems were based on the chemical inputs required for each gallon of throughput and from the horsepower and steam requirements of the systems.

Feasibility Study Results and Implications

Plant Investment Costs

The total cost of plant, property and equipment for a 330 ton-per-day steam pre-treated press was \$5.6M (U.S.) This included \$3.2M of equipment, \$800,000 of engineering equipment, building expenses of \$500,000 and raw and finished material storage of \$750,000. The pre-treated steam expeller system has a total horsepower of 1,100. The total cost of the extruder-expeller system was slightly less at \$4.1M. The extruder-expeller system required the use of just under 1,800 horsepower. The additional capital cost of adding biodiesel or food grade refining was estimated at \$5.5M and \$3.5M respectively. These costs represented the additional cost of equipment and final product storage. No additional land or building costs were included.

	Steam Pre-treated Press	Extruder-Expeller
Total Cost for Plant Property and Processing Equipment	\$5.6M	\$4.1M
Additional Capital Cost for Biodiesel Production	\$5.5 M	\$5.5 M
Additional Capital Cost for Food Grade Refining	\$3.5M	\$3.5M
Hourly Capacity (metric tonnes)	12.5/hour 300/day	12..5/hour 300/day
Annual Capacity (metric tonnes)	92,965	92,965
Extraction Efficiency: Manufacturer estimate	88%	91%
Extraction Efficiency: Used in Feasibility Model	85%	85%
Annual Production: Meal (metric tones)	62,500	62,500
Annual Production: Oil (gallons)	8.5M	8.5M

Return on Investment

Returns on investment for the different processing technologies were determined independent of Oklahoma state tax incentives available to agricultural producers investing in a new value-added processing operation. Several measures of return, including net present value (NPV), return on assets, and return on equity were computed for the two alternatives, but for the purposes of this report only internal rate of return and payback period are discussed.

While the two alternative mechanical oilseed extraction systems use very different technologies the estimated processing costs per ton was remarkably similar. The pre-treated steam system had lower total horsepower and lower electricity costs. However, the pre-treated steam system required a boiler and expenses for natural gas. Still, the total utility costs were still more than \$3/ton lower for the pre-treated steam system. Both systems required 10 total employees for 3 shifts/day operation (2 operators per shift, 1 maintenance and 1 logistic employee, and 2 administrative) for a total labor cost of \$5.11/ton. Maintenance costs were projected to be slightly higher for the steam pre-treated press. Fixed costs were higher for the pre-treated steam system, reflecting the higher depreciation and interest expenses. The total costs per ton were very similar for both systems at approximately \$232/ton (\$32/ton excluding canola seed purchase).

	Steam Pre-treated Press	Extruder-Expeller
Seed	\$200	\$200
Electricity	\$5.03	\$8.19
Total Utilities	\$5.80	\$8.97
Labor	\$5.11	\$5.11
Total Variable Costs	\$22.97	\$27.54
Overhead Costs	\$9.86	\$5.83
Total Costs	\$232.82	\$233.38

The basic process of crushing canola seeds and marketing crude canola oil and canola meal was projected to be feasible using either crushing technology. The extruder-expeller was projected to have a slightly higher internal rate of return due to its lower initial cost. However, both systems had internal rates of return over 21%, indicating that they have potential as profitable producer-owned businesses. Both systems had payback periods of slightly over 5 years. The returns for the integrated canola crush/biodiesel and canola crush/food grade refining were slightly higher than the returns for the stand-alone crushing facility. The addition of biodiesel production increased the rate of return slightly more than did food grade refining.

Table 4: Internal Rate of Return for a Stand Alone Canola Processing Operation and Integrated Canola Processing/Biodiesel or Canola Processing/Food Grade Refining System		
	Steam Pre-treated Press	Extruder-Expeller
Canola Crushing	21.38%	23.74%
Canola Crushing with Biodiesel	24.92%	27.8%
Canola Crushing with Food Grade Refining	23.73%	26.17%

Sensitivity Analysis

The impact of changes in the price paid for canola seed, the price received for canola oil and the price received for canola meal are summarized in Table 5. The projected return on investment was very sensitive to the price paid for canola seed with each half cent change in canola seed price influencing the internal rate of return by almost 25%. The sensitivity analysis highlighted the importance of modeling the price required for canola adoption. The return on investment was also very sensitive to the price received for canola oil. The sensitivity analysis indicated that a canola processing operation must source canola at a price of \$0.105/lb. or less to be profitable. The canola adoption projections described previously indicated that a producer price of \$0.095/lb. for the wheat/canola rotation returns to exceed that of continuous wheat.

When storage and handling costs are considered (approximately \$0.01/lb. over the production year) it appears that the cost of canola seed is the key risk factor for the proposed processing facility.

Each one cent change in canola oil changed the internal rate of return by over 20%.

Taken together, these components of the sensitivity analysis suggested that the processing business should be structured with firm delivery commitments and should pursue marketing commitments for the oil. Returns were less sensitive to the price received for canola meal. The price received for canola meal could fall by over \$10/ton before the business became unprofitable.

Table 5: Sensitivity Analysis for Stand-Alone Canola Processing Operation (Extruder-expeller)

Canola Seed (Baseline=\$0.105/lb)	NPV	IRR	B/C	ROA	ROE	Payback
\$0.095	\$ 42,491,792	76.58%	1.7322	48.45%	96.89%	2
\$0.100	\$ 26,042,496	51.05%	1.4487	30.98%	61.96%	3
\$0.105	\$ 9,593,200	23.74%	1.1653	13.52%	27.03%	5
\$0.110	\$ (6,856,096)	NA	0.8819	-5.67%	-11.34%	
Canola Oil (Baseline=\$0.244/lb)	NPV	IRR	B/C	ROA	ROE	Payback
\$0.254	\$ 19,974,762	41.35%	1.3442	24.54%	49.08%	4
\$0.244	\$ 9,593,200	23.74%	1.1653	13.52%	27.03%	5
\$0.234	\$ (788,362)	2.10%	0.9864	2.16%	4.32%	
\$0.224	\$ (11,169,924)	NA	0.8075	-12.19%	-24.37%	
Canola Meal (Baseline=\$144)	NPV	IRR	B/C	ROA	ROE	Payback
\$145	\$ 10,702,602	25.72%	1.1844	14.69%	29.39%	5
\$144	\$ 9,593,200	23.74%	1.1653	13.52%	27.03%	5
\$143	\$ 8,483,798	21.72%	1.1462	12.34%	24.67%	6
\$132	\$ (3,719,626)	-6.58%	0.9359	-1.40%	-2.80%	

Summary and Conclusions

The analysis identified four regions in Oklahoma where the projected canola adoption was sufficient to supply a canola processing operation. Steam pre-treated expelling and extruder/expeller technologies provided a similar internal rate of return while the solvent-based technology appeared infeasible due to capital costs and the scale required to be financially

feasible. The extruder/expeller system required less initial capital outlay but had higher projected utility costs than the steam pre-treatment system. The extruder/expeller system showed slightly greater returns for interested producers given the project size and operating assumptions used in this study.

The integration of a biodiesel production facility was projected to moderately increase returns but also required significantly higher producer equity requirements. However, the currently increasing values of petroleum-based diesel and the subsequent rise in the price of biodiesel may represent the potential for greater future returns if the producers are able to raise the capital required to add a biodiesel refinery. Development of a food grade further refining operation was not indicated to be feasible at the modeled scale of production.

The sensitivity analysis identified canola seed and canola oil prices as important risk factors with less sensitivity to meal feed pricing. Competition may also become a factor influencing the availability and pricing of canola, although at the time of this study's publication the only regional competitor was a small start-up cold press facility utilizing less than 25 tons of canola per day.

The feasibility assessment methodology described in the paper has broad application to a wide variety of oilseed processing ventures. Furthermore, the crop adoption modeling methodology incorporated in the study may be of interest to other researchers examining the regional adoption of new crops designed for food or biofuel production.

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