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Quinoa ... The Next Cinderella Crop for Alberta?

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Executive Summary

The main objective of the study was to investigate the market, technical, agronomic and economic feasibilities of producing Quinoa in Alberta and selling it in domestic and international markets.

The production of Quinoa is feasible under Alberta conditions if we use appropriate early-maturing cultivars, and agronomic practices to control weed and diseases. Agronomic work (variety selection, weed control, disease control, fertilzation requirement) to stabilize yields, enhance quality, and further enhance adaptation to Alberta conditions will be necessary.

In the wake of this revitalization both Bolivia and Ecuador have been able to increase their production and to develop domestic and export markets for Quinoa. The quantities exported are not large, with combined exports of Bolivia and Ecuador only surpassing 3,000 mt in the year 2003. The major export destinations for Bolivian Quinoa are the U.S., France, the Netherlands and Germany. The biggest importers of Ecuadorian Quinoa are the U.S., distantly followed by the U.K. Even though South American Quinoa exports remain small, they have indeed doubled from 1998 to 2003. However, it is notable that while total export tonnage has increased more than 200 percent, the total export value for Quinoa exported measured in USD has only risen by 75% over the same time period.

The retail system shows a variety of Quinoa prices, with two points emerging. First, the price quoted in North America for Ecuadorian Quinoa is lower than the price for U.S. Quinoa. Second, the prices posted in Germany are lower than the majority of prices posted in North America, even though the freight costs to Europe are higher. It was found that South American producers are able to produce and process Quinoa more competitively than North American producers, and that the North American retail market displays the highest value for Quinoa.

The organic markets, the non-allergenic markets and non-GMO markets hold the most promise for Quinoa grain and Quinoa flour. A growing market is the specialty food sector catering towards people affected by celiac disease and those suffering from diabetes.

Beyond the traditional markets for Quinoa, there are a number of potential uses for Quinoa fractions. Quinoa starch granules are very small, and there is increasing interest for their use in special products. Saponins are being studied as to their insecticidal, antibiotic, fungicidal and pharmacological properties. The oil content of Quinoa shows a calculated global mean of 5.8%, higher than that of normal maize. Also, the protein in the Quinoa oil press cake could be an important complementary protein for improving the nutritional quality of both human and animal foodstuffs. Thus, while the health food market will sustain a good niche-crop production, future opportunities are certainly contained in the component strengths of the crop.

In terms of economic feasibility, Quinoa can likely compete within the present crop portfolio in Alberta. Furthermore, although Canadian Quinoa production is not as competitive internationally as that from South America, the high retail margins versus the cost of goods will allow Canada room to deliver into domestic and export markets. Also, the established container handling capacity and container routes in Alberta will render a handling advantage over non-mature shippers. Nevertheless, unless Alberta can harness special ties to the food industry to pursue the industrial uses of the crop, the market for Quinoa will remain a niche market.

Overall, traditional Quinoa markets are indeed viable for Alberta (given some agronomic support), but they will remain small for the foreseeable future. New industrial uses are certainly promising, but not in place to date.

Introduction

Quinoa (*Chenopodium Quinoa* Willd.), a so-called "super food", is considered as the most nutritious grain in the world. It is one of the main food crops in Latin America, but recently has raised interest in North America, Europe, and Asia. Quinoa has a variety of uses in the food, feed, food processing and other non-food/industrial uses.

Given the trends towards healthy food, healthy environment and a bio-based economy, Quinoa is well positioned to provide Alberta's agriculture, food, feed and non-food industries with potentially promising opportunities.

Quinoa can be classified according to its saponin concentrations as either "sweet" (saponin free or having less than 0.11% saponins on a fresh weight basis) or "bitter" (containing more than 0.11% saponins). The saponins in Quinoa represent the major antinutritional factor found in the grain. However, most of these saponins are concentrated in the outer layers of the grain, which facilitates their removal industrially by abrasive dehulling or traditionally by washing the grains with water. Saponins have been investigated as potent natural insecticides, which would have no adverse effects on higher animals including human being. Other interest in saponins is in their antibiotic, fungistatic, and pharmacological properties. As a source of saponins, Quinoa have been relatively little studied their potential commercial uses remain unknown.

Conversely, the development of new zero-saponins Quinoa varieties potentially presents tremendous opportunities for the food processing industry. Quinoa produces a cereal-like grain, but with a higher protein content and a better balanced amino acid composition than cereals. The starch grains in the endosperm are unusually small (2-4 μ m in diameter), which gives the starch unusual functional properties, with several potential uses in the food processing industry. These may be of value in fillers for the plastics industry, low-calorie milk-based products, anti-offset and dusting powders and cosmetics. Quinoa is not a grass, and therefore its cultivation could assist the control of weeds and diseases in areas where cereals are currently continuously cultivated. It is tolerant of drought and infertility.

However, is the large-scale production and marketing of Quinoa physically and economically feasible in Alberta?

Objective

The main objective of the study was to investigate the market, technical, agronomic and economic feasibilities of producing Quinoa in Alberta and selling it in domestic and international markets.

The ultimate goal is to introduce Quinoa to Alberta as a source of a starch, fat replacing ingredient in many diet products, high quality protein and saponin products for industry, and as a contribution to crop diversification and the competitive use of set-aside or marginal lands.

Methodology

1. Primary data (interviews with industry players) and secondary data (internet search, market reports, and databases) were collected and analysed to assess the market feasibility. Specifically, information on world production, market size and trends, key players, importers and exporters of Quinoa; current and potential uses of Quinoa products and by-products, and market opportunities and barriers specific to Alberta was collected and analysed.
2. An extensive literature search on the agronomic practices and requirements of the crops, as well as the challenges to grow Quinoa were documented and analysed to assess the technical feasibility of producing

sufficient yield with adequate seed quality. Quinoa uses in food and the quality of the seed were also documented.

3. An economic feasibility assessment was performed to assess whether we can cost-effectively grow Quinoa in Alberta and be profitable.
4. The information from #1, #2 and #3 was analysed to perform a SWOT (Strength, Weaknesses, Opportunities and Threats) analysis and determine whether Quinoa is a viable option for Alberta producers and processors.

Results

Overview of the Nutritional Quality of Quinoa

Both the seeds and the leaves of the Quinoa plant can be eaten. The leaves are typically cooked and served as a side dish, similar to spinach or beet greens. Relative to other commonly consumed grains, Quinoa has excellent nutritional quality (Table 1).

Table 1: Major Nutrients in Quinoa and Common Cereal Grains

	Quinoa	Wheat	Barley	Rice	Corn
Moisture	9.3	12.8	10.1	10.2	10.4
Energy (kcal)	374	329	352	371	165
Protein (%)	13.1	15.4	9.9	6.8	9.4
Total lipid (%)	5.8	1.9	1.2	0.6	4.7
Ash (%)	2.9	1.9	1.1	0.8	1.2
Carbohydrate (%)	69	68	78	82	74
Total dietary fiber (%)	5.9	12.2	15.6	1.7	Not reported

Source: USDA, 2005

Protein

Researchers in Colorado reported that Quinoa grown there exhibited protein levels ranging from 12 - 18% (Johnson and Croissant, 1985). While Quinoa does tend to have higher total protein relative to other grains, it is the nutritionally balanced amino acid composition of the protein that has generated particular interest. The relative lack of the amino acid lysine is a major concern when cereal grains are the main source of dietary protein. Low lysine is of particular concern when wheat and corn are major protein sources. In contrast to most plants, Quinoa has relatively high lysine levels and its total amino acid complement that is regarded as highly balanced. At one time there was considerable interest in using Quinoa to alleviate protein deficiency in Latin America (Cusack, 1984). The UN Food and Agriculture Organization, the US Agency for International Development, and the Canadian International Development Research Centre have all investigated the expanded use of Quinoa as a protein source for marginalized populations during the 1970s and 1980s.

Table 2: Key Amino Acid Content of Quinoa and Common Cereal Grains

	Quinoa	Wheat	Barley	Rice	Corn
Isoleucine	0.47	0.54	0.36	0.29	0.34
Leucine	0.79	1.04	0.67	0.56	1.16
Lysine	0.73	0.40	0.37	0.25	0.27
Methionine	0.26	0.23	0.19	0.16	0.20
Threonine	0.46	0.43	0.34	0.24	0.35
Valine	0.59	0.68	0.49	0.41	0.48

Source: USDA, 2005

Lipids

USDA (2005) reports average Quinoa oil content to be approximately 6%. The literature reports a range of about 2 – 9% (Cardoza and Tapia, 1979; Romero, 1981). These percentages are roughly the same as corn, but much less than oilseeds such as canola (40 - 44% oil) or soybean (20 - 25% oil).

The fatty acid profile of Quinoa oil is similar to corn or maize oil (Koziol, 1991). As with canola, soybean and most cereals, linoleic acid (18:2) is the predominate fatty acid. Kleiman et al. (1972) reported the presence of methyl cis-5-hexadecenoate (5 – 12%) and methyl cis-5-octadecenoate (1%). Other researchers do not appear to have confirmed the presence of these two unusual fatty acids.

Table 3: Oil Quality of Quinoa and Common Cereal Grains

(values expressed as percent of total oil)

	Quinoa	Wheat	Barley	Rice	Corn
Predominate acid	**18:2**	**18:2**	**18:2**	**18:1**	**18:2**
Saturated	**13%**	**23%**	**26%**	**32%**	**16%**
Monounsaturated	**34%**	**22%**	**16%**	**37%**	**31%**
Polyunsaturated	**53%**	**55%**	**58%**	**31%**	**53%**

Source: USDA, 2005

Roman Przybylski, currently of the University of Lethbridge, published some research on Quinoa lipids in the 990s (Przybylski et al., 1994).

Carbohydrate

The two main carbohydrate components of Quinoa are starch and dietary fiber. There appears to be little to differentiate Quinoa fiber from other cereal fibers, although information about Quinoa fiber is rare in the scientific literature. Starch makes up 55 – 65% of Quinoa and is characterized by its very small granule size, less than 3 um (Wolf et al., 1950; Atwell et al., 1983). Taro starch is one of the few commercially available starches with a similar granule size. Small granule starches typically are good for dusting applications (useful in candy manufacture) and for some flavor applications as a carrier substance.

All starches are made up of a mixture of straight-chain amylose molecules and highly branched amylopectin molecules. Quinoa starch has less amylose (11%) than most commercial starches (Lorenz, 1990). High amylopectin corn and barley varieties are known as *waxy* varieties. Quinoa starch would be expected to have some similar properties as these *waxy* cereals. Like *waxy* corn starch, Quinoa starch has superior freeze-thaw stability to normal corn starch (Ahamed et al., 1996). Modified starches would be expected to exhibit even greater freeze-thaw stability. Quinoa starch has a relatively low gelatinization temperature of 57 – 64°C (Atwell et al., 1983). It exhibits higher viscosity than wheat starch, but not as high as corn starch (Ahamed et al., 1996).

Minor Components

The vitamins concentrations reported in Quinoa are typical of similar grain-based foodstuffs (USDA, 2005). With respect to minerals, several reviewers have commented on Quinoa's relative richness in phosphorus and iron (Table 4). As a point of reference, an equivalent serving of beef contains about 166 mg/100 g phosphorus and 2 mg/100 g iron (USDA, 2005).

Table 4: Select Minerals in Quinoa and Common Cereal Grains

	Quinoa	Wheat	Barley	Rice	Corn
Calcium (mg/100 g)	60	25	29	60	7
Phosphorus (mg/100 g)	410	332	221	136	210
Iron (mg/100 g)	9	4	3	4	3
Sodium (mg/100 g)	21	2	9	5	35

Source: USDA, 2005

Saponins

The use of Quinoa as a foodstuff is complicated by the presence of a class of compounds called saponins. Saponins are also present in soybeans, common beans, chickpeas, alfalfa, and numerous other plants. They are soap-like natural compounds that impart a bitter taste to Quinoa. At high enough concentration, saponins will cause intestinal damage. One test for the presence of saponins is to look hemolysis (blood cell rupture). Another test is the development of a soapy lather in water. Saponins can be thought of as soaps that dissolve cell membranes.

Chemically, saponins are glycosidic triterpenoids. Some reports suggest that oleanolic acid is the major Quinoa aglycone, with lesser amounts of hederagenin also present (Ma et al., 1989; Meyer et al., 1990). Other researchers have identified numerous other saponin aglycones in Quinoa (Gee et al., 1993). Various sugar groups can be linked to the aglycone (Ma et al., 1989; Meyer et al., 1990). Total saponin concentration typically ranges from 2 – 6% and is concentrated in the outer layers of the seed (Cusack, 1984). The saponins are always removed before Quinoa is consumed. They are soluble in water and pure alcohol and can be removed either by washing or mechanically.

Low saponin Quinoa varieties are said to be available from Latinreco SA, Quito, Ecuador (Gee et al., 1993). Varieties with less than 0.11% saponin apparently have no bitter flavor.

Food Uses

Considerable research has been conducted on Quinoa utilization. Scientists at Colorado State University (Fort Collins, CO) have lead much of the research. The Pillsbury Company, Nestle SA and Nutrasweet Company have also contributed to the research.

Saponin Removal

Saponin removal is the essential first step in any utilization of Quinoa as a food product. On a small-scale, saponin removal could be accomplished by washing the seed with cold running water (Mahoney et al., 1975). Alkaline water wash followed by pounding and rubbing was also used (Simmonds, 1964).

Mechanical removal of the pericarp will likely to be the most economical method of reducing saponins, although probably not as effective as washing. Various pearlers and other mills have reportedly been used (Reichert et al., 1986b; Becker and Hanners, 1991). Commercial producers in South America use large abrasive drum mills (Boersch, 2005). Reichert et al (1986a,b) developed a Tangential Abrasive Dehulling Device at the Plant Biotechnolgy Institute in Saskatoon that could effectively remove saponins from Quinoa. Yields of 85 – 95% were possible, depending on the Quinoa variety.

Traditional Uses

Quinoa was traditionally used similar to rice. Other traditional uses include soups and mixed grain dishes, biscuits and in a beverage called "chica blanca" (Cusack, 1984). Dehulled Quinoa seed is generally available in North America at larger health foods and on the internet.

Snack Food

A research project in India investigated the use of Quinoa starch blended with soy flour to produce a deep-fried dry noodle product used as a snack food ingredient (Ahamed et al., 1997). Considerable work has been done at Colorado State University exploring the application of extrusion technology to Quinoa processing. Coulter and Lorenz (1991a,b) used a water wash to remove saponins from Quinoa and then attempted extruding Quinoa/corn blends. Popped Quinoa is available on various websites in North America. The popped Quinoa can be used as a snack food or as a garnish, particularly for salads. Popped Quinoa does not appear to have been addressed in the scientific literature.

Pasta

Several North American companies currently distribute pasta products that include Quinoa as an ingredient. Quinoa Corporation (Gardena, CA, www.Quinoa.net) sells pasta (spaghetti, elbows, pagodas, linguine, shells, rotelle) made from a corn-Quinoa blend. Northern Quinoa Corporation (Kamsack, SK, www.Quinoa.com) distributes milled Quinoa, Quinoa flour, and pasta (spaghetti, fettucine, spirals, elbows) made from a rice-Quinoa blend. Gabriele Macaroni Products (Los Angeles, CA, www.gabrielepasta.com) is one company that produces specialty pasta with Quinoa.

Flaked Quinoa

Flaked Quinoa is readily available as a breakfast cereal. There is little in the scientific literature related to flaked Quinoa.

Baked Goods

It is clear that many people have attempted to incorporate Quinoa flour into a variety of baked goods. A coarse bread called Kispina was produced in South America at one time (Coulter and Lorenz, 1990). Lorenz and Coulter (1991) have perhaps best documented some of the issues related to the use of Quinoa in baked products. They produced Quinoa flour by first removing the pericarp using a barley pearler and then milling the dehulled Quinoa in a Udy cyclone mill. The flour had higher protein, fat and ash content compared to wheat flour. Bread made with up to 10% Quinoa flour was judged acceptable.

Because Quinoa does not have gluten-forming protein, higher substitution levels resulted in lower loaf volumes. Bread with 30% Quinoa flour had a distinct bitter aftertaste. Similarly, up to 10% Quinoa flour resulted in acceptable cake products. Chlorination of the Quinoa flour did not substantially improve cake characteristics.

The fact that Quinoa does not have gluten-forming protein opens up opportunities for the food industry serving celiac disease-suffering consumers.

Cream Substitute

Because the starch granules are so small, Quinoa starch has a very smooth mouth feel. Researchers at Nutrasweet have developed a process to use Quinoa starch as the basis for a carbohydrate cream substitute (Singer et al., 1990). Nutrasweet has not commercialized this technology to date. Lack of consistent Quinoa starch supply and an abundance of gums that could also be used as cream substitutes might be some of the reasons that Nutrasweet has not pursued this product. The process of isolating pure Quinoa starch may also be difficult (Atwell et al., 1983).

Infant Cereal

A multi-grain infant cereal (including Quinoa) is in the market place. Nature's Path Foods of Delta B.C. Canada produces 8 Grain Synergy Multigrain, Mesa Sunrise and Heritage Breakfast Cereals using Quinoa. The website address is http://www.naturespath.com.

Non-Food Uses

Quinoa has seen some limited use as a cover crop and as a forage crop. As an animal feed ingredient, price is a constraint.

As a by-product of processing Quinoa for food, the saponins may have some potential for further processing. Traditionally, Quinoa saponins were used as natural detergent for washing clothes. There may be opportunities to exploit the soap-like characteristics of saponins. Researchers have suggested other uses:

- Insecticide (Basu and Rastogi, 1967)
- Antibiotic/fungicide (Basu and Rastogi, 1967; Agarwal and Rastogi, 1974))
- Agent to improve drug absorption (Basu and Rastogi, 1967)
- Cholesterol-lowering agent (Oakenfull and Sidhu, 1990)

Quinoa starch granules are small. There are a number of current and potential uses of starches with small and narrow granule sizes, and there is increasing interest for their use in special products, for example, in fine printing paper, plastic sheets, as a binder with orally active materials and as a carrier material in cosmetics.

The protein in the Quinoa oil press cake could be an important complementary protein for improving the nutritional quality of both human and animal foodstuffs.

Little work has been reported exploring the technical and commercial feasibility of these ideas. Quinoa fractions would have to be shown to be as effective and as inexpensive as products already on the market for them to be much commercial interest.

Can We Successfully Grow Quinoa in Alberta and Produce a Reliable, Stable and Acceptable Quality Crop?

Depending upon the variety, Quinoa crop matures in 90 to 125 days after seeding in southern Colorado, USA. A major constraint for growth in northern parts of Europe, Canada and in high altitude regions is the short growth season, because Quinoa requires a longer growing season, in order to secure seed harvest. For northern regions, where the growing season is relatively short, early maturing cultivars are recommended.

Quinoa requires short day lengths for early flowering and cool temperatures for excellent growth. Air temperatures, which exceeded 35 °C tended to cause plant dormancy or pollen sterility. Quinoa plants are usually tolerant to frosts (–1.1 to 0 °C). Plants exposed to below –2.2 °C at mid bloom stage could lose over 70% seed yield due to flower abortion. However, they can tolerate the temperature as low as –6.7 °C after the grain has reached the soft-dough stage.

Quinoa is currently grown in Saskatchewan and Manitoba. About 80 percent is grown organically. In the late 1980s/early 1990s, some Alberta farmers successfully grew Quinoa. Research at the Crop Diversification Centre South in Brooks, Alberta has demonstrated that Quinoa can be successfully grown in Southern Alberta.

The major production problems centre on weed problems and the poor ground cover of Quinoa early in the development of the plant, problems with pests (e.g. the stem-borer), and heat sterilization of the flowers during bloom. In Colorado, grassy weed control alone increased seed yields from 640 kg/ha to 1,822 kg/ha. Weed control via herbicides has been effective and several herbicides (i.e. Metamazide, Propachlor, Linuron, Propyzamide and aloxium sodium) have shown promise.

Fungal diseases such as damping off (*Sclerotium rolfsii*), downy mildew (*Peronospora farinose*), stalk rot (*Phoma exigua* var. *foveata*), leaf spot (*Ascochyta hyalospora*) and grey mold (*Botrytis cinere*a) and bacterial blight (*Pseudomonas* sp.) are important in Quinoa grown South and North America and in Britain.

A wide range of pests can damage Quinoa crop during seed germination up through harvest and seed storage. However, entomologists at the Colorado State University do not consider insect problems to be a yield-reducing factor for Quinoa.

Gandarilllas (1982) reported that Quinoa responds only to nitrogen with no measurable response being observed for either phosphorus or potassium. Studies in Colorado have indicated that maximum seed yields are possible with 168- 200 kg N/ ha and at higher rates of nitrogen levels decrease seed yields as a result of late maturity and severe lodging incidences (Johnson, 1990). Currently, recommendations in South America and Colorado are 120 kg of urea/ha. Nitrogen applications have also significant impact on protein content of Quinoa seed. Gandarrillas (1982) reported that on average, every kg of ammonium nitrate applied per ha, would increase the seed protein content by 0.1%. Under the growing conditions in Colorado, protein content of seed of Quinoa cultivar CO407 ranged from 16.2 to 18.6%.

Quinoa is a somewhat drought tolerant crop with a total water requirement of 25.4 - 38.0 cm during the cropping season on sandy-loam or loamy-sand soils.

The crop can be harvested mechanically with conventional equipment. A sorghum header attachment is recommended for Quinoa, although platform headers can usually be used as well. Grain must be dry prior to storage.

Field studies conduced in Colorado indicated that depending upon variety, seed yields of Quinoa ranged from 1,351 to 1,948 kg per hectare (Robinson, 1986). An Alberta producer reported, depending on weather conditions, Quinoa seed yield ranged from 672 to 1,790 kg per hectare (ADF News 1991). Seed yield of up to 4000 kg per hectare has been reported in Kenya. In Saskatchewan, yields are said to be highly variable, and can range from zero to in excess of 2,000 lbs. per acre. In Saskatchewan, the average yield over the past five years (2000-2004) is said to range between 750 - 1,250 lbs. per acre.

In terms of quality, the Quinoa crop in Saskatchewan is somewhat smaller and darker in colour than the South American exports. However, this does not seem to have been a problem, especially into the North American market.

However, although yields have been variable in Saskatchewan, Dr. Sarah Ward of Colorado State University reports that Quinoa has done well in field trials in Northern Michigan. There should be no reason that Quinoa could not be successfully adapted to the Canadian Prairies, because, as Ward says, it is not the elevation, but the temperature that is critical to the Quinoa plant (Ward, 2005).

In short, the production of Quinoa is feasible under Alberta conditions if we use appropriate early-maturing cultivars, and agronomic practices to control weed and diseases. Agronomic work (variety selection, weed control, disease control, fertilization requirement) to stabilize yields, enhance quality, and further enhance adaptation to Alberta conditions will be necessary.

Is There a Viable Market for Quinoa and Quinoa Products?

Major Producers of Quinoa

Peru, Ecuador, and Bolivia are the major producers of Quinoa (Table 5). World Quinoa acreage has been increasing steadily in the last four years. Quinoa is also produced on limited acreage in Chile, Argentina, Brazil, USA, England and Canada. There is a small acreage grown on the Canadian Prairies, especially in Saskatchewan and Manitoba. Approximately 1,600 acres of Quinoa is currently grown in Saskatchewan, primarily to supply the Northern Quinoa Company (NQC) based in Kamsack. Because of the variability in production, NQC also still imports product from South America to augment domestic supplies.

Table 5: Reported World Production (1998 – 2004)

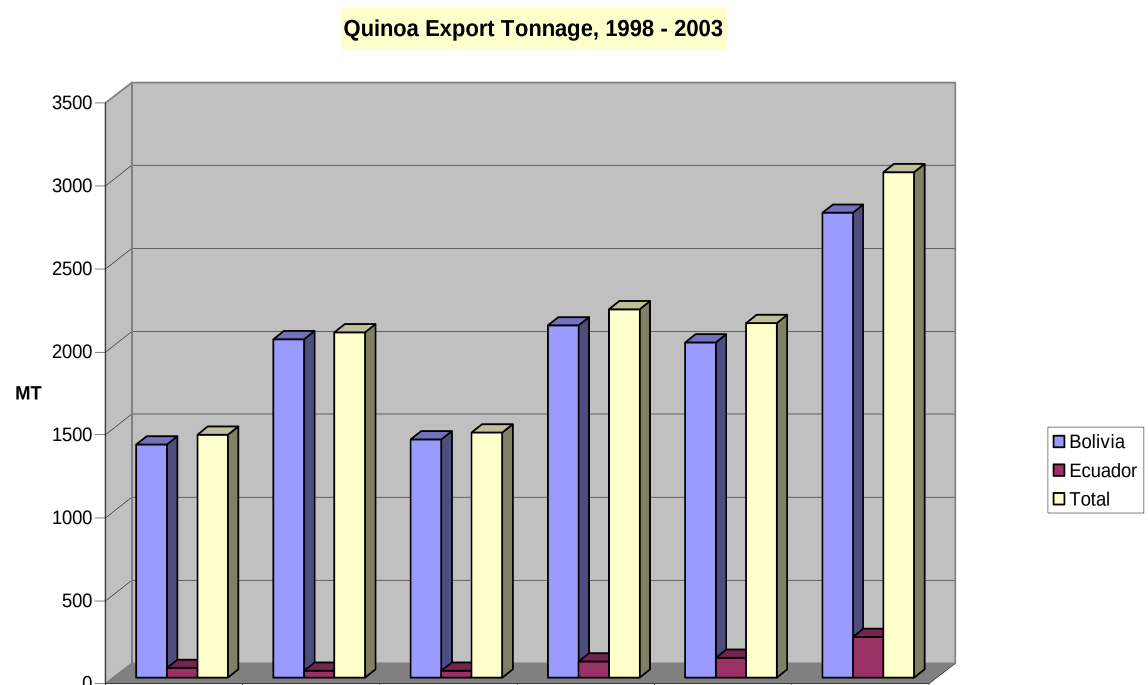
Quinoa - Reported World Production (basis FAO data, 1998-2004)

Country		Unit	1998	1999	2000	2001	2002	2003	2004
World	Area Harv	Ha	70,234	66,742	67,036	62,251	64,951	69,600	70,400
Bolivia	Area Harv	Ha	37,714	35,963	36,847	36,000	36,500	40,600	40,600
Ecuador	Area Harv	Ha	1,800	1,800	1,300	650	600	1,000	800
Peru	Area Harv	Ha	30,720	28,979	28,889	25,601	27,851	28,000	29,000
World	Yield	Hg/Ha	7,097	7,773	7,879	7,336	8,340	7,546	7,514
Bolivia	Yield	Hg/Ha	5,380	6,256	6,455	6,389	6,438	5,911	5,911
Ecuador	Yield	Hg/Ha	5,211	5,211	5,000	4,923	4,900	5,190	5,000
Peru	Yield	Hg/Ha	9,314	9,814	9,825	8,729	10,906	10,000	9,828
World	Production	Mt	49,843	51,877	52,817	45,668	54,167	52,519	52,900
Bolivia	Production	Mt	20,291	22,498	23,785	23,000	23,500	24,000	24,000
Ecuador	Production	Mt	938	938	650	320	294	519	400
Peru	Production	Mt	28,614	28,441	28,382	22,348	30,373	28,000	28,500

FAOstat data, 2004 (last updated December 7, 2004)

Quinoa and Quinoa Products Markets

Whole Grain and Flour Market - The quantities exported are not large and combined exports of Bolivia and Ecuador only surpassed 3,000 mt in 2003. Nevertheless, exports have been growing steadily and have more than doubled since 1998 (see Chart 1). Quinoa production in the traditional production areas of South America is being revitalized.

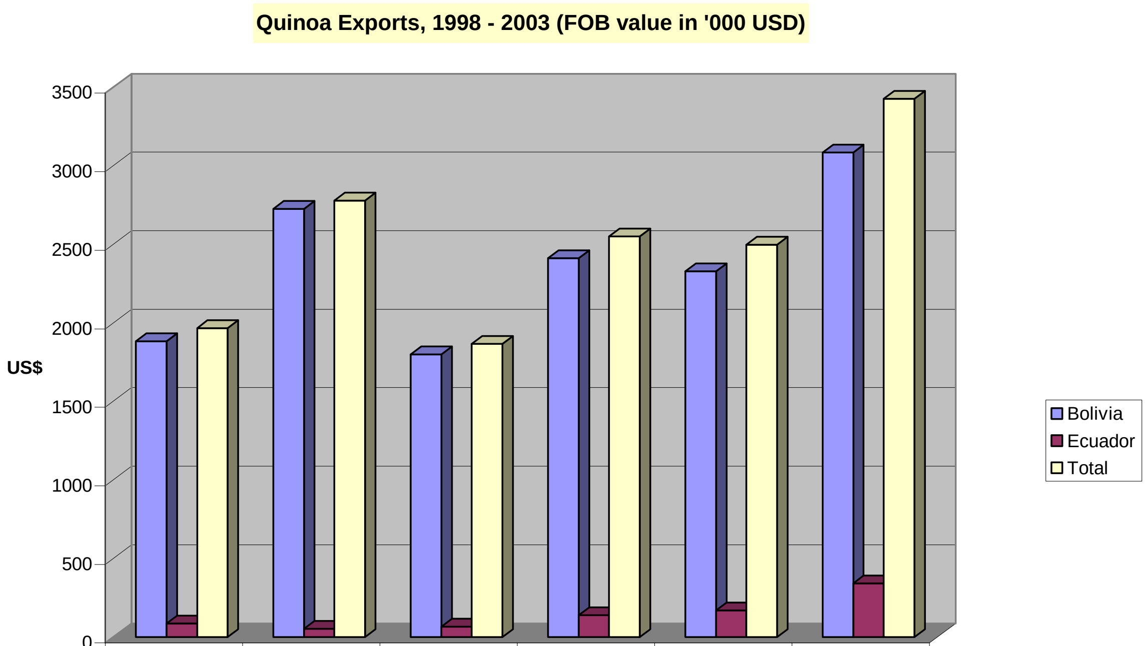


	1998	1999	2000	2001	2002	2003
Bolivia	1405	2038	1436	2123	2019	2802
Ecuador	58	42	42	98	119	245
Total	1463	2080	1478	2221	2138	3047

Year

Figure 1: Reported Quinoa Export Tonnage (1998 - 2003)

Exports from South America (the only recorded Quinoa export region) remain small, but have doubled from 1998 to 2003. However, it is notable, that while total export tonnage has increased more than 200 percent, the total ‘Free on Board’ (FOB) value for Quinoa exported measured in US$ has only risen by 75 percent over the same time period.



	1998	1999	2000	2001	2002	2003
Bolivia	1883	2726	1801	2411	2328	3085
Ecuador	85	53	67	139	170	343
Total	1968	2779	1868	2550	2498	3428

Year

FAOstat data, 2004 (last updated December 7, 2004)

Figure 2: Total Quinoa Export Value from Bolivia and Ecuador (1998 – 2003)

The FOB export prices for Quinoa by destination for the years 2000 to 2003 in Bolivia and Ecuador varied between US$ 555/mt (destination Spain) to US$ 4,000/mt (destination UK).

The major export destinations for Bolivian Quinoa are the USA, France, the Netherlands and Germany. Smaller tonnages are shipped to Canada, Japan and miscellaneous small importers in South America, Europe and Asia.

The biggest importers of Ecuadorian Quinoa are the USA, distantly followed by the UK. In general, the export Quinoa markets are small, but gradually increasing. Ecuadorian trade authorities report that most of their exported Quinoa is shipped as dry, deresinated seed with the seed dehulled. Other types of exports include popped (insufflated) Quinoa and Quinoa flakes for use in granola, snacks and chocolates, and similar products

The total current Quinoa consumption in the USA and Canada, combined in the specialty food market is estimated to be close to 3,000 mt. Approximately 80 percent of the market is for organic products.

In Canada, a small, specialized domestic and export market for Quinoa has been established on the Prairies by Northern Quinoa Corporation (NQC) in Saskatchewan. Quinoa production and marketing in Canada is primarily fostered by NQC. Nevertheless, to date the acreage in all of Canada has been small (~1,600 acres), and production has been fraught with difficulties. NQC is covering some of their sales with Quinoa imported from South America and from the United States. Even so, some specialty and bulk food stores in Canada purchase South American Quinoa and Quinoa flour via U.S. wholesalers. The Canadian export volumes to date are very small. Shipments have been made to the USA, Mexico, Germany and the UK. The sales to these markets target the gourmet food sector, health food and organic markets and the ethnic South American market.

The FOB export prices for Quinoa by destination for the years 2000 to 2003 in Bolivia and Ecuador varied between USD 555/mt (destination Spain) to USD 4,000/mt (destination U.K.). The average FOB export value of Quinoa amounted to USD 1,176/mt for the time period (2000 to 2003). In general, prices for the North American and European markets were higher than to South American neighbours. This may well reflect the 'specialty-status' of Quinoa in North America and Europe and the preference for organically certified product.

Currently, the bulk of Quinoa marketed in the USA goes into specialty food "bulk-bin" stores and into stores that specialize in organic product. A growing market is the specialty food sector catering towards people affected by celiac disease (CD) [1.7 million people in the USA and 0.3 million in Canada suffer from CD]. As well, Quinoa is also suitable for people suffering from diabetes [13.5 million in the USA and 2.2 million in Canada suffer from diabetes].

The organic markets, the non-allergenic markets and non-GMO markets hold the most promise for Quinoa grain and Quinoa flour. From an economic point of view, Quinoa grain and flour only becomes price competitive with other cereals in the organic, the non-allergenic and the non-GMO markets. It is more competitive with the pulse crops, as long as the comparison is not on a protein basis.

Value-Added Markets – Do They Exist and What Are They?

Inspite of the growing demand in specialty markets, the market for whole Quinoa seed, Quinoa flour and Quinoa flakes is relatively small. The question arises as to where else Quinoa could be marketed to usage. In this section, Quinoa fractions, starch, saponins, oil content and composition, oil by-products and carbohydrate cream substitute are addressed in turn.

Starch: Amylopectins are a branch-chained starch. As an amylopectin, the starch is superior to common starches as a thickener. Quinoa starch granules were found to be complex conglomerates of four to six micro granules. The micro granules were, in turn, ten times smaller than starch granules from wheat or corn. There are a number of current and potential uses of starches with small and narrow granule sizes, and there is increasing interest for their use in special products, for example, in fine printing paper, plastic sheets, as a binder with orally active materials and as a carrier material in cosmetics.

- Fat replacements – Aqeuous dispersions of small starch granules are known to produce a creamy, smooth texture that exhibit fat-mimetic properties. The small starch granules found in Quinoa may find commercial applications as carbohydrate-based fat replacers. In food applications, micro granular and uniformly sized granule starch produces a smooth mouth-feel, which may have an application, for example, in lower calorie cheesecakes, cookies and frozen desserts.
- Biodegradable films – Small granule size substantially increases the level of starch that can be incorporated without compromising the quality of the film. Commercial application of biodegradable films will have application to garbage bags, composting bags, grocery bags, and agricultural mulches.
- Carrier materials – Granule starch can be combined into potentially useful porous spheres when sprayed with bonding agents. These porous spheres may be useful in the food industry to contain flavour essences or other components, and to control the release of these essences over time or until it is heated to a certain temperature. Chewing gum or dry mixes are potential examples.

Note the development of improved methods to refine small granule starches is a pre-requisite to the development of new applications and new markets for starches with small granules (Lindeboom et al., 2004). NutraSweet holds a 1993 European patent for a cream substitute with Quinoa starch. However, as far as MCV could ascertain, there has been no commercialization of the patent.

Saponins: Quinoa seeds are covered with saponin, a resin-like substance that is extremely bitter and forms a soapy solution in water. Saponins cannot be digested and can sometimes cause intestinal damage or reduce intestinal absorption of nutrients. There are two types of saponin:

- saponin in white Quinoa, which can be used in the production of pharmaceutical steroids; and
- a more common type prevalent in other colors of Quinoa, which is used in soaps, detergents, beer, shampoos, cosmetics and synthetic hormones.

Because they are toxic to various organisms, saponins are being studied as to their insecticidal, antibiotic, fungicidal and pharmacological properties. The pharmacological interest in saponins is their ability to induce changes in intestinal permeability, which may aid patients in absorbing drugs (Koziol, 1993).

Quinoa Oil: On a fresh weight basis Quinoa shows an oil content ranging from 1.8 to 9.5 percent with a calculated global mean of 5.8 percent oil content higher than that of normal maize. Quinoa oil is high in polyunsaturated acid. It contains more linoleic acid, linolenic acid, and sterols than corn oil.

By-Products of Quinoa Oil Production - Oil Press Cake as a Dietary Supplement: Oil press cake contains 40 percent protein. Quinoa protein is an exceptionally high quality. Results of four different studies on the protein efficiency ratio (PER) of Quinoa in feeding trials with rats, expressing the PERs as percentages of the casein control diets showed that:

- Raw Quinoa (both sweet and bitter) exhibited PER values from 44 to 93 percent and cooked Quinoa PER values from 102 to 105 percent.
- In comparison, raw and cooked wheat exhibited PER values from 23 to 32 percent of the casein control. It is rare for a vegetable protein such as that from Quinoa to approximate so closely the quality of casein.
- A comparison of the profile of the essential amino acids (in human nutrition) of Quinoa with that of maize, rice and wheat shows that Quinoa protein is particularly rich in lysine and contains more histidine, methionine and cystine.

The protein in the Quinoa oil press cake could be an important complementary protein for improving the nutritional quality of both human and animal foodstuffs.

Overall Value-Added Quinoa Product Potential

Quinoa offers oil, which is rich in polyunsaturated fatty acids, a protein whose quality approaches that of casein, and a starch that can be converted into a cream/fat substitute, all of which are marketable as products or as natural additives that should appeal to today's health conscious consumer. The saponins removed from bitter Quinoa may find niches in pharmaceutical preparations or in programs of integrated pest management.

However, despite being a promising "rediscovered" crop with important nutritional characteristics, the current industrial use of Quinoa is limited by small-scale production which results in prices for the grain that are too high to be commercially competitive with wheat, rice and barley. Further interest, research and the development of improved methods of commercial Quinoa cultivation will help ensure that Quinoa regains the prominence it once enjoyed in South America.

In England, industrial uses, such as a flow improver to incorporate starch into flour products, the plastics industry, anti-offset and dusting powders and complimentary protein to improve the amino acid balance in human and animal diets are now being examined.

In short, there is no doubt that the demand for Quinoa is increasing, but the total tonnage required is still small. It does allow for a niche market production, but does not lend itself to large-scale production. The organic markets, the non-allergenic markets and non-GMO markets hold the most promise for Quinoa grain and Quinoa flour. The industrial use is currently limited by small scale production which prohibits Quinoa to compete with wheat, rice and barley in the fraction market. There are definite opportunities in the fractions market for the special attributes of Quinoa fractions, especially for the starch component, but they have not yet been realized and exploited by the food industry. The development of a special market for Quinoa will probably have to go hand in hand with Quinoa processors and industry. The fact that patents for Quinoa component products exist, does show that there is some awareness and interest for Quinoa fractions within the food industry.

Can We Cost-Effectively Produce Quinoa in Alberta and be Profitable?

To perform this analysis, we used information obtained from Saskatchewan, as information on cost of production under Alberta conditions is not available. As well, to perform the analysis, the following assumptions were made:

- Quinoa cultivated in dark brown soil zone in Saskatchewan.
- Yield per acre for conventional and organic Quinoa is respectively 800 lbs/acre and 400 lbs/acre.
- Pricing per pound for conventional and organic Quinoa is respectively $0.30/lbs and $0.60/lbs.
- Two (2) rotation years are required to grow the crop.

Based on the Saskatchewan model, which is deemed to be the closest to Alberta's current economic and agronomic conditions, it is evident that producing Quinoa, either organic or conventional, can be profitable (Table 6). The net income per acre is $64.46 and $130.45 respectively for conventional and organic Quinoa.

Sensitivity analysis revealed that the major areas of focus are the yield per acre and pricing. For example and based on the Saskatchewan model, if we increase yield per acre to 1,000 lbs, an increase of 25%, the farmer's net income before taxes would double from $64.4 to $124.46 per acre for conventional Quinoa. A 25% increase in yield for organic Quinoa would translate into a 46% increase in net income before taxes from $130/acre to $190/acre.

A price increase of 10% (from $0.30/lbs to $0.33/lbs) for conventional Quinoa would result in 37.3% increase in the farmer's net profit before taxes, going from $64.46 to $88.46: A net income increase of $24 per acre. A 10% price increase for organic Quinoa would result in an 18.5% increase in the farmer's net income before taxes.

Break-Even analysis revealed the end point at which farming Quinoa stops costing money to produce and sell, and starts to generate a profit for the farmers is 585.13 Lbs per acre and 182.58 lbs/acre respectively for conventional and organic Quinoa.

The same analysis revealed that in order to recover production and sales costs while the current yield is maintained, both organic and conventional Quinoa has to be respectively sold at least at $0.27/lbs and $0.22/lbs.

Notwithstanding marketing challenges, farming Quinoa can be an attractive and profitable business operation if farmers are able to produce a consistent yield of at least 800-lbs/ acre and 400-lbs/acre respectively for conventional and organic Quinoa.

Table 6: Quinoa Production Cost Estimate – Saskatchewan

	Baseline		Yield Increase Scenario (25% increase)		Price Increase Scenario (10% increase)	
	Quinoa (Conventional)	Quinoa (Organic)	Quinoa (Conventional)	Quinoa (Organic)	Quinoa (Conventional)	Quinoa (Organic)
Type of Rotation		Fallow		Fallow		Fallow
Rotation years required to grow the crop	2	2	2	2	2	2
Soil zone	D.Brown	D.Brown	D.Brown	D.Brown	D.Brown	D.Brown
Revenue Per Acre						
Estimated Yield (lb./acre)*	800	400	1,000	500	800	400
Est. on farm mkt.price (cent/ lb.)	0.30	0.60	0.30	0.60	0.33	0.66
Estimated gross Revenue	240.00	240.00	300.00	300.00	264.00	264.00
Expenses per Acre						
Variable Expenses/Acre						
Seed	1.50	1.50	1.50	1.50	1.50	1.50
Fertilizer- Nitrogen	35.00	0.00	35.00	0.00	35.00	0.00
Phosphorus	9.00	0.00	9.00	0.00	9.00	0.00
Sulfur & Other	1.70	10.00	1.70	10.00	1.70	10.00
Chemical- Herbicides	0.00	0.00	0.00	0.00	0.00	0.00
Insecticides	30.00	0.00	30.00	0.00	30.00	0.00
Seed Treatment/Fungicides	0.00	0.00	0.00	0.00	0.00	0.00
Machinery Operation- Fuel	6.50	6.50	6.50	6.50	6.50	6.50
Repair	10.00	10.00	10.00	10.00	10.00	10.00
Custom Work & Hired Labour	3.00	3.00	3.00	3.00	3.00	3.00
Crop Insurance Premium	0.00	0.00	0.00	0.00	0.00	0.00
Utilities & Miscell.	2.97	2.97	2.97	2.97	2.97	2.97
Interest on Variable Expenses	1.09	0.80	1.09	0.80	1.09	0.80
Total Variable Expenses	100.76	34.77	100.76	34.77	100.76	34.77
Other Expenses/Acre						
Building Repair	1.20	1.20	1.20	1.20	1.20	1.20
Property Tax	4.25	4.25	4.25	4.25	4.25	4.25
Insurance & Licenses	1.60	1.60	1.60	1.60	1.60	1.60
Machinery Depreciation	14.50	14.50	14.50	14.50	14.50	14.50
Building Depreciation	1.15	1.15	1.15	1.15	1.15	1.15
Machinery Investment	8.70	8.70	8.70	8.70	8.70	8.70
Building Investment	1.38	1.38	1.38	1.38	1.38	1.38
Land Investment	23.00	23.00	23.00	23.00	23.00	23.00
Total Other Expenses	55.78	55.78	55.78	55.78	55.78	55.78
Labour & Management	19.00	19.00	19.00	19.00	19.00	19.00
Total Expenses	175.54	109.55	175.54	109.55	175.54	109.55
Summerfallow Cost						
Total Rotation Expense	175.54	109.55	175.54	109.55	175.54	109.55
Returns per Acre						
Returns over Variable Expenses	139.24	205.23	199.24	265.23	163.24	229.23
Returns over Rotation Expenses	64.46	130.45	124.46	190.45	88.46	154.45
Break-Even Yield (lbs./ acre)						
To Cover variable Expenses	335.87	57.95	335.87	57.95	305.33	52.68
To Cover Rotation Expenses	585.13	182.58	585.13	182.58	531.94	165.98
Break-Even Price (per lb.)						
To Cover variable Expenses	0.13	0.09	0.10	0.07	0.13	0.09
To Cover Rotation Expenses	0.22	0.27	0.18	0.22	0.22	0.27

Table 7: Yield Comparative Analysis

	Fababean	Wheat	Canola	Conventional Quinoa	Organic Quinoa
Revenues					
Yield (bu or lbs/acre)	32.9 bu	48 bu	32 bu	800 lbs	400 lbs
Normal Long-term Prices	4.14	4.48	7.31	0.30	0.60
Total Revenues	136.206	215.04	233.92	240.00	240
Variable Costs					
Seed	39.60	10.00	36.00		
Innoculants	3.35				
Fertilizer	11.55	34.15	43.20		
Herbicides	30.00	23.00	30.00		
Other	37.00	33.00	35.50		
Total Variable Costs	121.50	100.15	144.70	100.76	34.77
Fixed Costs (10)	42.00	42.00	42.00	74.78	74.78
Net Income Before Taxes	-27.29	72.89	47.22	64.46	130.45

Assuming that production and marketing challenges are resolved, farming Quinoa, particularly organic Quinoa, is more profitable than Fababean, wheat and canola. Conventional Quinoa is more profitable than Fababean and canola, and has the potential to be even more profitable than wheat if either yield or pricing improves.

Competing on a cost production basis - comparing the cost of production in Canadian dollars per acre, the following ranking emerges:

(a) Ecuador is the cheapest producer with a cost of $123.10/ acre,
(b) Canada is second with a cost of $175.00/ acre,
(c) The USA is the most expensive with a cost of $258.00/ acre.

This finding also corroborates the comment by NQC that it is less costly to import Quinoa than to produce it in Saskatchewan. MCV also believes that the processing costs (cleaning plus de-saponization) in South America are less costly than in Canada, but have not been able yet to quantify the processing costs with reliable data. The cheaper production and probably processing costs are certainly a threat to a future expansion in Quinoa in North America.

As a conclusion of the financial analysis, we do not recommend, nor promote widespread intensive Quinoa farming until yield consistency of at least 800 lbs/acre for conventional Quinoa and 400 lbs/acre for organic Quinoa can be obtained, as well as a price of at least $0.27 lbs and $0.22 lbs respectively for organic and conventional Quinoa can be achieved. Furthermore, although Quinoa production is not as competitive in Canada as in South America, the high retail margins versus the cost of goods will allow Canada room to deliver into the export markets. Note also the high import prices compared to production costs. The established container handling capacity and container routes in Alberta will render a handling advantage over non-mature shippers.

Alberta's Competitive Advantage / Disadvantage?

The SWOT analysis below summarizes the strengths, weaknesses, opportunities and threats that exist for Quinoa from an Alberta perspective (Table 8).

While the health food market will sustain good niche crop production, future opportunities are certainly contained in the component strengths of the crop. The main threat to Quinoa production in North America is the production potential and the low production and processing cost structure in South America.

Canada, and in particular, Alberta does not have an overall competitive advantage to produce, process and market Quinoa. The production costs from South America are smaller, creating a threat to Canadian production. The processing costs in South America are likely smaller as well. However, Canada's production costs are more advantageous than those in the USA. This should assure Canada a role in the domestic/USA market, especially in the expanding health food market in North America. On the other hand, unless Alberta can harness special ties with the food and non-food industries to pursue the industrial uses of the crop, the market for Quinoa will remain a niche market.

From a farmers' view, Quinoa production currently does look advantageous on the basis of return per acre in comparison to traditional crops. However, with a yield spread of 0 - 2,000 lbs. per acre, the production risk is enormous unless strides can be made in the adaptability of the crop to the Prairies.

Table 8: SWOT Analysis, Quinoa

Strengths Uses: • Whole seed • Flour • Flakes Known potential uses: • Small granule starches (various applications) • Saponins • Oil • Oil Press cake (as a dietary supplement)	**Opportunities** • U.S. and domestic health food markets • Growing celiac and diabetic markets • Value added gourmet markets • Various potential industrial uses
Weaknesses • Current industrial use of Quinoa is limited by small-scale production • Need to be able to produce 'competitive' yields/ production costs • Prices for the grain too high to be commercially competitive with wheat, rice, and barley	**Threats** • Unconfirmed ability to produce Quinoa in Canada with yields consistently above 1,000 lbs/acre • Several South American countries are exporters of Quinoa with the ability to increase production and exports • Ability to produce good quality Quinoa in Canada

Table 9: Alberta's Competitive Advantage / Disadvantage

• Processing costs are smaller than in the USA. • Closeness to the USA market (celiac disease, diabetes). • Alberta has export expertise, container capacity, regular export routes (freight advantage to Europe). • Potential to access industry. • Retail margins are big relative to cost of production.	• Alberta does not have an overall competitive advantage to produce and process Quinoa (see cost of production in South America). • The overall demand for general Quinoa is small. • More agronomic work needs to be done (yield, variation, production, risk).

Conclusions

- Traditional Quinoa markets are indeed viable for Alberta (given some agronomic support), but they are small in the foreseeable future.
- Organic markets, non-allergic markets and non-GMO markets hold the most promise for Quinoa grain and Quinoa flour.
- While both domestic and export markets are growing, the combined domestic and export markets currently only amount to about 4,700 mt, offering niche market opportunities.
- New industrial uses are promising, but not in place to date.
- It is definitely positive that industry is aware of some of the excellent attributes of Quinoa fractions, but alliances with industry are necessary to encourage and further the active usage of Quinoa fractions.
- Agronomic work to enhance and stabilize yield, enhance quality, and further adaptation to Alberta conditions will be necessary.
- We do not recommend, nor promote widespread intensive Quinoa farming until yield consistency of at least 800 lbs/acre for conventional Quinoa and 400 lbs/acre for organic Quinoa can be obtained, as well as a price of at least $0.27/lbs and $0.22/lbs respectively for organic and conventional Quinoa can be achieved.

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Feedback Survey

Quinoa … The Next Cinderella Crop for Alberta?

We are interested in any feedback you can provide. Please take a moment to fill out this survey and return it by e-mail, fax or regular mail to the address noted below. THANK YOU!

Please circle your answers:

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