CANOLA CRUSHING: LOCATION OF A FOOTLOOSE INDUSTRY[1]

Dr. Barry E. Prentice, University of Manitoba

Introduction

With the settlement of Western Canada, governments sought to maximize the physical volume of agricultural exports. As the region matured, policy goals shifted to embrace the maximization of export revenues through value-added processing. With the exception of meat packing however, value-added processing had limited success on the Prairies because of the subsidized freight rates for bulk grain exports, the pricing policy of the Canadian Wheat Board, and the distance to consumer markets.

In the mid-1970s, plant breeders were successful in converting an industrial oilseed (rapeseed) into one considered safe for human consumption. This new crop, renamed canola, proved easy to export in the same bulk handling system as wheat and other grains, but a processing industry was also established to serve domestic demand. After receiving GRAS status (Generally Regarded as Safe) by the FDA in the United States in 1985, the crushing industry expanded to meet North American demand. The canola crushing industry in the Prairie snow consumes about half the crop, while the remainder is exported as canola seed to be processed at destination markets.

This paper examines the economic logic that underlies the location of the canola processing industry in Western Canada. The analysis begins with a review of the literature on the economics of plant location, transportation and footloose industries. Subsequently, a discussion of export markets is presented for canola seed and its processed products (oil and meal). The footloose nature of the industry is considered with regard to rail and marine transport. The paper ends with some thoughts on the opportunities for growing Prairie food processing capacity with other field crops.

Economics of Plant Location

The location of processing plants has been the subject of academic analysis for nearly 100 years. Alfred Weber (1929) Edgar Hoover (1948) and Walter Isard (1956) set out the economic theory of plant location based on the importance of transportation. Weber defines some inputs as "ubiquities" that are available everywhere. Processes that are weight-losing are located close to the source of the raw material, while processes that are weight-gaining by the addition of ubiquitous materials (e.g. air, water) are more likely to be found near the centres of consumption. His analysis is based largely on industrial processes, and the optimum location for processing multiple inputs. Weber's location theory assumes that only weight and distance matter for transportation costs, but stresses the importance of agglomeration and scale economies. Industries can be more successful by clustering at locations with desirable ubiquities, while agglomeration and scale leads to improvements in transportation infrastructure.

Hoover (1948) expands on the impact of transportation costs, and discusses food processing.

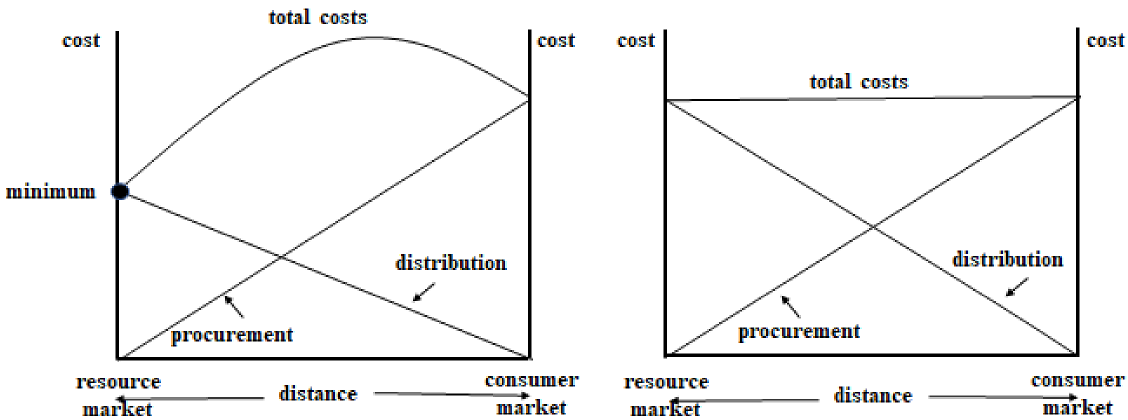
> "To sum up, it appears that goods going into any final product assume their most easily transferrable forms (in the sense of ease of physical carriage or simplicity of commercial exchange) at the intermediate stages of production. The earliest stages usually involve bulk reduction, preservation, grading and standardization or heavy fuel consumption, so that the products are more easily shipped and sold than the initial materials. On the other hand, the

[1] 54th Annual Meetings of the *Canadian Transportation Research Forum*, May 26 - 29, 2019 at Vancouver, British Columbia

final stages of processing and handling goods usually involve differentiation, sub-division into smaller lots, more bulk and more value in relation to weight and greater perishability in both physical and style terms. The products are more expensive to ship and sell than are the products of which they are were made." (Hoover, pp. 36-37)

Hoover's general model for processing plant location is illustrated in Figure 1. Transportation costs are assumed to be a function of distance and weight (or volume, if more important). The processing plant can be located near the raw material source, at the location of final consumption, or anywhere in between. The most favoured location depends on the sum of the procurement costs for the raw material and the distribution costs of the finished product. At the source of the raw materials, the procurement costs are assumed to be negligible and only the distribution costs are considered. At the consumer market, only the procurement costs are relevant.

Figure 1 Theoretical Model of Plant Location for Food-Processing Industries after Hoover



Model A: Weight-losing Process Model B: Footloose Industry

Model A represents the case for a weight-losing process where the plant can minimize transportation cost by locating near the resource market. If this were a weight-gaining process, the costs would be reversed and the consumer market location would be favoured. Model B illustrates the case of a footloose industry. In this example, the process neither gains or reduces weight, and so from a transportation perspective, it could be located anywhere along the continuum from resource market to consumer market.

Allen and Stone (1989) point out that the "footloose concept is not used consistently". Weber considered footloose industries as being those with minimal transportation costs that could locate anywhere. High-value products like watches and cameras fit this profile. Hoover (1948, p. 46) generalizes that "… early stages of production are material-oriented, and late stage production is market-oriented, while intermediate stages are relatively "foot-loose" as to transfer considerations." Allen and Stone (1992) subsequently take to the task of defining the concept of a footloose industry. They reference Alonso (1964) who suggests that firms can be more footloose, if 1) the relative price of transport inputs decline, 2) technical change reduces the weight of raw material per unit of output and 3) value-added processing reduces the percentage of transport inputs in the final product's price. Other researchers go on to suggest the importance of communications, energy and labour costs as factors influencing footloose industry locations.

Not mentioned in this literature is the special case of food processing industries in which the final product(s) does not change appreciably in weight or volume from the raw material being processed. Honey is often identified as such a footloose food processing industry. After straining and pasteurization, the weight of honey and beeswax is unchanged. Consequently, honey produced on the Prairies is processed by the BeeMaid Cooperative at Winnipeg, or shipped in barrels to Toronto and processed by BillyBee. Both products sell competitively at retail outlets all over Ontario.

Henderson and McNamara (2000) and Lambert, et al. (2007) use econometric analysis to examine the factors influencing the location of food processing plants in the U.S. Their analysis is based on the categorization developed by Connor and W. Schiek (1997)who classify food processing plants as supply-oriented, demand-oriented or footloose. Table 1 presents a modification of this work, with some extra divisions and reorganization with regard to footloose industries.

Table 1 Categorization of Food Processing Firms by Locational Orientation

Supply-Oriented Firms Weight/Volume Losing	Demand-Oriented Firms Weight/Volume Gaining	Footloose Firms Neither Gaining/Nor Losing
Storable Input	Storable Input	Storable Input
Cane Sugar	Soft Drink Bottling	Honey
Nuts and Seeds	Pasta	Oilseed Crushing
Rice Milling	Potato Chips and Snacks	Corn Ethanol
Beet Sugar	Beer	Wet/Dry Corn Milling
Malt	Pickles and Sauces	Wheat/Oat Milling
Spirits and liquor	Cookies and Crackers	
Perishable Input	Perishable Input	High-cost Production
Meat Packing	Fluid Milk	Canned Specialities
Cheese/Butter/Ice Cream	Bread and Rolls	Frozen Specialities
Frozen/Canned Seafood	Manufactured Ice	Chocolate Confections
Poultry	Animal feeds	Sugar Confectionary
Rendering	Frozen Baked Goods	Flavourings
Dried/Canned/Frozen Fruits		Pet Foods
Dried/Canned/Frozen Vegetables		Flour Mixes and Doughs
Wines and Brandy		

Source: Adapted from Henderson and McNamara (2000) and Connor and W. Schiek (1997)

Processes that lose weight or volume are more likely to be supply-oriented. Any other alternative may be unrealistic for highly perishable agricultural products, like canned fruit. If the raw materials are storable, the transportation cost advantages of weight losing processes can be significant. As examples, about six kilograms (kgs) of sugar beets are reduced to one kg of sugar, and two kgs of potatoes are reduced to one kg of frozen French fries. Supply-orientation is reinforced for processors of perishable products that can be reduced in weight and gain a longer shelf-life. The location of plants for processing dairy products (cheese, butter and ice cream), canning fruit and preparing meats are all highly supply-oriented.

Food processing that adds Weber's ubiquities of air and water are demand-oriented and locate close to the consumer market. Weight-gaining food products are soft drinks and beer; volume-gaining products are snack foods, like potato chips and crackers. Perishability can also factor into consumer market location decisions. Every large city has fluid milk, manufactured ice and bakery products produced close by. Processors need to minimize transportation costs and to assure "freshness". The location of processing plants for fragile products that can be damaged by handling and transport, like cookies, may also be demand-oriented.

Footloose products have minimal changes in either weight or volume, but may vary greatly in value. The footloose group of food processing is sub-divided into low value, storable raw materials and higher value-added foods whose production costs account for most of the final price. Examples of high-value products are confections and specialty foods, like chocolates. Transportation costs are immaterial to Swiss chocolate processers. They are far from the cocoa plantations and export to consumer markets around the world. The location of processing plants for footloose field crops is more complicated. Any food processing by-product or waste is usually sold as animal feed. Corn ethanol plants produce alcohol and dried distiller's grains (DDG) in fixed proportions that have to find separate, and possibly dispersed, markets. Similarly, oilseed crushing plants produce oil and meal jointly in fixed proportions with minimal change in weight or volume. The higher the volume of the by-product the more important its transportation costs.

This theoretical background categorizes canola seed crushing as a footloose industry, but does not explain why half the processing occurs at plants located in Western Canada, while half of the crop is exported and processed at destination markets. The next section examines the production, processing and export of canola seed, canola oil and canola meal.

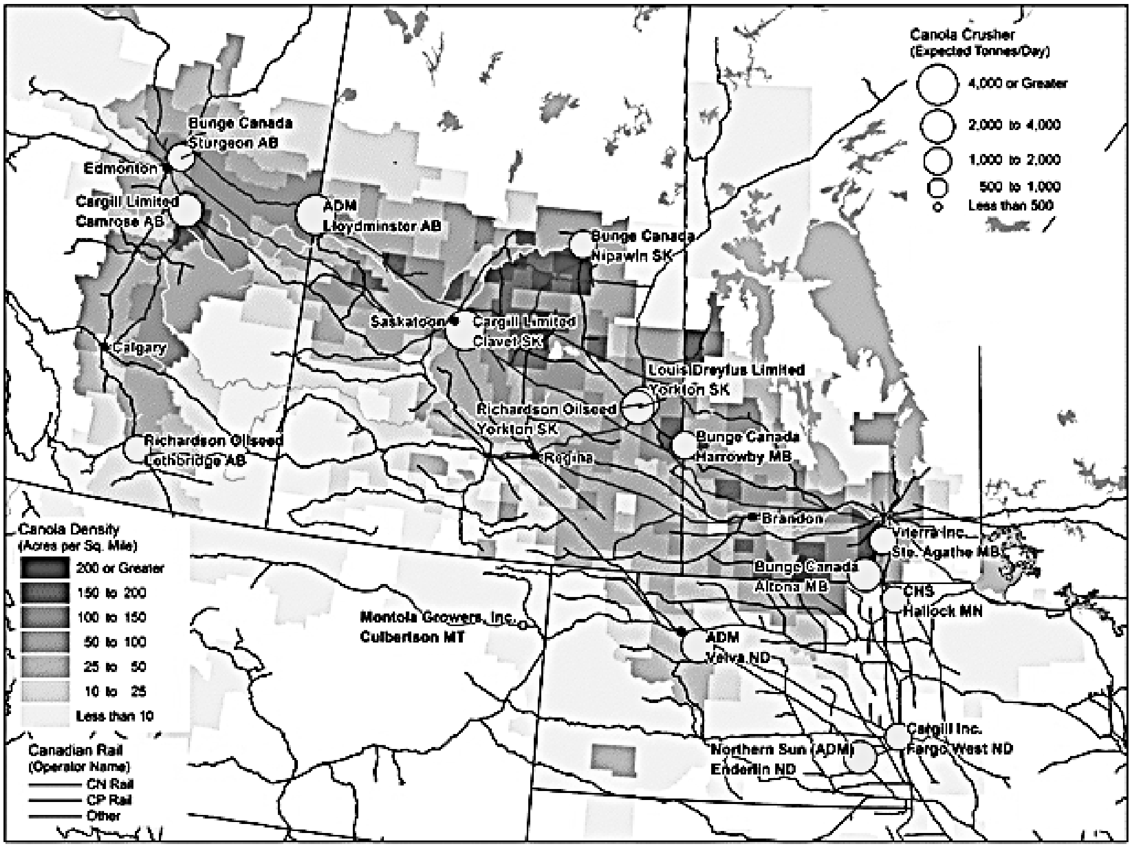
Production, Processing and Exports

Canola seed is processed at 14 canola crushing plants located across Canada (11 on the Prairies and three in Eastern Canada) and at four crushing plants located in North Dakota and Minnesota. The area of canola production and the location of canola processing plants are presented in Figure 2. The zone of canola production does not extend far into the U.S. because of growing conditions and competition from other crops like corn and soybeans.

Canola oil is used as cooking oil and is favoured for frying. A variety of canola developed specifically for deep frying accounts for about 12 percent of the market. About one-quarter of the canola oil production is consumed domestically and the remainder is exported. Canola meal is used as an animal feed supplement and is particularly desirable for dairy rations because it increases milk production. Canola seed, oil and meal to offshore markets move by rail under the Maximum Revenue Entitlement (MRE) freight rates to the ports for shipment by sea. Canola oil is transloaded to ocean tankers at Vancouver. Canola oil and meal exports to the U.S. are transported in private railcars at full commercial rates.

Table 2 presents the five-year average of canola seed, oil and meal shipments to the top-10 export markets, for the period 2013 to 2017. Canola seed is exported widely, but China is the largest importer. Over the past 5 years, China has purchased 39 percent of canola seed exports. China, the United States and Mexico are the only markets that have a presence in the top-7 of all categories. Japan is the second largest seed importer, but a small importer of oil. South Korea is a major importer of oil and meal, but not canola seed. Viet Nam imports only canola meal. The United States accounts for 63 percent of all Canadian canola oil exports during this period and 88 percent of canola meal exports.

Figure 2 Canola Productionand Crushing in Western Canada.



Source: Map courtesy of CN Rail

Table 2 Top-10 Canadian Export Markets for Canola Seed, Oil and Meal, Average, 2013-2017

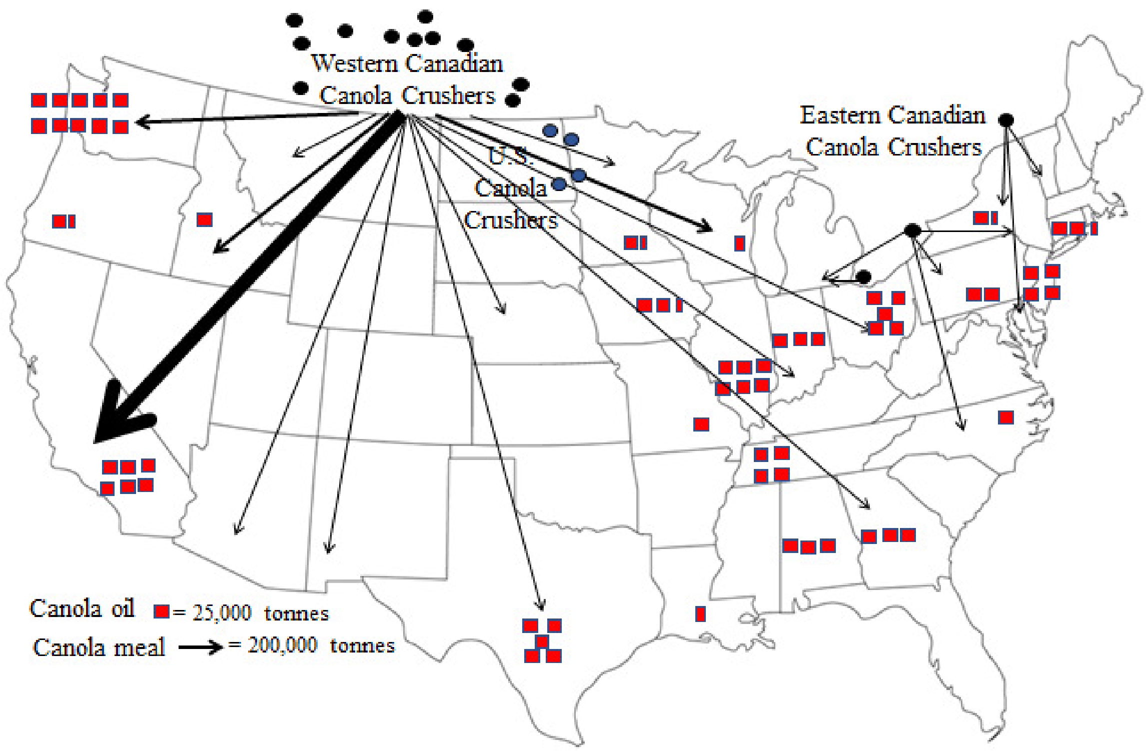
Canola Seed Country	5-year Average (tonnes)	Canola Oil Country	5-year Average (tonnes)	Canola Meal Country	5-year Average (tonnes)
China	3724351	United States	1612094	United States	3373394
Japan	2201552	China	645239	China	527647
Mexico	1415030	South Korea	89858	Thailand	54277
Pakistan	744771	Chile	60418	Viet Nam	40655
United States	590972	Mexico	45916	Ireland	29423
UAE	424453	Hong Kong	32630	Mexico	19330
France	314705	Malaysia	30594	South Korea	14765
Bangladesh	90968	Portugal	27700	Spain	13750
Germany	72123	Taiwan	12578	France	13687
Singapore	56219	Italy	11988	Japan	8285
Others	143065	Others	49598	Others	8168
Total	9778210	Total	2618614	Total	4103381

Source: Statistics Canada

Processed Product Transportation

Figure 3 summarizes a three-year average of canola oil and meal exports to the U.S. by market size and location. The geographical distribution of canola oil and meal markets in the U.S. has minimal correlation with the distance from Western Canada. Canola oil markets are consistent with the location of human population concentrations. Canola oil is shipped in railway tank-cars to bottlers, deep fryers (e.g. snack food processors) and to distribution centres where the oil is transloaded and trucked to numerous smaller food processors. These uses are typically demand-oriented. The large volume of shipments to Washington State is an exception. Here canola oil is blended with mineral oil to create bio-diesel.

Figure 3 Three-year Average Exports of Canola Oil and Meal, 2015-2017



Source: The data to construction this map is available at Prentice (2018) or the full report on request from Transport Canada, Econ. Analysis Directorate.

The markets for canola meal are a function of beef and dairy production locations. Seven of the top-10 dairy states are the largest receivers of canola meal. The Southwest is generally feed deficient, and the canola meal market in California is six times bigger than any other state. California also produces 20% of the total U.S. milk supply (Wisconsin at 13% is second, and New York at 7% is third). In the Upper Great Plains, the Western Canadian crushers have to compete with local US canola crushers. Canola meal exports to the Northeast and Great Lake States, could be coming from the three crushing plants located in Ontario and Quebec.

The separation of joint-product end-markets reinforces the location of canola seed processing near the production zone in Western Canada, but agglomeration and scale economies also play a role. With 11 processing plants, enough traffic is generated for the railways to provide consignments of 10 cars or less on a regular service basis. In the case of California, the volume of canola meal is sufficient to justify unit trains.

Other factors that influence plant location include trade barriers, subsidies and regulations. Export sales of canola oil to the U.S. were prohibited there for human consumption prior to receiving GRAS status. As a result, the first canola seed crushing plants were built in Canada for the domestic market. By the time canola became accepted for use in the U.S., the Canadian crushing plants were well established and created the agglomeration economies to attract other processors.

For years, the Canadian canola industry has complained about the discriminatory import duties imposed by Japan. The Japanese permit canola seed to be imported duty-free, while applying high import tariffs on canola oil and meal produced in Canada. Removal of these tariffs under the new Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP)could change the economics of exporting canola oil to Japan. If the Japanese need for oil exceeds the demand for canola meal, then importing a tanker of canola oil, which has higher density than the seed, could reduce shipping costs[i].

The processing of field crops is generally footloose, but with the right strategies more value can be added in Western Canada. As Allen and Stone (1992) observe being footloose is not the same as being random. Many factors can influence location in addition to transportation and logistics costs. Henderson and McNamara (2000) and Lambert, et al. (2007) examine wage rates and quality, local tax policies and amenities, as well as agglomeration economics and availability of transportation services. They also identify access to factor inputs or the raw materials as important. The canola crushers benefit from being located in the centre of the production area. They can contract directly with local producers to guarantee access, and have canola delivered to their door on a just-in-time basis year-round. Having a shorter supply chain also eliminates the margins paid to intermediaries.

Conclusion

Whether or not canola processing's success yields insights for the location of other crop processing plants to Western Canada is unclear. A new yellow pea processing plant is being built at Portage La Prairie to extract vegetable proteins, powdered fibres and starch. Access to a large production centre for peas, tax increment financing and availability of sustainable hydroelectric power are all cited, in addition to the workforce, as reasons for the location in Manitoba (Food Processing Technology). The location of consumer markets for pea protein, fibre and starch are unknown. If they are geographically differentiated like canola oil and meal this could encourage other pea processing plants to join them.[ii]

An increase in other footloose food processing of field crops in Western Canada may be possible. For years, the policies of the Canadian Wheat Board (CWB) and rail freight subsidies for grain discouraged processing on the Prairies. New oat milling plants were established after oats was removed from the CWB, and six out of seven are located in Western Canada. In contrast only 18(out of 48) wheat mills are located on the Prairies and many of these date from before the CWB(CNMA).As food processing moves towards more fabricated food products, like "veggie burgers", the opportunity exists to add value on the Prairies by extracting components from grain crops. The canola crushing industry demonstrates that footloose food processing industries can be attracted to Western Canada. Vegetable protein extraction may be the next opportunity to capture a value-added processing industry before destination markets install competing facilities and import the raw materials from Western Canada to supply this footloose industry.

References

Allen, Ralph C. and Jack H. Stone. (1989) "The Locational Criteria of Footloose Firms: A Formal Model." The Review of Regional Studies. Vol. 19, No 2.

Allen, Ralph C. and Jack H. Stone. (1992)“What Is a Footloose Industry? An Issue in Semantics.” *The Royal Geographical Society (with the Institute of British Geographers)*. Vol. 24, No. 3 (Sep., 1992), pp. 302-308.

Alonso, William. (1964) "Location Theory," Regional Development and Planning: A Reader, by John Friedmann and William Alonso, Editors, MIT Press, Cambridge, MA, 1964, reprinted in Readings in Urban Economics, by Matthew Edel The Locational Criteria of Footloose Firms: A Formal Model 17and Jerome Rothenberg, Macmillan, New York, NY, 1972,16-37.

Canadian National Millers Association (CNMA).http://canadianmillers.ca/index.php

Connor, J.M. and W. Schiek.(1997)*Food Processing: An Industrial Powerhouse in Transition*. 2nd ed. John Wiley and Sons: New York.

Food Processing Technology. “Roquette Pea Protein Manufacturing Plant, Portage la Prairie, Manitoba” https://www.foodprocessing-technology.com/

Henderson, Jason R. and Kevin T. McNamara. (2000) “The Location of Food Manufacturing Plant Investments in Corn Belt Counties.” Journal of Agricultural and Resource Economics 25(2):680-697.

Hoover, Edgar M. *The Location of Economic Activity*, McGraw Hill Book Company, Inc., New York, 1948.

Ingredion. https://globenewswire.com/news-release/2018/12/13/1666706/0/en/ingredion-invests-140-million-to-accelerate-growth-in-plant-based-proteins.html

Isard, Walter. (1956) *Location and Space-Economy: A General Theory Relating to Industrial Location, Market Areas, Land Use, Trade, and Urban Structure.* Boston, MA: Technology Press of Massachusetts Institute of Technology, 1956.

Lambert, D.M., K. T. McNamara and M.I. Beeler. (2007) “Location Determinants of Food Manufacturing Investment: Are Non-metropolitan Counties Competitive?” American Agricultural Economics Association Annual Meeting, Portland, OR, July 29-August 1, 2007.

Prentice, Barry E.(2018) “Canada’s Canola Supply Chain: Issues and Dimensions.” *Proceedings. 59th Annual Meetings* of the Transportation Research Forum, Minneapolis, Minnesota: https://editorialexpress.com/cgi-bin/conference/download.cgi?db_name=TRF18&paper_id=60

Weber, Alfred (1929). *Alfred Weber's theory of the location of industries.* English Edition, With Introduction and Notes by Carl Joachim Friedrich, Chicago, Ill: The University of Chicago Press, 1929.

---

[i] If the Japanese market has adequate demand for both end-products, processing at the final market location may still be favoured. Nature provides the canola seed with a durable package (the seed coat) that allows it to be stored and handled inexpensively through the bulk handling system.

[ii] Another pea and pulse processing plant expanding at Vanscoy, Saskatchewan to produce similar goods. (Ingredion) Also, Parrheim Foods, located in Saskatoon, processes peas, beans and waxy hulless barley varieties.