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College of Agriculture and Bioresources
DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS
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A Report on Breeding Priorities for the High-Value Pea Processing Sector in Western Canada (*Extended Version*)

Prepared by: Kim Sanderson,[1] Sandro Steinbach,[2] and Nicholas Tyack[1]

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BE WHAT THE WORLD NEEDS

[1] Department of Agricultural and Resource Economics, University of Saskatchewan, Room 3D34, Agriculture Building 51 Campus Drive, Saskatoon, SK. S7N 5A8 Email: nicholas.tyack@usask.ca

[2] Department of Agribusiness and Applied Economics, North Dakota State University, Dept 7610, PO Box 6050, Fargo, ND. 58108 Email: Sandro.steinbach@ndsu.edu

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Introduction

The PEA^{ce} project represents a collaborative effort to explore the evolving landscape of high-protein pea processing in Canada, with a particular focus on the intersection of plant breeding, market demand, and processor priorities. This report presents findings from a comprehensive series of interviews and surveys conducted with Canadian pea processors, aiming to capture their perspectives on current challenges, innovation trends, and future opportunities in the sector. The research investigates key themes such as protein content and functionality, the potential of gene editing technologies, climate-smart certification, and the broader market environment shaping the pulse processing industry.

Through detailed qualitative interviews and survey data, the report offers insights into the attributes processors value most in pea varieties, the economic and technological pressures they face, and their views on the role of plant breeding in maintaining Canada's competitive edge in global markets. The findings are intended to inform plant breeders, policymakers, and industry stakeholders about the nuanced needs of the processing sector, supporting the development of pea varieties that align with both market realities and sustainability goals. This work underscores the importance of cross-sector collaboration in advancing innovation and resilience in Canada's pulse industry.

Industry Overview

Pea Production

For 2024, Canadian dry pea production was 2.6 million tonnes (Mt) (Agriculture and Agri-Food Canada, 2025). The Canada Grain Commission (2024) reported 2,806,304 insured acres of peas were seeded in Canada in 2024, accounting for 9% of the seeded acres. In Alberta there were 1,158,263 acres of peas, representing 16% of seeded acres, Saskatchewan 1,482,677 accounting for 9% of seeded acres, and in Manitoba, 165,364, making up 3% of seeded acres. When combined with carry-in stock the total supply for 2024-25 is estimated to be 3.3 Mt (Agriculture and Agri-Food Canada, 2025). Compared to the five-year average, 2024 Canadian seeded area fell 14.5%, production was 11.6 % below average while yield was up 3% (Government of Saskatchewan, 2024). Industry leaders expected Canadian pea seeded acres for 2025 could fall by as much as 16% below 2024 acres (Penner, 2025). Statistics Canada forecast a rise in seeded area in 2025-26 of 9% to 1.42 million hectares (Mha), with production expected to rise by 4% to 3.1 Mt and supply rising by 13% to 3.77 Mt due to higher carry-in stock (Agriculture and Agri-Food Canada, 2025).

Yellow peas are the predominant market class in Western Canada with approximately 75% of production (Barker, 2023). Yellow peas do not bleach in the field and can withstand delayed harvest better than some other classes, including green peas. Producers choose them because harvest timing is less critical. Yellow peas are widely purchased by grain buyers making delivery cost effective. The

CDC Meadow variety of yellow peas continues to dominate the market despite lower yield potential relative to other, newer varieties, ranking fifth from the bottom in performance trials amongst 22 varieties currently on the market (Reed, 2024). The popularity of this variety with farmers may be due to early maturity and seed integrity.

Yellow pea acres are expected to drop in 2025 due to current and potential tariffs in key markets (Penner, 2025). The largest buyer for these peas is China where they are used for protein extraction and vermicelli noodle production. The Indian subcontinent purchases them for human consumption such as dal and North America uses them for fractionation. Fractionation for protein as a food ingredient is a growing market in North America. Yellow peas are also sold into the livestock feed markets.

Green peas account for about 15 to 20 percent of Canadian production (Barker, 2023). Achieving a quality green pea requires more care in production relative to yellow with growers typically seeding them first so they can harvest them at the right time to reduce bleaching and will usually take the crop off at a higher moisture content and dry the peas to maintain the quality and limit bleaching. In addition, green peas are usually processed by more specialized buyers, requiring close access to facilities to reduce costs, and making selling a little less convenient than delivery to a grain buyer.

The Indian sub-continent and several South and Central American countries import green peas for human consumption. They are also used in livestock feed. Green pea buyers are less price sensitive and lower supply and there is limited competition internationally in this market (Penner, 2023). Green pea acres may account for a higher percentage of Canadian pea production in 2025 due to the green pea price premium over yellow peas (Agriculture and Agri-Food Canada, 2024).

Domestic Use of Peas

A 2022 market report by Pulse Canada indicated about 15% of Canadian pea production was expected to be used in domestic processing and that domestic pea use is diversifying out of feed and into other non-feed uses, with most peas produced on the prairies going into human food either through domestic processing or exports markets (Saskatchewan Pulse Growers Association, 2025). Specific Pulse Canada 2030 goals for peas include tripling domestic use and to have 50% of Canadian production processed into value-added products for the U.S., Europe, and South America markets (Chorney, 2023).

Global Production

Global pea production in 2024 remained unchanged from 2023 with Russia the biggest producer. (Boersch, 2025). The global production for 2024 is estimated to be 11.78 Mt a rise of 1.8% over 2023. Competition for Canadian peas come from the U.S., Ukraine, Russia, Australia, and EU. India is a large pulse producer but most of its production is consumed domestically.

The OECD-FAO (2023) Agricultural Outlook 2023-32 report projects the largest growth in pulse production in the next 10 years will be in the regions of South and Southeast Asia, North America, and Sub-Saharan Africa. Over the coming decade, yield growth is projected on average to contribute 79% to global production growth of the main crops covered by the Outlook. Projected rates differ across regions and countries due to differences in production technologies, management practices, natural resource endowment, and local climatic conditions. In high-income countries, the growth in yields is projected to be smaller than the world average for the main crops, except for pulses. Yields in these countries are already close to the production frontier and further increases are constrained by stricter environmental regulations. However, production and investment in nitrogen-fixing crops known for their productivity-increasing properties are expected to expand to meet sustainable food production objectives.

Trade

World pulse markets are considered volatile due to trade barriers, fluctuations in world supply and difficulty predicting demand growth in some markets. The top 10 dry pea exporters based on value in 2022 were Canada, Russia, Turkey, USA, France, Australia, Ukraine, Latvia, India, and Argentina (International Trade Centre, 2024). Canada accounted for almost 40% of the exports followed by Russia at 16% and Turkey and the U.S. at 8% and 7%, respectively. Collectively these four countries accounted for about 70% of the supply for the 2022 global trade in peas. Canada and the U.S. are considered the two primary global suppliers of green peas (Penner, 2023).

Canada continued to be the top exporter of dry peas in 2023 at 1.1B USD and 2.5 Mt (World Bank, 2025). From 2018-2022, China, the U.S., and Bangladesh were Canada's leading export markets, importing on average a combined 77.7% of Canada's supply to world markets. This market concentration combined with market volatility arising from fluctuations in supply and demand for pulses and geopolitical instability create significant marketing risks for pulse producers. To address this, Pulse Canada has recently announced a target of 25% of Canadian pulses going to new and diversified value-added markets by 2030 (Chorney, 2023).

Statistics Canada forecast Canadian 2024-25 exports to fall to 2.1 Mt, a drop of 0.3 Mt from 2023-24 due to import tariffs from China and the threat of resumed tariffs from India (Agriculture and Agri-Food Canada, 2025). Carry-out stocks are forecast to rise due to weakened export sales. Domestic use in 2024-25 is expected to be up to 612Kt from 584Kt in 2023-24. Moving forward Statistics Canada expects exports to fall and domestic use to rise in 2025-26 to 1.3Mt and 770Kt, respectively.

In 2023, China was the largest importer of dry peas at 2.6 Mt, with Canada the largest supplier at 1.5 Mt followed by Russia at 0.9 Mt (World Bank, 2025). Canada's share of China's pea markets fell from 93.1% in 2020 to 59.5% in 2023. Russia's share of China's market for 2023 was 34.2% (World Bank, 2025) and they are expected to continue to grow that market share for yellow peas, shutting Canada

out of the lower quality or feed markets (Penner, 2024).Near horizon potential disrupters to Canadian pea exports include India's volatile trade restrictions which could see import restrictions on Canadian peas reinstated depending on domestic production, the inability to predict what retaliatory tariffs China might impose going forward, and the threat of tariffs from the U.S.

High Protein Market

The Protein Industries Canada Global Market Forecast released in September 2023 predicts strong growth potential for the plant-based meat segment to continue, with North America and Europe accounting for more than 70% of this market by volume and value of between $88 and $139 billion USD by 2035 (Ernst & Young, LLP, 2023). Peas are expected to make up about 20% of the projected demand for proteins in the plant-based meat market, which would potentially utilize between 10, and 15 Mt of peas by 2035. The plant-based baking fortification market is anticipated to be substantially smaller but could still utilize between 55 and 85 thousand tonnes of peas by 2035. Industry research (Data Essential, 2023) on understanding consumer expectations around plant-forward foodservices offerings found that just over half of the Americans surveyed (n=1,501) in 2023 were open to plant-forward eating with health as the primary motivator to plant-based eating but cost and taste identified as barriers to increased consumption. Consumers indicated they are most interested in plant-forward foodservice and restaurant offerings that contain bean, lentils, and other legumes and least interest in dishes that mimic the meat experience.

Globally, the pea protein market was valued at $2.12 billion USD in 2023 and expected to grow from 2024 to 2030 by a CAGR of 12.1% (Grand View Research, 2024). Canadian exports of protein concentrates, and textured protein substances have grown in value from $2.3 million USD in 2018 to $156.9 million USD in 2022 (International Trade Centre, 2024). In 2022, $140.3 million USD of protein products went to the U.S. representing almost 90% of the Canadian exports that year and about 37% of the U.S. imports. The U.S. is the largest consumer of pea protein globally with the North American market responsible for 33.1% of the revenue in 2023 (Grand View Research, 2024). However, trade data suggests that the largest volume importer of protein concentrates and textured protein substances (HS 210610) from 2018 to 2022 has been Chile, importing 215.2 Kt compared to the U.S. with the second highest volume of 69.8Kt in 2022 (International Trade Centre, 2024).

A 2023 Economic Development Canada report (2023) suggests the Indo-Pacific region is anticipated to experience a significant decline in agricultural potential due to climate change and population growth pressures. This combined with expected growth in the plant protein market, make Asia-Pacific region a significant marketing opportunity for Canadian exporters. The signing of CPTPP has reduced trade barriers for exporting. Protectionist policies and unpredictable import restrictions are a key challenge and risk to growing Canadian exports in this region.

Volatility in global pulse commodity markets has led to increased interest in expanding domestic processing of pulses. In a November 7, 2023, news release Protein Industries Canada (2023) stated investing in ingredient manufacturing, food processing, and bio-products in the protein industries would add $25 billion to the Canadian economy and create 17,000 jobs. Protein Industries Canada indicated it would be announcing new investments of more than $100 million in the Canadian protein sector. However, inflation, rising borrowing costs and difficulty securing capital investment combined with slower than expected growth in global plant-based consumption by consumers has slowed expansion in the Canadian pulse processing sector (Earnst & Young, LLP, 2023).

Genetics and environment are the biggest influencers on the level of protein found in pea seed (Barker, 2023). The Canadian Grain Commission reported that the mean protein content of western Canadian No. 1 green peas tested in 2024 was 25.8% compared to 25.3% in 2023 (Wang, 2024). Western Canadian No. 1 grade yellow peas had a mean protein content of 24.9 % in 2024 compared with 23% in 2023. The interest in plant-based proteins means buyers may begin to look for peas with higher protein. Currently there has been limited movement on the part of processors to pay producers a premium for protein content. The processing sector has been focused on improving technology to maximize extraction of the desired proteins and utilization of the starch and fibre by-products.

Pulse Canada announced in 2023 a focus on finding high-value and volume end uses for the pea protein processing by-product of pea starch, exploring industrial applications such as bioplastics (Chorney, 2023). Protein Industries Canada (2020) recently funded a project related to utilizing by-products as a micro-nutrient fertilizer. The project includes installing a new manufacturing process that will produce up to about 6,500 tons per year of micronutrient fertilizer and create 25 jobs.

Research into patent filing and grants for pulse starches shows a significant increase in activity beginning in 2017 and peaking in 2019 at just over 30 applications, with most starch-related innovation occurring in China, the US and to a lesser extent Europe (Pulse Canada, 2024). Of the 190 patents evaluated, 136 were for pea starch and 25 for lentils. Of the 190 filings evaluated, 105 were for food end-use market applications, with many looking to address the functionality of pulse starch that makes it challenging to use as a direct replacement for other starches. The beneficial attributes of pea starch for analog products include the ability to gel, develop viscosity, holed water, and contribution to texture of final products. Pulse starches are also being used in various applications including gluten-free baking, snacks, sauces, batter and breading products and beverages. However, the most widely adopted food use for pulse starches is in noodles and pasta, with pea starch gaining popularity in this application. Non-food applications include industrial, cosmetic, and pharmaceutical products, as well as animal and pet feed.

Genome Editing

Genome editing has introduced new challenges related to regulatory distinctions and traceability, creating the potential for new types of regulatory and trade issues. For developers of new varieties of pulses destined to be sold in international markets, an awareness and understanding of the regulatory environment of current and potential trading partners is important (Vora et al., 2023).

As plant breeders look to develop and apply genome editing techniques to commodity crops that are primarily sold in international markets, it is anticipated they will be subject to multiple, inconsistent, and non-science-based regulations as they traverse different jurisdictions. Genome editing has introduced new challenges related to regulatory distinctions and traceability, creating the potential for new types of regulatory and trade issues. For developers of new varieties of pulses destined to be sold in international markets, an awareness and understanding of the regulatory environment of current and potential trading partners is important. A recent study of global genome editing regulations revealed that China has recently purchased significant gene editing intellectual property (Clarke and Hobbs, 2024).

The current regulatory frameworks for genome editing of the top 10 importers of peas (based on value) as well as Canada's top 10 export markets in 2022 (based on value) is shown below. What is interesting to note is that five of the top 10 importers including Pakistan, Turkey, Iraq, Bangladesh, and Ethiopia do not currently have specific regulations that apply to genome edited crops. However, Bangladesh is known to be discussing regulations that are expected soon, although how they will apply to genome-edited crops is uncertain. Of Canada's top export markets, the number without specific regulations that apply to genome edited crops increases to six including Pakistan, Bangladesh, Cuba, United Arab Emirate, Peru, and Thailand. The lack of specific regulations that apply to genome edited crops in countries importing dry peas creates uncertainty in terms of the potential for a future market access risk should Canada proceed with developing and growing gene-edited peas. It is important to remember that these are the top export markets for commodity peas not value-added pea ingredients which currently make up a very small percentage of export sales. However, if the value-added ingredient market is to grow it will need to grow export sales and processors indicated that they are starting to export to Europe and Asia including South Korea and Japan. While Japan, like Canada, has exempted gene-edited crops from regulation, a 2019 study revealed Japanese consumers define naturalness as the lack of artificial manipulation and consumer perceptions of gene editing and naturalness negatively correlated with those of conventional crossing differing from the view of scientific experts (Otsuka, 2021). Europe regulates gene-edited crops the same as GMOs while South Korea does not currently have specific regulations for gene-edited products (Vora et al., 2023).

Table 1: Regulatory Framework for Genome editing as of 2023 (Vora et al, 2023)

Top 10 World Importers Peas 2022 HS code 071310	Regulatory Framework for Genome editing as of 2023
China (Canada top 10)	Plants created using gene editing are allowed and subject to the same regulations as plants created through traditional breeding. GMO regulations are still being developed.
Pakistan (Canada top 10)	No specific regulations currently apply to genome edited crops. Discussions may be occurring.
Türkiye	No specific regulations currently apply to genome edited crops. Discussions may be occurring.
USA (Canada top 10)	Gene-edited crops are not subject to the stricter regulations that apply to GMOs because they are classified as conventional plants. No confirmation by regulatory authorities required before release into the market.
Iraq	No specific regulations currently apply to genome edited crops. Discussions may be occurring.
Bangladesh (Canada top 10)	No specific regulations currently apply to genome edited crops. Discussions are known to be occurring, and regulations are expected to be released, but it is uncertain if it will be adapted to genome-editing crops.
Ethiopia	No regulatory pathway currently in place for gene-edited crops.
Germany	Gene-edited crops are regulated like GMOs in the European Union with regulation concentrating on the procedure rather than the outcome. There is a proposal from the European Commission for a new legal framework suggesting a relaxation of EU regulations affecting gene-edited crops.
Italy	Gene-edited crops are regulated like GMOs in the European Union with regulation concentrating on the procedure rather than the outcome. There is a proposal from the European Commission for a new legal framework suggesting a relaxation of EU regulations affecting gene-edited crops.
Belgium	Gene-edited crops are regulated like GMOs in the European Union with regulation concentrating on the procedure rather than the outcome. There is a proposal from the European Commission for a new legal framework suggesting a relaxation of EU regulations affecting gene-edited crops.

Additional Canada 2022 top 10 export markets based on value	
Cuba	No regulatory pathway currently in place for gene-edited crops.
Philippines	Gene-edited crops are exempt from GMO regulations but require proper confirmation by regulatory authorities before release into the market.
Columbia	Gene-edited crops are exempt from GMO regulations but require proper confirmation by regulatory authorities before release into the market.
United Arab Emirate	No regulatory pathway currently in place for gene-edited crops.
Peru	No regulatory pathway currently in place for gene-edited crops.
Thailand	No regulatory pathway currently in place for gene-edited crops.

Objective

PEA^{CE} is an interdisciplinary project employing state-of-the-art genomic technologies to increase the quality, profitability and resilience of peas grown in Canada. The GE^{3}LS portion of this research examines the potential constraints to the expansion of pea cultivation and associated markets. This high-protein pea processor survey investigates processors' plant breeding priorities and begins to explore the market potential of climate-smart certification programs and pea varieties developed using different technological approaches. We engaged stakeholders in higher-value pea markets to identify the traits most important to this industry and assess the potential premium these products could command. While producers have voiced an interest in genome edited crops, to our knowledge Canadian processors have not been formally consulted on this issue (T. Stephanson, personal communication, February 1, 2024) This research looks to address this by gathering input from pea processors on the use of gene editing in pea plant breeding.

Methods

Prior to undertaking this research, we conducted a review of the Canadian pea and pulse industry literature to obtain a comprehensive description of both the domestic and international markets for field peas. Meetings to discuss the research objectives were held with the Canadian Pulse Association, Saskatchewan Pulse Growers Association, Alberta Pulse Growers, Manitoba Pulse and Soybean Growers, and Protein Industries Canada. Based on the meetings and the literature review, a short online SurveyMonkey survey and semi-structure interview instrument were developed to explore the pea attributes that processors value, and price premiums for high protein peas. The anonymous survey included nine questions that asked about processing capacity, the pea attributes that were important to processors, and premiums paid for pea protein (**Appendix 1**: Online SurveyMonkey questions). Open-ended, multiple choice, and Likert scale questions were used in the survey. The 10-question interview guide (**Appendix 2**: Qualitative interview questions) asked respondents their thoughts on the plant-based food market, the pea attributes of value to processors, the use of gene editing in pulse breeding, and the marketing potential of a climate-smart certification program. The research project was approved by the University of Saskatchewan Behavioral Research Ethics Board on April 10, 2024.

Introductory emails and follow-up reminders were sent to 34 prospective participants. Primary processors, food ingredient processors and food manufacturers were invited to participate. Of those invited, 12 agreed to participate and were sent a follow-up email providing additional information about the project, a copy of the consent form and a link to the online survey. Virtual interviews were conducted using Zoom between May and November 2024. Interviews took between 45 and 90 minutes to complete. Zoom's recording feature was employed to create a transcript of the conversation with participants. Of the 12 interview participants, six completed at least some of the online survey questions. Two respondents stated that processing volumes and capacity at their facilities was proprietary information, and we believe this may explain the low survey response rate. Given the low response rate, the survey results are reported on along with the findings of the qualitative interviews within this document.

A semi-structured interview format was used to allow respondents to offer their opinions on the high-value pea market and information relevant to pea plant breeding. Before beginning the interview, respondents were asked if they had read the consent form and to give their verbal consent to participate in the interview. Participants were also asked if they had completed the online survey, their willingness to have the interview recorded, and if they agreed to be quoted either by name or anonymously. At the end of the interview, respondents were asked if there was anything else relevant to the project not already covered in the interview they thought breeders should know.

The high protein pea ingredient products produced by processors participating in the study included protein flour, concentrates, and isolates. The specific interview questions asked varied depending on the participant's job within the company, the company's role in the supply chain, and the type of products produced. Participants held a variety of roles within the companies they represented including export sales, procurement, CEO, operations, and R&D, adding to the diversity of perspectives and responses gathered through the interview process.

Canadian Pea Processing Sector

Through the interview process, information was gathered about high protein pulse processing in Canada. Respondents were asked about the percentage of pea protein processors extracted from current pea varieties and their processing capacity. The two primary methods for extracting pea protein currently being employed by Canadian processors are dry and wet fractionation. Dry fractionation is different from wet in that it does not use chemicals or water and is considered the more cost-effective method, but the protein purity is lower than that achievable by wet fractionation (Shanthakumar et al., 2022). The processors interviewed were asked if they had minimum protein level requirements for the peas they processed and what percentage of protein they were on average able to extract from the peas. Only a few processors stated they had a minimum protein requirement for the peas they purchased. Most processors indicated they did not have a minimum but that the average protein level in Canadian peas was about 23% which they had come to expect in the peas they purchased. Occasionally an environmental production issue would affect the protein level available in a particular year and this was a concern to some processors.

"…we try and keep our protein between 21 and 25% is kind of the target range."

"And you are going to see protein anywhere from 20% to 27% like we did in our plots, so you're going to average 23%. You build your processing plant around that."

"Generally, the peas we're bringing them are 23 to 25%. …the general grading factors don't affect the protein quality so we can use feed and forage peas as well."

"I think that facility has been relying on casting the net and getting the farmers that have gotten lucky and gotten the higher protein and if it is not there, then we have to muddle through it. Fractionate whatever we can get our hands on. …in years when it is lower, we definitely struggle to make sure that we have enough wiggle room to meet that with our buyers which are typically 6-to-12-month supply contracts which means we need a stable supply over a long period of time. It is a challenge for us."

Processors were asked if they contracted for peas directly with producers. Almost all processors indicated they do contract at least some of their peas directly with producers, generally within a 100-to-200-kilometer catchment area around the processing facility.

"We do buy production contracts and spot throughout the year. We're buying directly and we do production contracts, acreage contracts as well..."

"So, we tend to buy yellow peas within a 200-kilometer radius of the facility for the protein plant. If there's not much or if there's a crop problem, we would have to go outside of that."

"We'd have to contract to get 75% of our needs within 100 kilometers."

"We're about a hundred-mile radius around our facility."

"So, if you are at 15,000 to 20,000 tons of protein annually, you're looking at 85,000 to 100,000 tons of whole peas out of the field. We can draw that within an hour and a half of us."

In the interview and the survey processors were asked about premiums for protein levels and what that premium was. Not all processors paid a premium for protein levels and those that did indicated it was limited and varied depending on the availability of peas that met their protein requirements.

"Our facility in Saskatoon is willing to pay a 25 to 50 cent premium in the market at any given moment to get the protein levels we need. We are paying the premium if it is justified."

"We have done protein incentives where if it's on the driveway, it's 25 we'll give you 50 cents more per bushel."

"So, there's competition in the area. Generally, if we're buying in the area, we're all paying the same amount. Whoever sets the first buying, that's where you're at for that week."

"Again, we do pay a premium at our facility, but it is a finite amount of quantity, and it only really works and pencils out to a premium of $9 to 18 per metric ton, I mean it is only really worth it if you are within a 100 miles of the processing facility…"

The online survey asked respondents to indicate their willingness to pay for a pea that could consistently provide 27% protein. The responses ranged from a premium of 1-5% and 11-15%, for an additional 4% of protein content. This is consistent with the interview findings that while processors were interested in peas with higher protein, the price premiums offered to producers were limited.

When asked about the protein content of the pea ingredients they produced, it varied by processor depending on the process employed to extract the protein. Dry fractionators reported achieving between 50 and 65% protein content in their products while wet fractionators could achieve protein isolates of over 80% protein.

"Protein percent, let's say if it's 25, so multiply that by 2.2 with the most efficient air classification systems, and that should be your outbound protein. So, 25 inbound is 55% outbound."

"We are generally selling a 50 to 55% pea flour…"

"Generally, the peas we're bringing them are 23 to 25% and so our product going out is generally around 60% protein... I 'm not super familiar with the wet but it's probably 15 to 20% better."

"I would say that we extract over 80% of the starting protein in the pea. …we are 83% minimum (protein) on a dry weight basis for the isolates that we sell."

"you're looking to achieve an 85% purity on wet fractionation."

"...you have a 20% protein pea, they're only extracting 16%, I can get 20%, I can get a 100%."

Processing Technology

Respondents were asked about the protein extraction technology they employed and whether improving this technology was a current focus for processors. They were asked if the fractionation process and technology employed by companies in the sector was considered a source of competitive advantage. Most processors agreed that improving the processing technology was an important focus for the pea protein sector and that intellectual property related to processing was not generally shared within the industry because it could offer a market advantage. Many processors described themselves as continually evolving, innovating, and refining their processing of peas, often in response to an identified market need or request from a customer for new functional properties. Technology has been developed by the sector to address certain challenging attributes of peas including taste. Processors indicated they were using mechanical processes to remove the pea flavor. One processor described it as a means of adapting the environment, "layering on" more technology to make their products more valuable and create larger margins.

"That is exactly what is going on. Some companies have massive research and development divisions within themselves that are constantly being working on … How can we make it better? So, we can sell for a better price or get more efficient within our own operations to make more money and profit drives ingenuity and technology…. That is just business trying to figure out the best way to be profitable and more efficient."

"I think the real advancements are coming in the wet fractionation. That's where the R&D and the new thoughts are coming in."

"We started looking at fractionation in 2015. At that time … our facility was going to be very much focused on having the ability to manipulate all those functional properties. And nine years later, you see more and more that food manufacturers are developing proprietary ways of taking native protein and manipulating it for their specific purposes."

"People think that the protein tastes bitter and terrible because it is a pea. That is untrue. …the process that they have is actually damaging their proteins. It takes an hour and a half for it to go from the beginning of the flour all the way through to the dryer to be a protein. Mine's 21 minutes. Their initial step is 45 minutes. I'm 21 minutes from beginning to end. So, my protein is out of there. … so, they don't have a chance to oxidize. They don't have a chance to get angry. They're natural. We're in a natural state."

Market Environment

The processing sector was described as very competitive with processors competing both on price and product innovation for additional market share. Processors believe there is great potential to expand the pea protein food ingredient industry in Canada but the capital to do so is lacking. Covid and general economic factors including inflation and interest rates were considered contributors to the slower market growth and limited access to capital the industry faces. The capital cost to build anything of sufficient scale was described as a barrier to entry.

"We just need some equity financing to get it going. …covid kind of took markets down, and then investor confidence, a lot of money went into much safer investments for that period of time, and it's just starting to come back out of that."

"So, my big plant has 3 lines that will produce 8,000 metric tonnes each a year. So, 24,000 metric tonnes of pea protein. That customer would need one and a half lines just to serve that one 400-million-liter oat milk contract. …that's just one skew. Right now, we have over 3,000 skews asking for our protein. … But none of these guys will give me the money to do it."

"…if we want to have more processing, we don't need access to grants, we need access to capital."

One explanation offered for the current heightened competitiveness in the market was that consumer demand for plant-based foods has not grown as fast as anticipated resulting in excess industry capacity and lower profit margins for processors. The time horizon for a return on investment for a capital investment in the sector was considered longer relative to other venture capital opportunities available. This has made investors hesitant to provide the capital necessary to grow the processing capacity.

"You are developing for a market that is not growing as fast as we wanted it to in North America. It is still fine in Europe and price parity has been reached in a few countries as far as plant-based products versus normal meat products. I think that going to be the big wall that we are going to have to get through, especially in North America."

"…. So, it's still increasing. But it's just there's a dampening in that increase in growth if you will. But it's still the largest growing out of all the food categories."

"…so, the investment has to be a long-term vision, and not someone who's looking to come in and invest and flip their money into triple and be out in three years, like that's just not going to happen."

Respondents were very aware that domestic processing was a small industry compared to the much larger international pulse commodity market in Canada. They understood the commodity and value-added markets were closely linked. The multinational processors were involved in supplying commodity peas to international processors and talked about the influence of this market on prices

and the viability of the pulse industry in Canada. Respondents mentioned the current anti-dumping case against China and the effect it was having on the pea protein supply in Canada.

"Our yellow peas are considered a very cheap, inexpensive protein source for the global market. And it is almost completely price driven and we have had almost zero requests from buyers overseas for any protein minimum or any other quality requirements or standards at all except absolute price…Peas are still almost exclusively exported, only a small amount is being processed domestically so the main demand is export driven today"

"I can often buy peas cheaper from the market, the trade on the track than I can actually buy them from a farmer and process them myself. …Larger companies basically are using it as a commodity to trade positions and speculate…because of the speculation we had a price the other day where peas in China were cheaper than I'd buy them from a farmer which makes zero sense."

" *When you look at the fractionation industry in particular, they're kind of at the mercy of the market, in that they can't come with all the demands that maybe they want to. And we've seen that already with some of the chemical usage that they tried to put in front of growers and growers told them, you know thanks but no thanks. That's not what we're going to do. And so, there's some things that again with growth, I think we'll get there but today its more of the growers can control."*

"Whether or not pea acres increase, you're going to see the amount available for export drop to fill the domestic needs."

"Agricorp is in the process of building a wet fractionation plant but that's in Malaysia. ...there are some companies in Korea and Vietnam that are already on board for the product. ...we will supply that plant with Canadian peas."

Respondents were asked about challenges facing their industry. One challenge raised by all processors was the ability to remain competitive in the price sensitive food ingredient market. Price was described as a key factor for pea ingredient buyers and processors were very aware of the need to be price competitive, commenting that any additional cost resulting from purchasing new pea varieties or establishing certification programs could not be passed on to buyers but instead would have to absorbed by processors or producers. Processors believed operating costs were significantly higher in Canada compared with the U.S, creating an advantage for their U.S. competitors. To remain profitable companies are focusing on finding ways to keep the prices of their products down while increasing sales volumes through product innovations.

"My most expensive cost are my peas going in right, and the food manufacturers on the other end are pushing down on me, saying, oh, you can't cost (more), you know I can't then pass it on as easily as we think. I can't just raise my price, right?... I did this whole calculation. I'm like, it's going to cost you a tenth of one penny per liter (to add our protein) and that's too much money

for them. So, I'm looking all the way down at the end of the supply chain. …So, whatever I pay my farmers, I'm just going to take the hit on it right. I will just take the hit because I can't pass that on."

"Profitability is low, like you are talking low, it is single digit margins. So, until you get to the retail industry where the margins go twenty plus you try to make every penny you can through the processing because it, that is all you are going to get. So, we cannot just mark it up 20% and expect everybody to buy, like grocery stores."

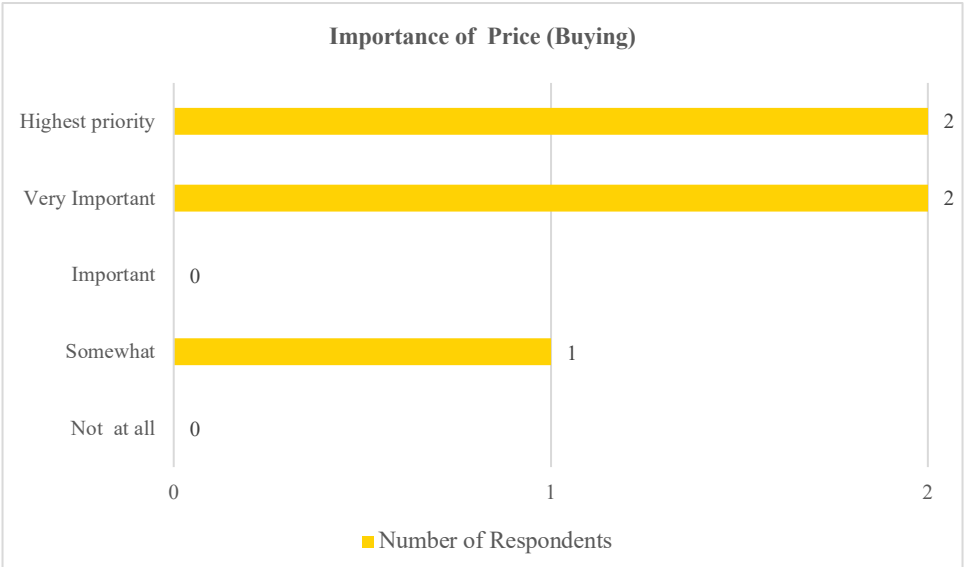
"We used to be able to get a price premium, pretty hard to now. Competition is pretty tough."

"…if we're bringing a new idea to a customer, that's always a question. Well, what would this cost? What's the increase in price compared to what you're selling us now? And is it good enough value for the benefit that it gives."

During the interview, several respondents described themselves as price takers, paying the market rate to get peas. The survey asked respondents to indicate the importance of price when sourcing and purchasing peas for processing. Four of five respondents to this question indicated it was either very important or the highest priority (**Figure 1**).

Figure 1: Importance of price when sourcing peas

For the products your company produces, what importance/priority do you place on price when sourcing peas to buy and process? Provide a rating from "not at all important" to "highest priority/importance".



Evolution of the high-value pea ingredient market

The structure of the industry was described as evolving, with the number of small independent processors declining, taken over by larger companies as the sector grows. The growing presence of the multi-nationals in the pulse processing sector is shaping the development of the industry and has put increased pressure on the independent processors who have limited resources to invest in the capital-intensive technology associated with wet and dry fractionation.

"I think, as an export company, just cleaning and shipping pulses, it's over built. ...I think if you were a small mom and pop operation, it would be difficult to sustain that because it used to be so specialized but now, with the big companies dealing with it, especially on red lentils, it's commoditized more. ...a lot of those facilities are still going but they've been absorbed by one of the bigger (facilities)."

"We didn't get into the pea protein game because we didn't feel it was very sustainable."

"So that's what Cargill and some of the big guys did to try to stop any new entrants into the market. They grandfathered themselves in …and made it all regulatory. So that's why I say the big guys control it. If you can't play inside that you're dead… You're not playing inside the big guy circle, so it doesn't really matter."

To remain competitive in the functional ingredient market, respondents were interested in improving the efficiency of their processing to reduce costs while growing sales to increase revenue and achieve the economies of scale that come from operating at higher volumes. Processors talked about the importance of cost-effective product and process innovations. The importance of continually finding new ways to add value and remain relevant in the food ingredient market was raised. Through this, processors hoped to create resilience within their company to withstand rising costs and growing competition in the sector.

"So, we have to be very cautious when we do innovation. If we want to come up with some kind of cutting-edge technology that's going to require a large investment on our end, then obviously we need to recoup that in the cost of the ingredient that we sell. And so, our customers need to be confident that the consumers will also help to recoup. And so, I think it's still quite sensitive right now."

"We're always trying to be more efficient, be more functional."

"I am concerned about wet fractionation right now, mainly because there's so much new technology coming down the pipeline… It uses an enormous amount of power, an enormous amount of water."

Respondents were asked to describe the innovation happening within their industry and where they felt the pea protein ingredient market was going. They were asked how plant breeding could support

the competitiveness of the Canadian processing sector. The varied responses to these questions signaled the heterogeneity in the sector and revealed the magnitude of product innovation and specialization that is occurring in response to market demand and the economic pressures currently faced by processors.

In the interviews respondents talked about the amount of product innovation and specialization occurring in the industry. As processors gain experience with peas, they are refining technology and processes to improve the desirable attributes of their pea products. This need to constantly innovate reflects both the competitiveness and the evolving market demands of the food industry. Innovation is fundamental to creating new products that allow processors to respond to changing market demands.

"If you're making a milk replacement or a butter replacement, or those types of things are going to have different characteristics… Everyone is somewhere a little bit different on the spectrum of organoleptic properties and functional properties, depending on what they're making. And so, for that reason I think that innovation is going to drive it."

"We want to get out of the scrum. If you're cleaning lentils and selling lentils just as lentils there's a lot of competition, so we found or what we've tried to do over the past 20 years is do something else, move up the value chain with our ingredients and we've had success there. We'll continue to keep trying to be innovative.... We're constantly looking at the market trying to figure out, okay what's next?"

" *"I really think there's always a focus on taste. There's always a focus on nutrition. But really, what's changing is where the market segment is focusing."*

The very competitive nature of the industry has led processors to continually develop products that allow them to enter new markets. In an effort to expand market share dry fractionators look to increase protein levels to allow concentrates to compete in some applications as an alternative to isolates. With the same objective in mind, wet fractionators look to reduce the cost of producing isolates to enter markets currently dominated by concentrates. All processors look to innovate to provide new products that solve problems for food manufacturers, continually reformulating to offer affordable alternatives to other food ingredient choices available.

"Two ways to get a market. Either you develop a market, or you steal it from another market"

"So right now they use pea concentrate, so dry fractionated protein, 65 to 70% protein. They don't want it anymore. They want the isolate because the isolate binds, it gels. It does all these great things. They'll pay more money to have that."

Processors believe that pulses and peas are making inroads into the ingredient market because of their versatility as a food ingredient. For example, pea protein functions well in clear beverages and is

being used as an egg and dairy replacement in food manufacturing. The combination of improved technology and processing experience are making it possible for processors to expand the application of pea protein in the ingredient market.

"We sell some of our high-grade human fiber into the pet food industry and they use it as a mineral carrier. So, it carries minerals in their snacks for pets."

"…so maybe it is a proprietary emulsify enzyme treatment or a proprietary heat treatment that is specific to a ground beef replacement, which has different texture and emulsification requirements than it would be for making breakfast sausage or a deli meat replacement. Each of them has different functional properties that they need. And so, we are finding more and more that innovation is really allowing food manufacturers to dial it into specific products."

"The farmers are going to get the win when I can take the protein and put it into alternative dairy, alternative cheeses. Those are my high value products. So, when I can make the high value products that will trickle down."

"That's the beauty of peas and lentils. All the pulses are very functional."

Processors are customizing products to meet the needs of specific customers. As both processors and food manufacturers learn more about the functional properties of peas, the demand for new pea ingredients to add valued attributes to a finished product or replace another ingredient has grown. A change that some processors have observed as the industry expands and begins to mature is the number of product innovations that are initiated by existing customers. Requests to "solve" issues or problems for customers by developing new specialized ingredients to address a need. Manufacturers are often looking to reformulate products to make them more affordable but without any perceived value loss to the consumer. As food manufacturers gain knowledge and experience with the functionality of pea ingredients, they look to push this frontier to replace "problematic" ingredients, add value, and reduce cost for their clients. Compared with other filler ingredients, pulses as functional ingredients are perceived by consumers as healthy and adding value to the products that contain them.

"We're always trying to solve problems. So, somebody is trying to make something or do something. We try to give them the best solution for them."

"The other thing that makes us attractive compared to our competitors is our ability to innovate in our team. People like Jen and our scientists and ease of working with our team to find some of these solutions, and to really kind of creatively think up some of the innovative solutions that take their product to the next level."

"We try and make ourselves stick as with sustainability or this other stuff. Are you going to get any more money out of it? Probably, maybe you might get a little bit for a while, but you're going

to make yourself sticky, means they're going to keep working with you…you start growing with them a little bit on some projects together. …That's how innovation works is you got a problem you're trying to build something. We try because pulses are so functional, we end up doing a lot of troubleshooting."

"*…clean label is really important to consumers. …that comes back to the ingredient manufacturer. So how do we take out, say methyl cellulose in a plant-based burger? How do we make a clean label milk alternative that doesn't have any hydrocolloids for suspension to overcome some solubility issues that plant-proteins have."*

Affordability is currently an important driver of reformulation and the development of new products in the food industry. Pulse ingredients have been perceived as more costly relative to the ingredients they can replace such as eggs or dairy. However, one processor pointed out that recent price inflation on eggs and dairy has made pulse ingredients more competitive and a cost-effective alternative to these traditional ingredients. This in combination with being non-GMO and a lower carbon food source, has opened new opportunities for pulse ingredients.

"As food manufacturers are innovating with different types of ingredients, I definitely think the affordability is becoming closer to parity to that of say dairy or meat type products, and I think it has to right, the consumer is requiring that of the industry and so we need to find ways to continue to allow that to happen."

One processor observed that while consumers are used to ingredient substitutions by food manufacturers to save money, what is somewhat unique about pea ingredients is the consumer perception of peas as not a filler but a healthy alternative. The image of pulses as "healthy" is allowing inroads into ingredient markets and thought by some to be creating a competitive advantage for peas as the replacement ingredient of choice relative to alternatives such as wheat flour or corn starch. Increasing affordability is usually at odds with increasing value in the food sector so as technology evolves and experience processing peas increases, the high-protein pea ingredient market has the potential to expand.

The interviews revealed that processors are also focused on product innovation related to the other elements of the pea including fiber and starch, reflecting their desire to get maximum value out of the entire pea. Getting value out of these by-products was considered key to remaining competitive. Many processors are utilizing the starch and fiber in their own products or selling them as ingredients to other food manufacturers. Processors talked about this from a sustainability perspective, but this also reflected an identified need to obtain the greatest return from processing.

"We want to minimize the amount of waste that we generate and maximize how we valorize each stream."

"All of our peas, the whole pea gets used."

"…there is a company in Calgary where they are taking starch with some protein in it and turning that starch into protein…say 65% starch content into 60 to 65% protein content. …it is low cost because they are buying the cheaper starch product like starch concentrate or starch flour and making a more expensive product with turning it into protein."

"Our starch that we get out of our process. We've tested with dairies because our process is different and the dairies milk production went up 17%, and they've had to use less protein enablers because their bodies make more protein."

The growing market demand for pea fiber ingredients was identified by several respondents as an important future opportunity for pea processors.

"…protein levels are a huge concern for North America. I think we all eat plenty of protein and is quite varied, so no one's suffering because of it. I think it's for sure going to be the next wave, and people are pointing out that we are in fact, not eating the recommended levels of fiber and a lot of companies are investing in that right now. We have a pretty hardy portfolio of fibers available for different applications, and it's because we recognize that this is going to be the next topic that everyone's talking about."

"The whole world is getting enough protein. They're not getting enough fiber.... Fiber is a train that is coming into the station. ...If you taste our pea fiber, there's no taste to it because it's clean, all the peas cleaned out of it."

"The way we are splitting technology, the hulls come off and we're able to clean them up and we actually sell pea fiber that greater than 90% total dietary fiber.... if you 're extruding something and you're having trouble making your extrusion work, we just add pea fiber in."

"We also have a pelleting mill, so we are able to offer protein and starch powder and protein and starch pellets. So, there are a few different applications for that. The pellets are much easier to ship in a rail car so we can do large bulk shipments of the pellets to different customers in the U.S."

Discussions with processors suggest the plant protein ingredient market is evolving quickly, and food ingredient sector is already beginning to talk about the attributes of faba beans that offer an attractive plant-based protein alternative to peas `.

"...where we're seeing some issues is the root rot...A lot of growers that used to grow peas are not at all, and some of our dry areas, they can't for six or seven years because of that. So, what we are seeing is some switching to Faba beans because they're resistant to that. So that's why we're trying to figure out can we use Faba beans in the same way."

"We do produce faba bean isolate. We just launched it a few weeks ago and in fact, we do offer that at a slightly higher protein content in our faba bean isolate than we do our pea protein

isolate. …I think it's a huge possibility; you know in the ways that pea is used in so many different applications. And there are some other benefits to faba that we can't necessarily achieve with peas. And so, I really hope that consumers embrace Faba as much as they have peas so that we can expand on that offering."

"So, I know that a lot of research has gone into faba beans. They used to be so long (maturity) that they were difficult to grow in the prairies but now they've got varieties that mature within 100 days."

Market Priorities

High Protein Content

The development of pea varieties that offered a higher protein content was a major focus of the interview and participants were asked specifically about the desire for pea varieties that would provide more protein. In the interview respondents were asked to identify the attributes they consider most important when purchasing peas for processing and were specifically asked about required protein content. Additionally, respondents were asked what percentage of pea protein they were able to extract through processing and whether improving the extraction technology was a focus for the industry.

The interviews revealed that although all respondents could agree that more protein content was always welcome, it was not in fact the highest priority or primary concern for most processors interviewed when discussing the development of new pea varieties. Through the conversations with processors, a number of possible explanations for why increasing protein was not the highest priority were identified including a lack of demand from the market, price sensitivity in the market, the current industry focus on functionality and product innovation, concerns related to the attributes of existing high protein peas, and related to this, fear of the trade-offs and inevitable "losses" of desired attributes in new higher protein varieties that could adversely affect both processing and product development. Although more protein was not a general concern, the functionality of the protein, and related to this, the attributes of the protein within the pea, were of interest to processors.

Respondents were asked about the protein content requirements of their customers. While this varied somewhat depending on the products being sold and the buyer (ingredient processor, food manufacturer, wholesaler), most processors indicated that they were able to meet the protein content needs of their buyer with their current product offering and so it was not raised as a concern by buyers. Essentially there was no current market "pull" to increase the protein content of the pea flour, concentrates, and isolates that are available.

"Certainly, we should have some good varietals out there that producers can plant to get the protein out of…. But what is the total pea protein production right now? Maybe a couple

hundred thousand tons and 2.5 to 3 million tons of pea production, so that is still a small percentage of the market."

"We test the protein on all incoming peas, but it generally doesn't drop below 23%. I've never rejected a load of peas because the protein was too low."

"I don't think there's a need to go higher in protein content than we already offer."

"We'll buy higher protein varieties, but we buy pretty much any peas that we can get our hands on because our facility we're running about 400 metric tons of peas a week, so we like to keep a few months' supply in the pipeline."

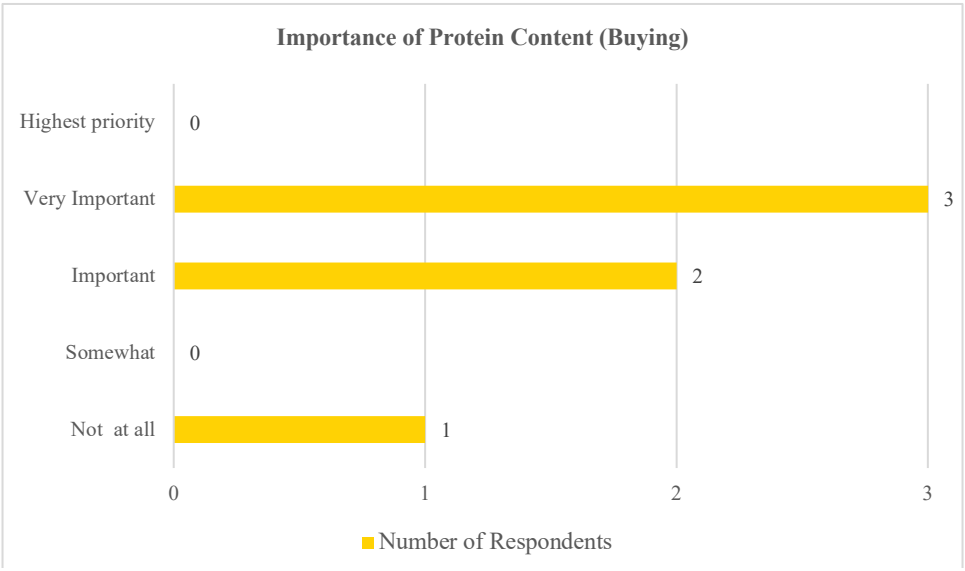
"As long as we're in the protein range we don't do a lot of protein segregation. … we try and keep our protein between 21 and 25%, is kind of the target range."

"We've seen some of these other varieties achieve upwards of 28, even 29 out in the field, …So there definitely is improvement in some of these varieties and for us, ideally, if the yields are there, we pay the conventional price and benefit. The economics are pretty tight in fractionating."

The survey asked respondents to indicate the importance of protein content when purchasing peas. Five respondents rated it as either important or very important, while one respondent indicated it was not important at all (**Figure 2**). The high ratings are consistent with the importance of protein for producing pea protein ingredients while the rating of not at all important may reflect processors comments that the peas available are meeting their minimum protein requirements and therefore not something considered a priority or concern when sourcing peas.

Figure 2: Importance of protein content when sourcing peas

For the products your company produces, what importance/priority do you place on protein content when sourcing peas to buy and process? Provide a rating from "not at all important" to "highest priority/importance".



The competitive nature of the market and price sensitivity of the food industry was raised repeatedly by processors throughout the interviews. Buyers were often described as highly sensitive to any price increases in the pea protein ingredients they are purchasing from processors. This led processors to believe that at least in the current market environment, their customers would not be willing to pay more for a product with higher protein content.

"Protein is a big thing…but like everything else, it is hard to get paid for it."

"…generally speaking, I would say at least today none of the end users are willing to truly willing to pay the premiums to justify those niche programs. …whether it is this protein conversation, or any other attribute. I think this market isn't quite there with being willing to put the money in front of people to actually justify all those things."

"For exports, there is 100% no protein requirements at all. …price is simply the main driving factor. It just follows the standard number 2 grade pea."

"But at the moment there's no premium being paid on the conventional market side."

As already discussed, one of the outcomes of the interviews was an understanding of just how competitive the pea protein market is, and the important role that technology is playing in allowing companies to improve their efficiency, reduce their costs, and improve and differentiate their product lines to create a competitive advantage within the sector. Interviews revealed that to lower operating costs and improve product quality, processors have been improving their technology and processes to

try to increase the amount of protein they can extract from the pea. Separating the protein from the starch was key because the more protein that can be utilized the more competitive the processor can be in the marketplace.

"…I'm coaxing that protein to come out, and it comes out, and then everything left over starch and fiber, I can take a 100% out. Everybody else, they have to take that starch and fiber out and try to get that protein to release from that starch and fiber. So, the reason why many want to do a higher protein is because …you have a 20% protein pea, they're only extracting 16%, I can get 20%, I can get a 100%."

"And so having protein go into the food grade pea protein isolate that we sell is a high priority versus it going into a side stream that may have lower value and go to animal feed… So, we are constantly monitoring the process to make sure that the individual components are being separated and going into the highest valued stream that they can go into."

Developing proprietary technologies and processes can create a competitive advantage not only in pricing but also in terms of the functionality of the pea ingredients produced. This is market driven with customers asking for specialized ingredients that serve a specific function and can replace other less desirable or higher priced ingredients within their products. The current focus on functionality and efficiencies is requiring processors to better utilize the protein within existing varieties.

"But really from a protein standpoint, how can we almost mix and match the individual proteins to get the right profile to deliver a certain function."

As IP is developed by individual companies, and product offerings become more specialized to meet the functional needs of specific buyers and expanding product applications, the nature of the protein within the pea has become of greater interest to processors. Processors are beginning to ask not only if plant breeders can increase the protein content but more specifically what proteins are being increased. The proteins that will benefit a particular processor depend on the processing technology being applied and the products that the processor is trying to create, and this changes as the market evolves.

"I think it could, depending on what protein fraction is enriched. So, if it were higher enzymes or higher small molecular weight proteins that get fractionated off during certain types of processes. And again, this would depend on the type of extraction process being used, then it would be of less benefit to us then if it were to be if you were enriching the protein group that we collect in our product."

Respondents to the survey were asked about the significance of pea protein quality (**Figure 3**) and functionality (**Figure 4**) when buying peas. They were also asked about the importance of micronutrients (**Figure 5**). Amongst the six respondents the importance ratings were varied for all three attributes. This likely reflects the heterogeneity of the products that processors are producing.

Protein quality and functionality each received only one rating of highest priority/importance and one of not at all important. Micronutrients did not receive the highest importance rating and was rated by one respondent as not at all important. The rating of not at all important may signal that processors are finding the peas available in the market meet their requirements and so the attributes are "not important" in the purchase decision as opposed to indicating the attributes do not matter to processors.

Figure 3: Importance of protein quality when sourcing peas

For the products your company produces, what importance/priority do you place on protein quality (amino acid profile and digestibility) when sourcing peas to buy and process? Provide a rating from "not at all important" to "highest priority/importance"

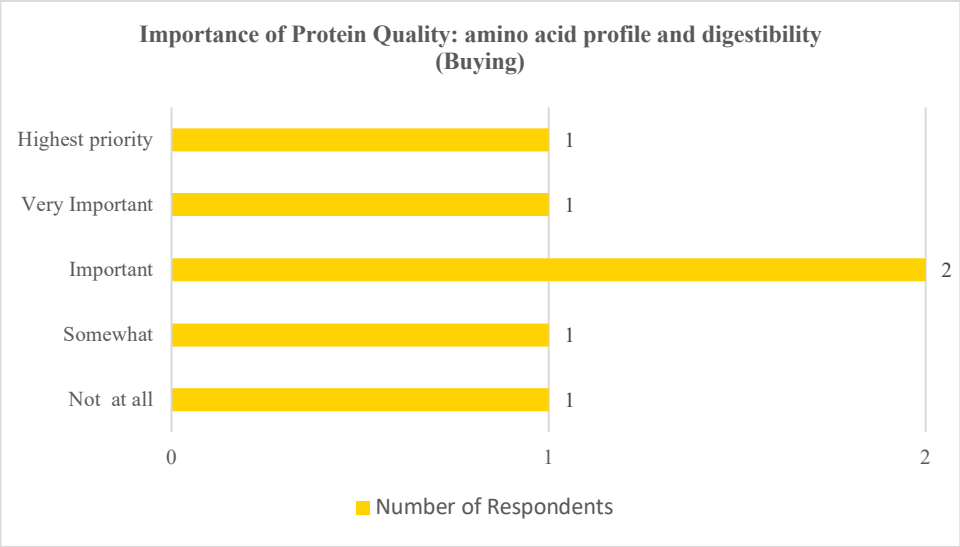


Figure 4: Importance of protein functionality when sourcing peas

For the products your company produces, what importance/priority do you place on protein functionality (viscosity, gelation, fat and water absorption, solubility) when sourcing peas to buy and process? Provide a rating from "not at all important" to "highest priority/importance"

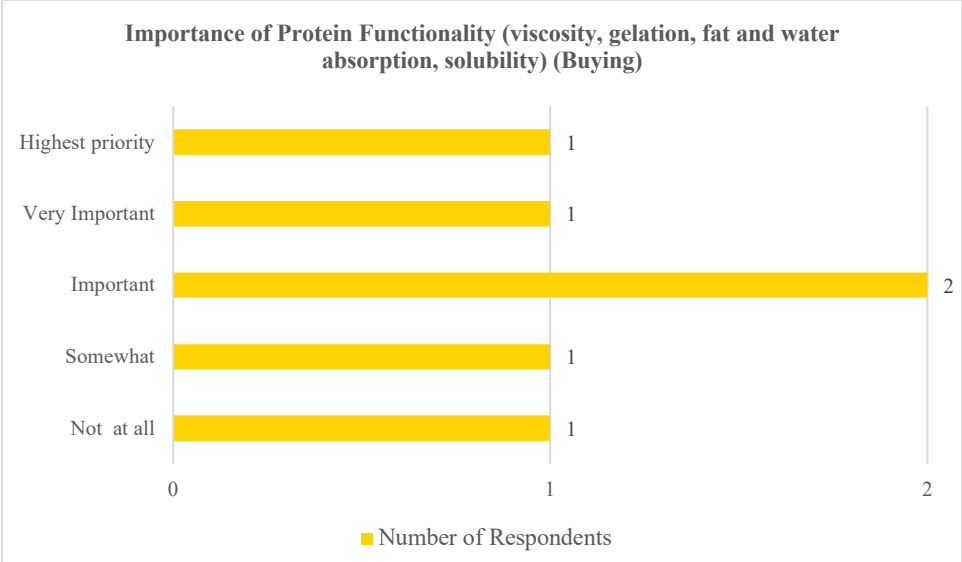
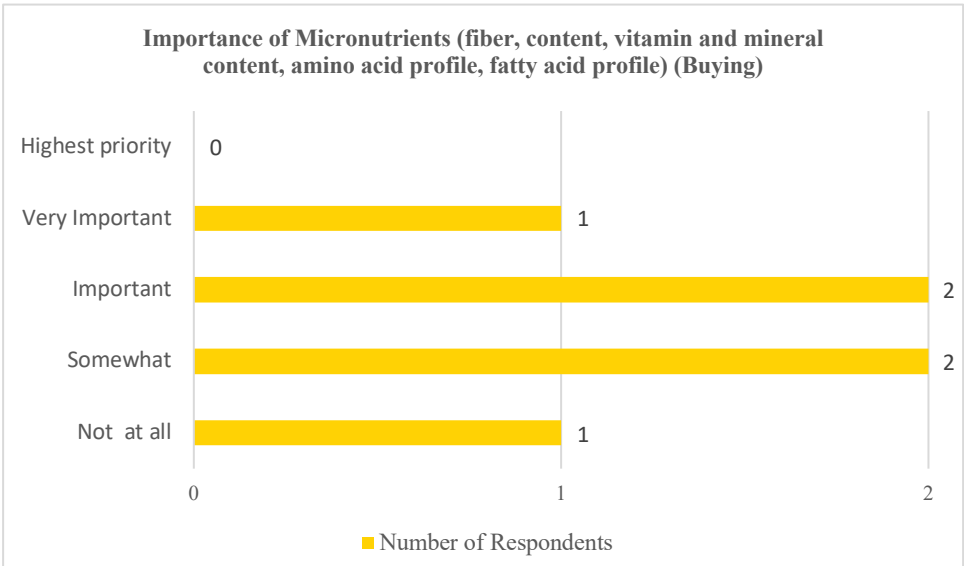


Figure 5: Importance of micronutrients when sourcing peas

For the products your company produces, what importance/priority do you place on micronutrients (fiber content, vitamin and mineral content, amino acid profile, fatty acid profile) when sourcing peas to buy and process? Provide a rating from "not at all important" to "highest priority/importance"



Dry fractionators acknowledged that there were limitations in terms of their ability to use technology to increase protein extraction from the pea, and these processors were more likely to indicate increasing protein content was a priority for future variety development.

"You're on the right course looking at protein. Why wouldn't we grow more protein if we can get more protein in our peas?"

"I have heard other dry mills cannot get up to 55%. I think over time with experience and of course technology, there have been some improvements, but I think there is only so much protein you can get out of a pea regardless of the tech innovation. Plus, you are still subject to year-to-year variations in the protein content."

Processors' experience with high protein varieties has led to a heightened awareness that improving specific attributes in breeding can result in compromises in terms of the other attributes the seed offers. There was concern over the possible trade-offs that were made in creating higher protein peas, either in terms of the loss of desired attributes or the creation of undesirable characteristics that negatively affected either the processing or product quality.

"What are we replacing to increase protein? Are we increasing the starch? Are we increasing the fiber? Are we increasing the sugar? Because whatever that is, I's telling you right now creates a different story. … Our process is different."

"By changing the percentage of protein versus starch and fiber, it changes my wet fractionation process. It changes the way it acts. So, we are changing the genetics of that pea, therefore it's changing the way that the proteins will release."

There were several processors that raised concerns with the attributes of existing high protein pea varieties. One repeated concern was the yield drag that was experienced with some new high protein varieties. Most felt the price premium received for the higher protein content did not offset the loss in yield for producers and so these varieties were not a viable alternative for the processing sector given buyers were not asking or paying for higher protein.

"At this point there's zero varietal preference being expressed by the buyers."

"*Utter catastrophe were the words they used on the higher protein peas, utter catastrophe on how they germinated, how they handled in the storage bin. So that's the other thing. The starch and fiber create a strength in that pea for storage. When we had a higher protein pea…they didn't handle moisture. They didn't handle storage conditions properly."*

"If you have a 30% (protein) pea, theoretically you should be able to produce a 66% protein concentrate, although I have never seen it without production adjustments. You can get 60, but

you are going to have very low yield, and a lot of your protein is going to end up going to the starch side. ...it runs a 2.2 conversion. At 30 they do not seem to get 66% unless they get a 14% yield, and you should be getting a 25 to 28% yield. I do not know if the protein in the high protein varieties is as accessible with air classification, it is odd…"

Gene Editing

Processors were asked to offer an opinion on using gene editing in plant breeding to address specific pea attributes. The recent use of CRISPR by Israeli Plantae Biosciences to remove the bitter taste from yellow peas (Watson, 2023) was offered as an example of how gene editing was already being used. The willingness of the plant-based food sector to adopt gene editing technology to achieve highly desirable attributes related to sustainability and palatability and production issues was discussed with interview participants.

Processors were generally supportive of what gene editing could do to address both production and functional attributes in peas. They understood the value for producers and the industry overall in addressing production issues such as root rot and drought resistance, as these were contributing to yield variability and affecting profitability for the entire supply chain. While overall respondents acknowledged the value of gene editing in achieving advancements in plant breeding, all raised concerns about ultimate consumer acceptance of the technology. Issues raised when discussing gene editing included the implications for the image of pulses, segregation of gene-edited varieties, regulatory considerations, as well as the implications for the commodity markets and international trade of pulses. While a few respondents were unsure whether this was something the industry would support, the majority believed that introducing gene editing at this time could potentially be detrimental to the food ingredient market and entire pulse industry.

"*My comments on gene editing; I think it is one of the greatest things to ever come around. We were working with a gene editing company as well, to produce varieties that have more of the traits that we would pay premiums for, so yes to gene editing, and it is separate from GMO… I think we have lost at least 10 to 15 years because of the reaction to GMOs in the advancement of farming and it almost happened with gene editing. So far, it is not classed in the same horrible, horrible light the GMOs are. With gene editing you can get rid of the bitter taste that ends up in the protein and not as much in the starch. There is lots of starting places where you can go."*

"I think in general; it could be game changing for the industry."

"I personally don't have an issue with it. And I think it's probably a good way to go…"

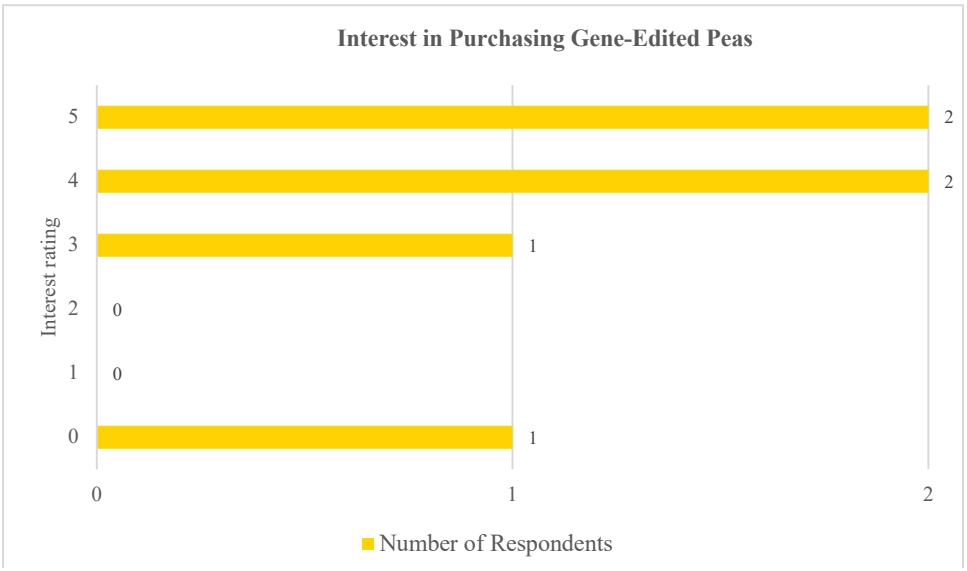
"I mean certainly from a practical standpoint there is a lot of technology there that is pretty exciting and I am sure there are lots of practical applications for it."

"We might be more inclined to say this is not as important if we could be non-GMO and have some advantages with speeding up mother nature as you say."

The survey data collected supported the interview findings that in general respondents were in favor of gene editing to improve attributes of value to processors (**Figure 6**).

Figure 6: Interest in purchasing gene-edited peas

On a scale of 0 to 5, with 0 being not at all interested and 5 being very interested, would your company be interested in purchasing gene-edited peas if this technology was used to improve attributes of value to you as a processor?



When asked about consumer acceptance of gene editing some processors anticipated a negative response from consumers and in turn negative implications for the pea ingredient market, while others were unsure how consumers might react and talked about a need to proceed with caution, advocating for significant education and consumer research before adopting this technology. When asked about consumer understanding of gene editing technology, many felt they did not distinguish it from GMO.

"Optics wise, I guess how its presented …I'm 100% for it but I don't know how it would be perceived in the public."

"I think it also would depend on what consumers are going to think of this as well. Are they going to be willing to accept this. Soy is sometimes good, sometimes bad, people accept it, or they won't."

"It might be advantage to us as long as the consumer is okay with it."

"At the end of the day I think it's all about education. And that is the challenge in today's world."

Several processors raised concern regarding the implications of introducing gene editing for the image of the industry. They saw the current consumer understanding of pulses as non-GMO as an advantage over other plant-based food ingredients. The words "natural," "clean" and "healthy" were used to describe pulses.

"Consumers now are wanting more clean labels and more minimally processed plant-based foods, and I feel bad for plant-based foods because they have us on such a pedestal that no other food has to stand up to, like beef doesn't, dairy doesn't..."

"Again, with Roquette, sustainability and sort of all-natural processing that we're very proud of right now, if something like that fits in with sort of our values and what we necessarily stand for."

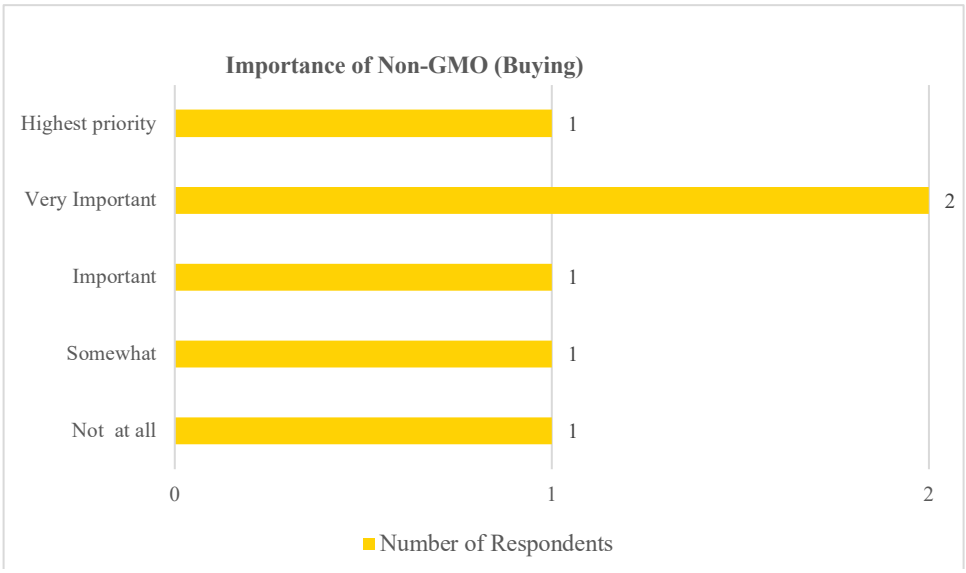
"Canada has no genetically modified peas and that's something that we can always point to without any reservation and know with confidence there's no genetically modified peas. Is gene editing going to be considered that, right?"

"I hope they don't get involved with gene editing in the pulses because that's one of the things they're non-GMO. It would be great if we can keep it that way. ...That would be a negative on our market."

The survey asked respondents to indicate the importance of non-GMO when purchasing peas for processing. The importance ratings by respondents varied (**Figure 7**). It may be that since all peas are currently non-GMO, the rating of "not important" simply indicates this attribute was not a consideration in the sourcing and purchasing decision. Conversely the rating of important and of highest importance reflects the priority processors place on purchasing non-GMO peas.

Figure 7: Importance of non-GMO when sourcing peas

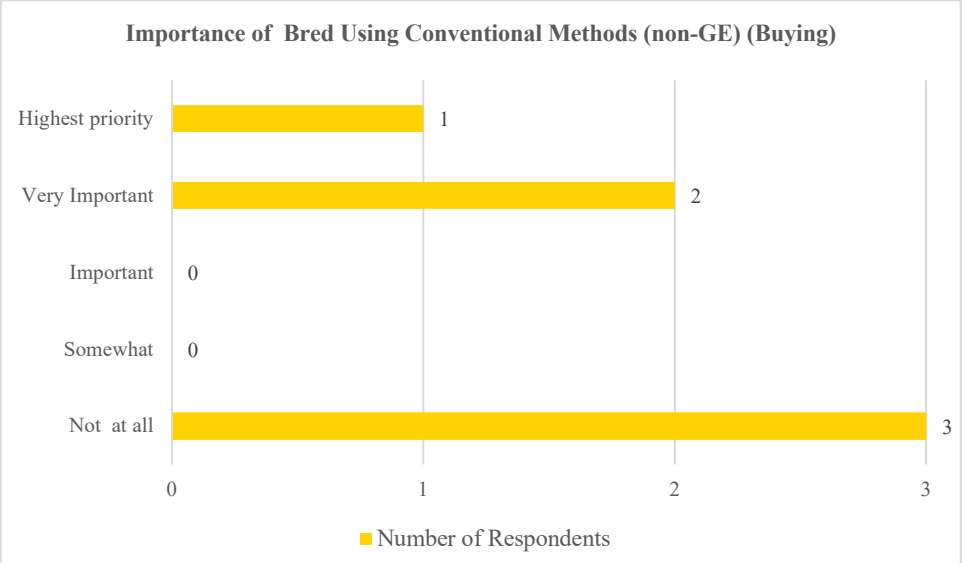
For the products your company produces, what importance/priority do you place on non-GMO when sourcing peas to buy and process? Provide a rating from "not at all important" to "highest priority/importance"



Survey respondents were asked a similar question about the importance of purchasing peas bred using conventional methods (non-GE). The responses to this question were more polar (**Figure 8**) with three respondents indicating it was not at all important and three respondents rating it either very important or of the highest priority. This may again reflect that some processors identified conventional bred as an assumed attribute of any peas they might purchase and so not an important consideration when purchasing while others answered the question to signal the importance to them of purchasing peas bred using conventional methods.

Figure 8: Importance of bred using conventional methods (non-GE) when sourcing peas

For the products your company produces, what importance/priority do you place on bred using conventional methods (non-GE) when sourcing peas to buy and process? Provide a rating from "not at all important" to "highest priority/importance"



The survey also asked respondents to rate the importance of non-GMO and bred using conventional methods as priorities for plant breeding. Overall non-GMO was given a relatively high importance rating by four of the six respondence. The importance of being bred using conventional methods was evenly split between being very/highly important and not at all important. This split may indicate that some respondents answered based on their support for gene editing in plant breeding while others answered based on concerns related to the possible negative market implications if gene editing were to be used.

The Implications of gene editing for accessing international pulse ingredient food markets and the larger Canadian commodity export market were raised. Several processors felt the use of gene editing could end up being a trade barrier for commodity sales which make up most of the market for Canadian peas. They cautioned discussing the implications for the processing sector in isolation of the larger commodity export market.

"It is an absolute issue for us as an industry. Is the Chinese government, I mean that is the largest market, other governments going to allow these gene-edited varietals into their marketplace. Again, and are they able to test for them, I am not sure, that is a whole different thing but yes, it is a concern. Even the thought of that being in the industry can create issues."

"Yeah, I mean I guess you have to look at it from a current market perspective versus maybe where we get to. But current market perspective, you want to be non-GMO, 100%. That's one of

the benefits of pulses. And it's very much a big thing in most of our destinations. I mean, if you went to GMO peas tomorrow, we'd have a lot of problems."

"We have to be careful about GMO because I am non-GMO certified. So, if we start doing genetic testing, I can't sell any of it into Europe. I'm done right. So that's also a concern of mine. … Canada is not the destination for our protein. We don't have enough people here. It's Europe. It's Asia. It's like South Korea that wants all my protein. They're going to ban soy protein. Japan's going to actually ban soy protein."

The questions of whether it was possible to test for gene editing and if it would be possible to segregate gene-edited products were brought up in several interviews. The metaphor of "pandora's box" was introduced and discussed. Once released, without knowing fully the response of the market, what were the potential negative implications for the industry? Concern was raised that even gene-edited varieties being available in the market could have implications for the entire pulse industry. Several participants raised the cautionary tale of the implications for the Canadian flax industry when Triffid flax was introduced and shut down exports of the crop to the EU (CBC News, 2010).

"And even if there were GMO varieties in production that would be a red flag. We're talking about a mustard right now. We're talking about that or have talked about that on peas and lentils for a while. Again, long term, maybe we have to go there. We'll see what that means, but today that is not what the consumer wants. They want non-GMO; they want gluten free."

"Unfortunately, I've had the privilege of being a part of the Triffid flax situation. That is exactly that, where something that wasn't even supposed to be out there did not get in there. And that's why we've lost effectively the European market. And so, it's a cautionary tale I guess, to our industry as well as yours …developing something for pea protein is different than developing a GMO variety…But I think it's better to get those hurdles in front of you ahead of time then figure that out after the fact and then have all the problems and potentially bad press and repercussions. So, I think again getting out ahead of it and speaking to it and understand what people want and need… is important."

"…obviously that kind of stuff makes us pretty scared considering what we have seen in the past. Different things like when the Triffid flax came out 15 years ago and what that did to the market. How we had to deal with that from the buyers overseas."

"I just look at what happened to flaxseed, and what it did to the market. And you know that was 20 years ago… just about killed the flax market in Canada. …so, is the win worth the loss? That's what you've got to decide."

"Look what happened with Canola. Even if you say you're using non-GMO Canola, the whole world thinks Canola is GMO. So, I personally would not like to see that happen to our pulse crops."

While participants understood that the Canadian regulatory environment distinguished between GMO and gene editing, some were also aware that certain key export markets did not necessarily share this distinction. The concern was raised that regulatory environments both domestically and internationally were not stable but rather shifting over time. What was permissible now, may not be in the future, and these regulations did not necessarily follow science but rather political and public will. One respondent provided the example of how testing for MRLs has evolved to allow for detection of smaller amounts of chemical residue, leading to regulatory changes to reduce the acceptable amounts of residue in some export markets based simply on consumer perception and fear rather than on the scientific evidence of harmful levels.

"If we start going down the gene-edited road and we haven't done the pre-work for acceptance. They'll just ban us."

"It is a situation of, does the definition change or perception of the definition change … anything related to GMO is no by today's definition. … My concern is that the definitions change because of the perception…just look at this whole chemical residue situation globally. …when you are talking about parts per billion and parts per trillion, like the testing…has changed. …Is it harmful at the level of testing that we're talking about to consume a product. No, it's not harmful at all."

Climate-Smart Certification

Processors were asked about their interest in a climate-smart certification program for their products and their thoughts on developing an industry-wide framework and set of standards for a certification program. Concerns and barriers to the development of an industry program and whether there was market value in such a program were also discussed during the interview. In general, processors agreed that a sustainability initiative was a good idea but that a climate-smart certification program was an idea whose time had not yet come. Some respondents saw benefits for the industry from a climate-smart program and a few thought farmers might benefit when marketing their product, most agreed that their buyers were not asking for this certification and would not be willing to absorb the cost of such a program through an increase in the price of pea ingredients. While there was general agreement that industry standards would be needed for a program to be feasible, most believed getting consensus on the definitions and standards necessary to develop such a program was a significant barrier. Several processors raised concern about the administrative burden of another certification program. Participants were asked about the MRV framework that Protein Industry Canada (PIC) was looking to develop for the industry, but most respondents were not familiar with this initiative and did not have any insights except to say that perhaps PIC might be in a unique position to develop national standards for the protein industry.

Most processors interviewed indicated that they had some interest in, or had taken steps to develop, sustainability initiatives within their company. Many saw the benefit in such a designation as a

potential competitive advantage even if they did not necessarily think it had market value in the form of a price premium. Several indicated they felt it might eventually be something the industry would support but that for now, they were focusing on specific environmental and sustainability projects internally.

"…peas have a good reputation worldwide, especially outside of Canada because of our zero-till or minimum till farming. Farmers are not going to run over their fields any more than they have to and burn fuel. So, it is good for the farmer, it is good for the industry, it is good for the environment. Yes, we would be interested in any of those types of certifications."

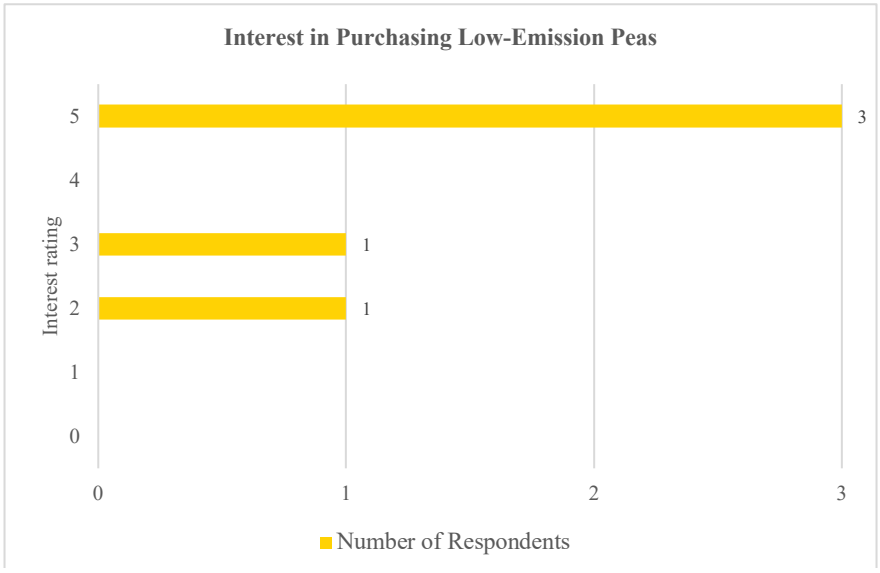
"I think that would be amazing. Like a 100%. I would love to see something where it's coordinated with the U.S. So that all of a sudden there isn't a U.S. system and a Canadian system and we're paying $2,000 in each country. But I would love to see that, I think that would be a huge, huge step….as long as the consumer is brought into the process and buys into it. If they don't buy into it, then it's not worth anything."

"Yes, we are developing that. We actually have a new division to our head office in Singapore, a sustainability and climate action division that started within the last year. So, it's something that new for us but it's definitely growing, moving that way."

The survey asked processors if they would be interested in purchasing low emission peas. Of the five respondents, three indicated they would be very interested in purchasing low emission peas (**Figure 9**). This is consistent with the findings of the interview, with participants indicating their company had an interest in ESG and sustainable practices. Respondents were not asked about their willingness to pay a premium for peas with this certification.

Figure 9: Interest in purchasing low emission peas

On a scale from 0 to 5 with 0 being not at all interested and 5 being very interested, would your company be interested in purchasing low emission peas (relative to a global or Canadian average) supported by detailed, farm-level emission data?



Some respondents indicated they had conversations with their customers about sustainability and ESG initiatives but there was a clear message from buyers they were still firmly focused on price and would not be interested in paying more for this type of designation. However, processors did not rule out the potential for a price premium in the future, although they felt there would need to be sufficient consumer pressure for that to happen.

"So, I think it's going to be a combination where companies like ours, and the companies buying from companies like ours, can pay a premium for what they want, but they don't care ultimately how it was grown as long as it meets their specs when they're selling it."

"But what I'm seeing in raising money and talking to the big guys… They are not putting their money where their mouth is. They have never asked me for any kind of clean certification. …So, chasing down that road is difficult because you're going to hear the noise that everybody cares, but when rubber hits the road, they don't care because it costs more money…. Careful with the noise, at the end of the day it's that cost per kg."

"…we definitely have that (ESG) as a conversation piece especially from the North American users, but as well as obviously the European users as well. That being said when you talk about putting pen to paper and paying for those things. They aren't there yet. There is a lot of talk but not a lot of action."

"Many of them have these mission statements to promote such things and to promote their company as being that, but at the end of the day none of them specifically require or even ask for anything like that."

"From the export perspective that would be great, you could give that to a buyer, here is a certificate of our handling, quality or safety, traceability, all these other things that we can give them, I mean are they going to pay for that? Extra? I mean probably not, peas are totally price driven, our biggest competitors are globally Russia, Ukraine, Australia, for these types of products. …I can't really see our customers wanting to pay a bunch more for it."

"...anything real concrete for the climate action on the contracting part hasn't come through yet, but I know it is coming. I just haven't seen what it's going to look like yet."

"I think there is definitely value in it and the ones that want it as cheap as possible and don't care about the quality, they will fight against that. But the ones that want that good quality, they're willing to pay for any efforts you make in that way."

The idea of developing an industry-wide program was discussed during the interview. There was general agreement that an industry initiative would be beneficial, and some felt essential if a program were to succeed.

"A lot of companies are talking about wanting to invest in the infrastructure in North America, and or Europe, but definitely North America so that they can drive that value chain and be able to make those claims and push all that through. Economically, I guess we'll see if it works."

"So, the more global or industry wide something is, the easier it is to implement and know what the roles are, as opposed to everybody having their own rules. So, I am a fan of it."

"On the sales side, I think taking the position that you are comparing one protein source against another…definitely has a lot of traction."

There was also agreement that getting the consensus necessary for an industry-wide program would be difficult because a consistent and agreed upon definition of terms like sustainable and climate-smart agriculture did not currently exist. Questions were raised about what and how it would be measured, and then how it would be validated. Such a system required an understanding of what type and forms of information and measurement were of interest and value to customers. Establishing quantitative measurements was considered a significant hurdle.

"We've got seven projects with different companies doing sustainability things from pollinator strips to intercropping... the problem is with sustainability; it's like everybody's got an idea about sustainability...And what are you comparing it to?"

Amongst those that supported the idea of industry standards there was some concern about the administrative and financial burden that it would bring for their individual companies. They talked of the many certifications and inspections they already undergo in a year and the cost associated with the regulations already in place. Several suggested that delivering the climate smart certification process within an existing certification program would be the most workable solution.

"The industry needs to demand it. You guys are pushing a wet noodle uphill, and they're not going to accept it right? There are just too many certifications already. So there, can you bolt it onto something right? If you can bolt it onto something …then I think you might have something."

While there was acknowledgement of the role producers would play in a certification program there was a lack of agreement on whether producers would benefit financially from such a program. One processor was aware of a producer who had been paid $55,000 for a sustainability program as part of a production contract with a major food manufacturer.

"Who are you trying to differentiate yourselves from? So are we trying to suggest that Canadian farmers are more climate conscious in their activities and trying to prove that objectively through scientific measurements that other farmers and other area of the world. I could see value in that. From a farm standpoint I don't see a lot of benefit in measuring it unless the purpose is to assert that we're doing it better than others."

"I think because it'll give greater market access, and maybe some better premiums. I think that will be passed on to the producer as well."

"…the agricultural commodity market can regulate itself, price wise and standards wise, but when you get into climate incentives or environmentally sustainable programs and carbon tax and everything else, the government oversees that. I think if a farmer is going beyond the call of duty and doing more than whatever that baseline ends up being, I think he should get rewarded through government incentives and programs just like companies cutting down on carbon emissions gets credit and so on. …the market cannot reward (the farmer) because the market is commodity oriented. It is not environmental."

"We felt we had to do something with sustainability. We're three years, this is the fourth year that we're doing some projects around sustainability with the growers, and the companies. Actually, we have companies that are paying the growers to do this stuff. They want the information…We're the bridge…we can put two and two together and make it happen."

It was suggested that this additional certification would eventually be simply a condition of market participation, and no additional premium would be offered.

"But they're (farmers) getting a lot of pressure, obviously, to use less chemical to do all the things, but could continue to produce a high value product that meets all the other requirements at the same time. You know, they're frustrated I would say, and what they're saying is hey fine! It this is what we have to do, that's what we have to do but pay me for it, and in their world …. they don't feel that they're being paid for it at all today. They're not getting that benefit. Now the response somewhat from the industry, I guess if you want to call it that, is their market access is the premium."

Several processors believed that producers were already doing much of what would be required for a climate-smart certification and that what would be required is documentation of those processes which had an administrative cost.

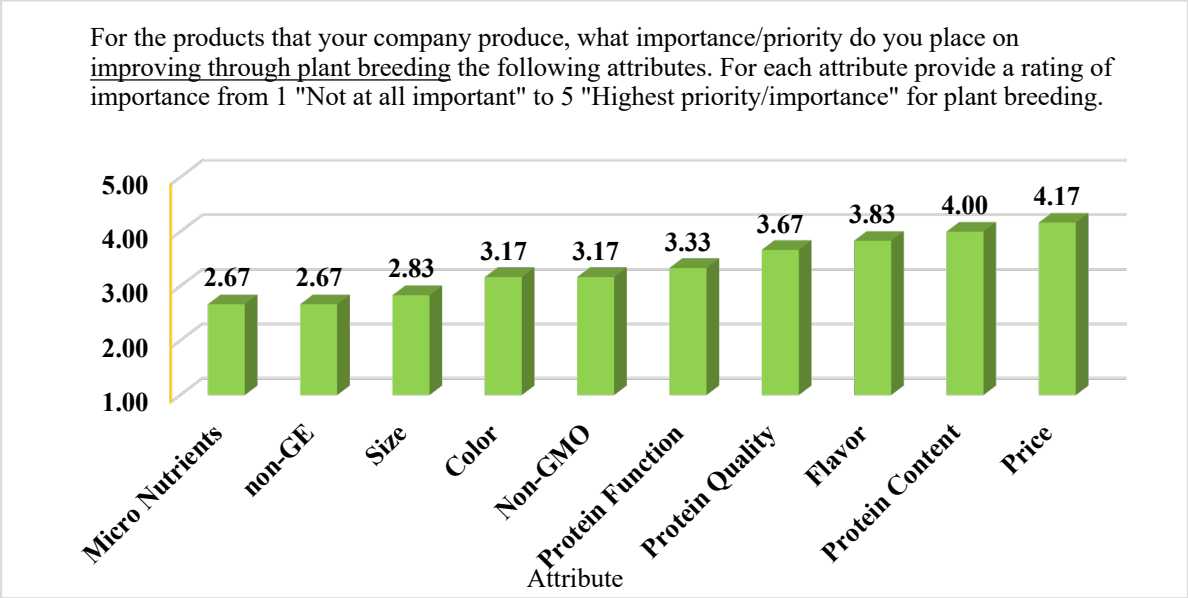
"Getting growers on board might be more difficult. There are a lot of forward-thinking growers but there's also a lot that this is the way I do it. And I'm not going to change kind of attitude. …I think there are probably a lot of growers that are already doing what they need to be doing. It's just a matter of record keeping …"

"it's a requirement of participating in the market, even as it is right now, before we really get into the full-fledged ESG environmental conversation in general."

Plant Breeding Priorities

Processors were asked several questions in the interview to ascertain what attributes they valued in current pea varieties and then what their priorities were for improving existing varieties as they looked to the future of the processing industry. To gather information on processors plant breeding priorities, respondents were asked about what attributes were most important when purchasing peas for processing, what constraints current varieties available posed for the processing sector and what attributes they believed plant breeders needed to focus on now to meet the future needs of the pulse food industry. Average ratings for the attributes evaluated are shown in **Figure 10**. Although the intention of the interview discussion of concerns with current varieties was to elucidate priorities for plant breeding, those comments are discussed to provide some insight into the attributes that processors value even if they are not necessarily the highest priority for improvement.

Figure 10: Average rating of importance of attributes for plant breeding



Concerns with Current Pea Varieties

Concerns with current varieties were focused on issues that affected the processing of peas including size, water absorption, and hull thickness. Taste was mentioned as an issue in existing pea varieties and identified by several processors as a priority for breeding as well. In general, the issue of consistency in the incoming raw material was a concern as this was related to the efficiency of processing. One respondent articulated this well.

"Consistency, I would say, in the composition of the incoming peas is another one, so that we can run our process consistently and not have to make changes based on variations of the incoming raw materials. Qualities of the peas, such as percentages of splits which we could lose as it goes over grates in our process."

A consistent size was desired for processing efficiency. While size was not described by all processors as a barrier to buying and processing peas, there was a consensus that different sizes required operational adjustments and segregation of peas.

" ***We want to size all the peas coming in, so they are consistent size for dehulling, because you have to dehull it before further processing to get the outside fiber off, so consistent size seed is very important, even though you don't hear companies talking about it. It is just easier in the cleaning process and the eventual process down the line. We selected varieties that we wanted that were consistent in size, that might vary from a 17-round whole to a 20-round whole, but not from a 13 to a 22 …I would love to see that in the seed guides. I do not think you see a size other than small, medium, large. What I would like to see is the variance within that variety from the***

plots. Did it range from a 12-round-hole up to 23, which would mean it is very inconsistent in size."

"Generally speaking, a larger seed is easier to dehull to remove the testa. And so, we get more efficiency that way."

"The uniform size is a major challenge. It's part of actually the competitive advantage for Canadian production into China in particular versus Russian origin, because there is a lot more variability in the shipments that they make. …So that's create challenges. That's from a splitting perspective from a fractionating perspective, more uniform. That can be the higher efficiency these operations run at. You know, the splitting efficiencies are significantly higher. So that's something that they want to see. And honestly, most years they're getting that from Canada. It's not that the varieties today are completely not conforming to that again. Some are better than others. If we can get even tighter on that, that's certainly going to be desirable... There is really nobody in the industry that wants variability in sizing."

"Size doesn't matter. In fact, we've run some trials with Faba beans and some different things so the equipment that we currently have does work on (other pulses)."

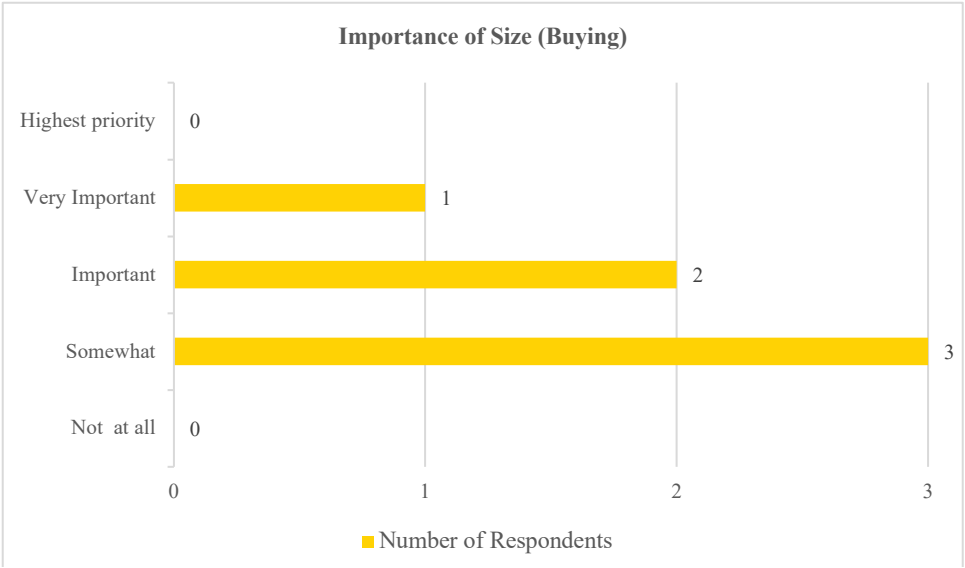
"Certainly, from an export standpoint we don't get any requests, they are going to be splitting and dehulling and processing them overseas, and we haven't heard any comments to that effect."

"Size isn't an issue...we like a medium size, too large isn't good, too small isn't good. ...different markets like different sizes and we just kind of match."

In the survey respondents were asked about the importance of size when purchasing peas for processing. The responses (**Figure 11**) were consistent with the comments made in the interviews that size was not of the highest priority and for only one respondent it was rated as very important. Three of the six respondents indicated it was somewhat important, supporting the interview findings that while consistent larger size was helpful for pea processing, it was not necessary.

Figure 11: Importance of size when sourcing peas

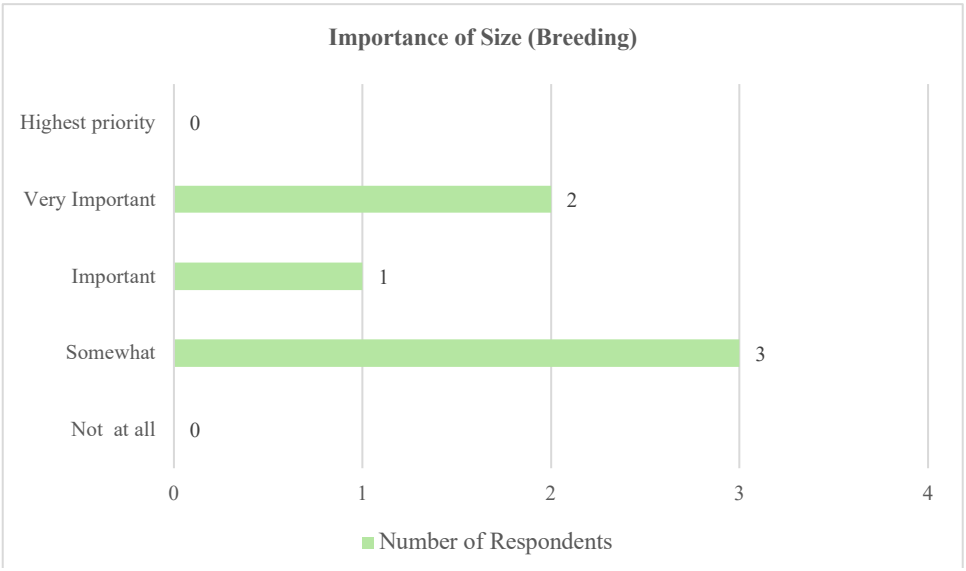
For the products your company produces, what importance/priority do you place on size when sourcing peas to buy and process? Provide a rating from "not at all important" to "highest priority/importance".



The survey also asked respondents about the importance of size as a priority for plant breeding. The results were similar to the importance when buying peas (**Figure 12**). Three of the six respondents rated it as somewhat important, consistent with what we heard during the interview that size was not a significant concern for processors.

Figure 12: Importance of improving size through plant breeding

For the products that your company produces, what importance/priority do you place on improving size through plant breeding? Provide a rating from "not at all important" to "highest priority/importance".



An initial step to processing the peas is dehulling. The ease with which the hull can be removed was important to processors from both an efficiency and functional perspective. Efficiency related to the time and effort required to dehull the peas and utility to the ability to remove the hull cleanly such that none of the usable pea was wasted.

"...I think when you talk about the fractionation of peas, its more about the functionality of things dehusking, dehulling. …These are very functional from a splitting efficiency, either reprocessing those peas that didn't get processed properly or they could become a by-product that they can't use again."

"Certainly, the efficiency at which we can de-hull dried peas and making sure that is as efficient and as exhaustive as it can be."

"Some of the varieties do have a little thicker, a little tougher skin. It doesn't prevent us from buying them, we just don't mix them with the other varieties because the settings for the machine would be different."

"We find that a lot of the water absorption might be variety but a lot of it is environmental. You take a drought year for example. Your hulls are a lot thicker in a drought year. The biggest thing for us is when we're splitting and dehulling is the moisture."

Taste was mentioned by several processors as something that limits the functionality of pea ingredients. As already discussed, the industry is developing technology to address this however

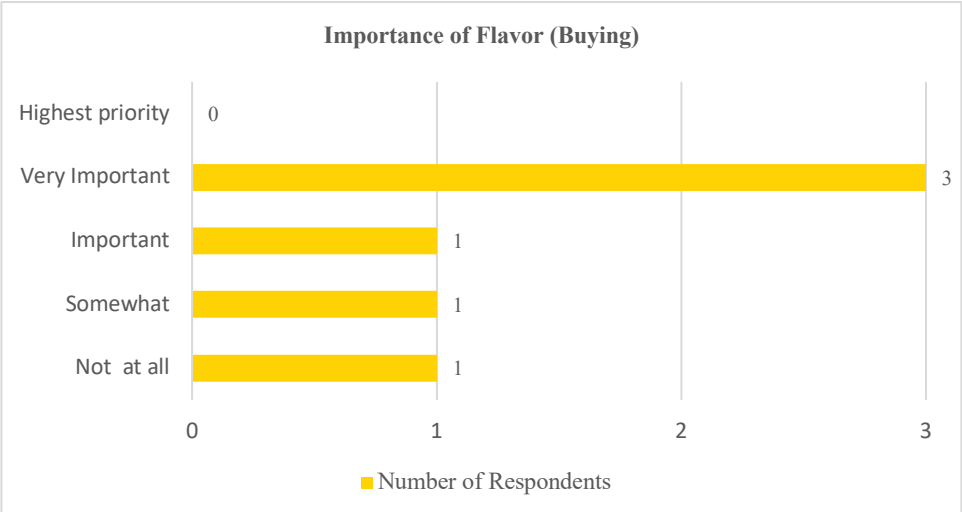
given the current focus of the sector on creating functional ingredients it may continue to be an ongoing issue raised by the market.

"So where is the industry going? It's growing, but it's going to stop if we don't make things taste better, because that is what everybody talks about, taste is king."

Respondents to the survey were asked about the importance they placed on flavor when purchasing peas for processing. Of the six respondents, half indicated it was very important, although no one indicated it was the highest priority (**Figure 13**). One respondent said it was not important at all. It is possible this processor has technology that addresses taste, or it is not an issue for the products currently produced.

Figure 13: Importance of flavor when sourcing peas

For the products your company produces, what importance/priority do you place on flavor when sourcing peas to buy and process? Provide a rating from "not at all important" to "highest priority/importance".



While most processors did not indicate a preference for specific varieties, one processor using new and proprietary processing technology for wet fractionation was able to identify preferences for specific varieties based on how they tolerated processing. Varietal differences in the processing of peas grown under drought conditions was mentioned by this processor. This may be a more significant issue moving forward as innovations in technology continue to occur.

"A droughted Carver pea I can remove the protein a 100%. No problem. A droughted Meadow pea, I cannot."

"If I take a New Delhi pea, and then the Lewochko, it's high in protein. When we go to crack it, it literally falls apart… You've now destroyed your ability to get a pure pea flour going into the process because bad in, bad out."

Priorities for Plant Breeding

While there were some consistent themes, the plant breeding priorities of processors were varied and likely reflect the diversity of processing technology being employed and the specialized nature of the products that processors are continually developing in response to the evolving demands of the food ingredient market. It is difficult to summarize these concerns, but they fit into categories related to operational issues including inputs, processing, product development, and competitive advantage.

Input concerns focused on the need to have a consistent amount and quality of peas to meet operational needs at an affordable price. Processors are very aware of their dependence on producers and the importance of ensuring that as a supplier producers remain viable. Yield was repeatedly mentioned as a priority for plant breeding. Processors wanted to ensure that breeding for specific traits did not result in yield drag and that new varieties continually improved yield to meet the anticipated rise in demand by the market. Processors understood that from the producer's perspective peas compete for seeded acres with other crops, so it was important that the per acre return be sufficient to persuade the producer to grow peas.

"If they're going to grow a special variety that has a higher protein, but the yield is lower, they're going to need a premium for sure."

"The focus in the past has been on, of course, yield and size of the pea. Those are probably two of the bigger attributes everybody has been trying to get you. You want a pea with a consistent size that yields well, so the farmers will grow it."

"I would love to see a carver pea that had a higher bushel per acre, was a more regenerative pea, was strong, shed the hull, stored really really well and I would pay more for that pea."

"Where I see you guys being able to really move the needle is giving these farmers two or three varieties, because you know one variety will get a disease at some point, but two or three varieties that are so hearty they can always depend on them. And Carver and McMurphy, they're great but aren't that hardy yet."

"…from a traditional export out of Vancouver perspective, yield is everything for us. To have a continual year over year growth in yield is still the main driver for us."

"…the protein is a big part of it, but as always yield and disease resistance are the two big ones that growers first always look at. What's the disease resistance and in this part of the world early maturity, the less days to maturity they can get, the more attractive it is to Saskatchewan and Alberta growers."

"They've developed the drought resistance in the canola …we need to keep doing the same things with our peas and lentils."

"The biggest hindrance that you have is your rotation. We've got 8 or 10 years on peas on a lot of rotation because of disease. The problem is if you solve the problem, then you're going to create another one."

"*Protein would be the main requirement, where the higher the protein, the more profitable your venture is. Second would be farmer economics, so you have to include yield there."*

"What if he (the farmer) could get 75 (bushels) in drought? Wow! What an amazing year. So, if he can do that, I am guaranteed supply. That's more important to me than sending me a 27% protein versus a 20% protein."

Processors raised several issues related to the processing of peas that they saw as a priority for plant breeding.

"If peas could go on dry land and not end up turning into a tiny rock, bb, pellets, because you can't dehull those very easily. You have to crush them."

"How thick is the hull, how easy it is to remove, is it 8% hull, Is it 10%? That is almost all loss when you are looking at the meat of the pea kernel. The farmer is subject to splitting deductions. If the hull content is not high enough to keep it from splitting when it hits the combine, it is not viable. Can you get it down to 5% hull, but with the hull adhered better, but which will make it harder to dehull? You know there is a lot of different attributes that you have to take into consideration and accept some that you do not want."

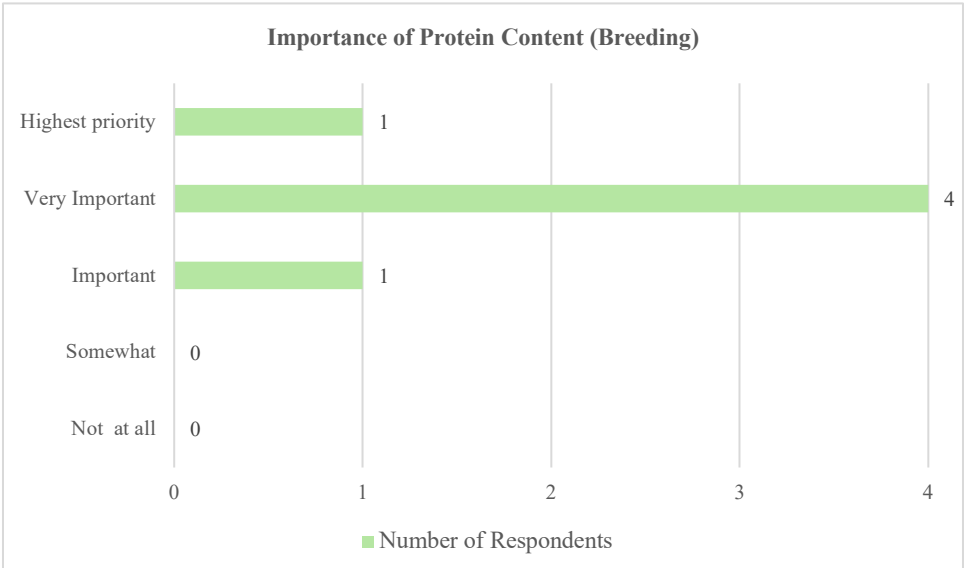
"A strong pea has strong protein in it. That is a pretty safe equation. So, when that pea is droughted out and it turns into this little pebble, it is all starch and fiber. It's not very good. So, what I'd ask them to focus on is taking the hardy ones that we have now and making them even more drought resistant or higher yields."

Although more protein content was not a top priority of most processors, the ability to separate it from other elements within the pea was identified as a processing issue by several respondents. Varieties that made it easier to extract more of the protein were of value to processors. Processors questioned whether breeding might be able to able to improve processing efficiency and make the protein more available by loosening the bond between protein and starch within the pea.

The survey asked respondents about the importance of protein content and all six respondents rated it as important or higher, with four of the six indicating it was very important (**Figure 14**). The question asks how important the attribute as a priority for improvement through plant breeding is. While the question was intended to ask about increasing the percentage of protein content, it is possible that respondents may have also interpreted improving content to be the actual qualities or attributes of the protein itself rather than the amount.

Figure 14: Importance of improving protein content through plant breeding

For the products that your company produces, what importance/priority do you place on improving protein content through plant breeding? Provide a rating from "not at all important" to "highest priority/importance".



Product development was dependent on the functional properties of the pea. The types and functional properties of the proteins in the pea were identified by processors as issues to be addressed by plant breeders. These requests reflect market demand for specific desired functions from pea ingredients but may also signal processors desire to improve the efficiency of their processing, reducing the time and processes required to extract the desired proteins from the pea.

"The ingredient companies take a native pea protein and then apply different technologies to it, whether it be an enzyme treatment or a heat treatment or a fermentation process or whatever it might be, to try and change the functionality or organoleptic of that protein, like the flavor, the mouth feel, the taste, and they're achieving that…"

"I hope that it gets better in the future, whether that's because technology becomes cheaper or we're able to do things at the breeding level that don't require such a large investment either on our side or on the food manufacturer side."

Breeding requests related to the protein in peas included more soluble protein, digestible protein, complete protein, quality of protein, and the ratio of the various types of proteins within the pea.

"Let's make it more soluble by gene editing. Let's make the pea plant produce more albumins than globulins and make it more digestible. Let's say if you can make a plant that's producing protein that's 90% digestible versus the 70% that we digest now… so you don't have to focus on protein being 25, if you can get a 20% pea that is 100% protein digestible to the average human."

"The soluble protein side of things is worth more money and has more applications than just producing one process, one protein from the pea."

"*I think, from the protein side, as we understand more how the protein profile influences its functionality, I think that we could then lean on the breeders, if possible, to produce peas with different ratios of the globulins that are present. I don't know if we are at that point right now to say I need a ratio of X to Y in order to get this particular functionality or you know A to Z to get a separate functionality. But I think that's kind of where the industry is moving towards. Pea protein, but it's a collection of proteins. It's not just one protein. And so, understanding how each one of those fractions of proteins contribute to its performance in an application. That's probably the biggest thing that comes to my mind from an R&D side in terms of how we could really leverage the breeding."*

"When you talk about soy versus say peas or others. One of the pro soy benefits is the Pdcast of one. So, for us to be able to say the same about peas would be great. …Anytime you can make a claim about one product and another product can't make that claim, I think, just by default, it becomes lesser than."

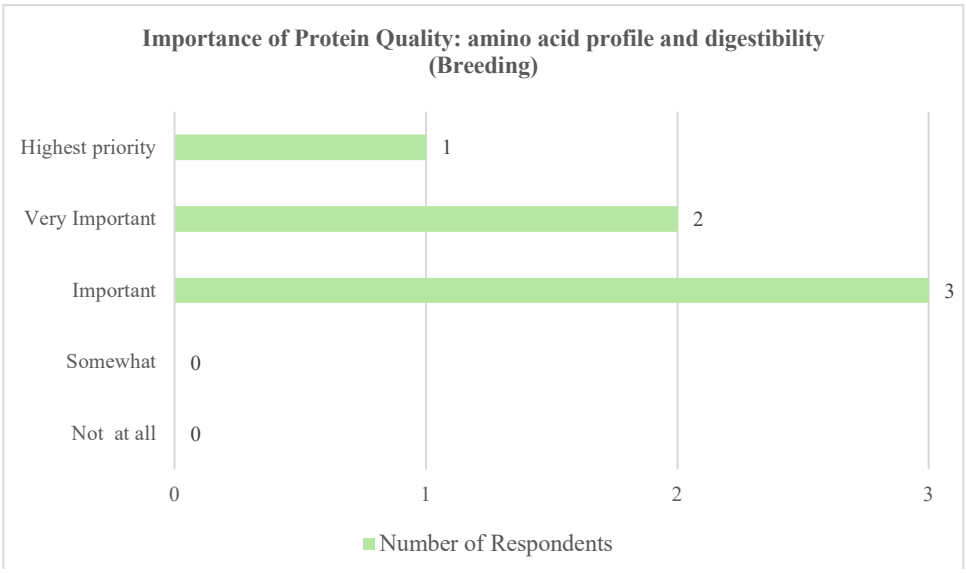
"I think if you could make it a complete protein. Fabulous."

"Consumers always want higher protein. So, if you could get more protein, more fiber and make it a complete protein that would be amazing."

In the survey, respondents were asked about the importance of protein quality and functionality, and micronutrients as priorities for plant breeding. Overall protein quality (**Figure 15**) and functionality (**Figure 16**) received relatively high importance ratings. Micronutrients were a slightly lower rating with three individuals indicating it was only somewhat important. The ratings for protein quality and functionality are consistent with what was said in the interviews about the importance of product functionality and quality.

Figure 15: Importance of improving protein quality through plant breeding

For the products that your company produces, what importance/priority do you place on improving protein quality through plant breeding? Provide a rating from "not at all important" to "highest priority/importance".



For the products that your company produces, what importance/priority do you place on improving protein functionality through plant breeding? Provide a rating from "not at all important" to "highest priority/importance".

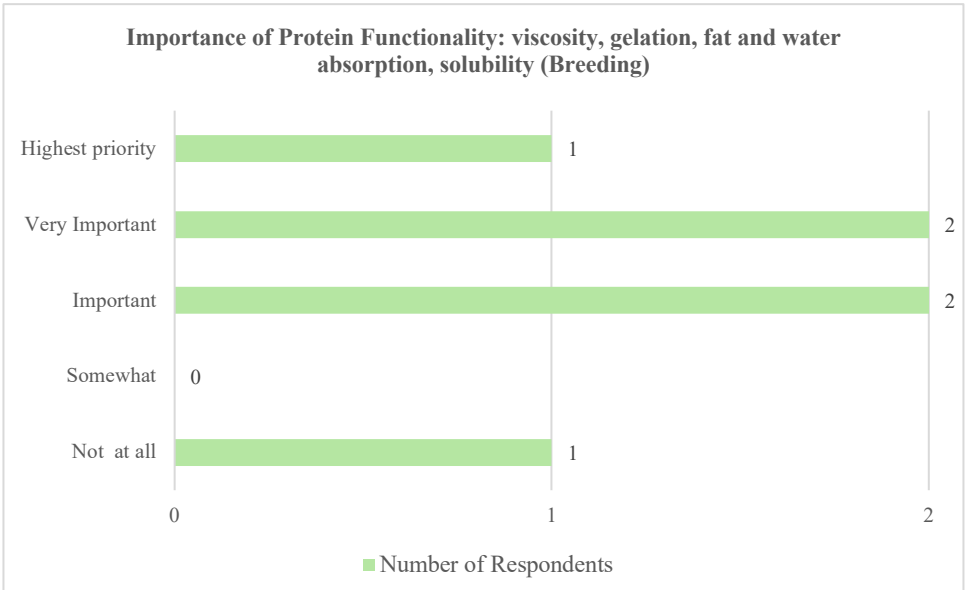


Figure 16: Importance of improving protein functionality through plant breeding

Pea products are being used by manufacturers to substitute for other ingredients in their food products. When used as a replacement for other ingredients like cornstarch and wheat flour, it was

considered desirable that the pea ingredient does not disrupt consumers expectations of the food item it is being used in. Color was raised as something that would improve the adoption of pea ingredients as a substitute in food manufacturing.

"The yellow color of protein is an issue for many, and buyers want a whiter pea. Something that would produce a whiter, less yellow protein would be good. … We had an orange pea 25 years ago, it did not last, as nobody liked an orange pea. Yield was good, it was a perfect size, gorgeous pea but it was orange…. So, what could have been a phenomenal pea for some, and unique characteristics died at that point."

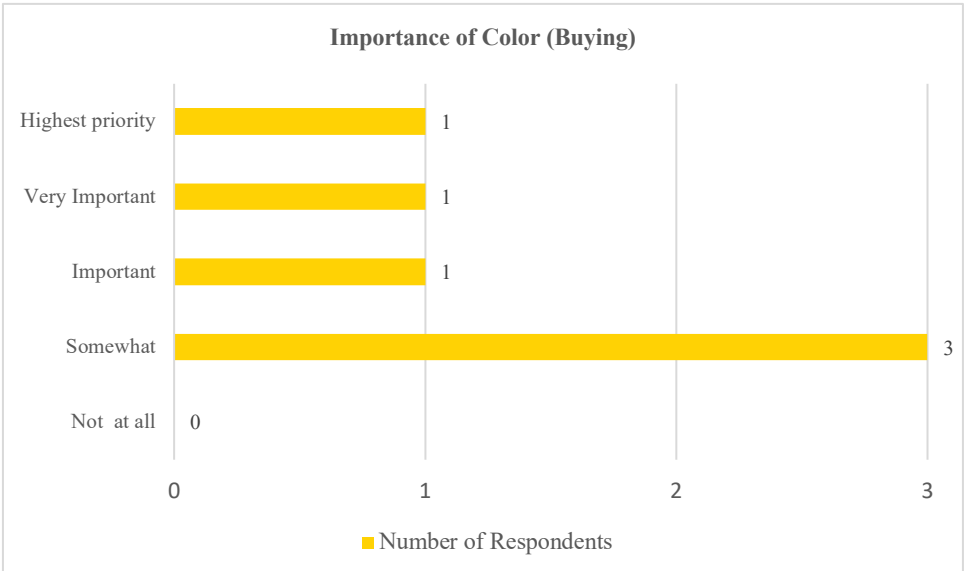
"Pea protein color, pea protein more digestible. For functionalities those are the two main items I would go for. As far as processing, low hull content is great for processing but unless it is a stronger hull, it is not feasible."

"So, color I guess is a bit important. Cost more than color. If something's too expensive, if we are looking to an ingredient supplier, if it's too expensive, that becomes a factor for sure."

In the survey respondents were asked about the importance of color when buying peas to process. The responses varied with one respondent indicating it was the highest priority and three indicating it was somewhat important (**Figure 17**).

Figure 17: Importance of color when sourcing peas

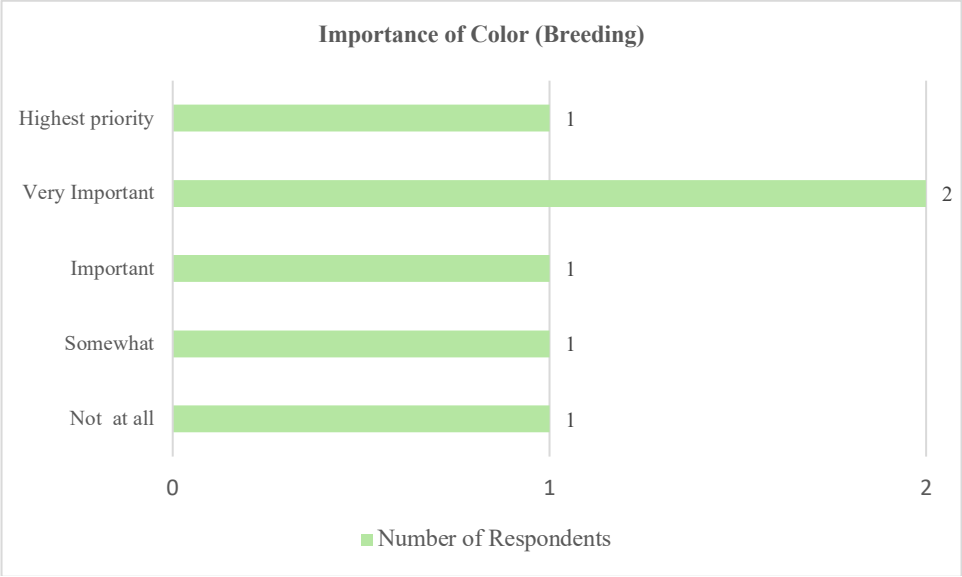
For the products your company produces, what importance/priority do you place on color when sourcing peas to buy and process? Provide a rating from "not at all important" to "highest priority/importance".



When survey respondents were asked about color's importance as a priority for plant breeding, responses were varied (**Figure 18**).

Figure 18: Importance of improving color through plant breeding

For the products that your company produces, what importance/priority do you place on improving color through plant breeding? Provide a rating from "not at all important" to "highest priority/importance".



With pea protein ingredients being developed for a variety of applications as the replacement for other ingredients, taste was considered by several processors as a breeding priority. Pea protein taste was described as a limiting factor in peas as a functional ingredient in food manufacturing. As mentioned earlier in the report, there were a few processors that felt taste could be addressed through processing but for most processors this was a desired attribute of new pea varieties.

"If you get rid of the bitter taste, then you do not need to add chemical flavoring or other flavors to it. Just starting off with a neutral pea protein change, for the processors down the line making burgers, they eliminate having to put flavor enhancements or maskers in the food."

"Going back to the specific discussion about flavor. That is a massive problem with pulse and pea protein in particular. Today it's the exact thing that is hindering things. An unfortunately, wo far from what we've seen is that adding salt or sodium and trying to mask the taste is the approach at the moment. …it's 100% a challenge that we need to overcome today."

"Taste is important. That it's not too strong of a pea flavor"

"…improvements to taste. …It's always something that consumers come back to us; it's a number one concern. So, if there is anything that can be done from the breeding side of that it would be great."

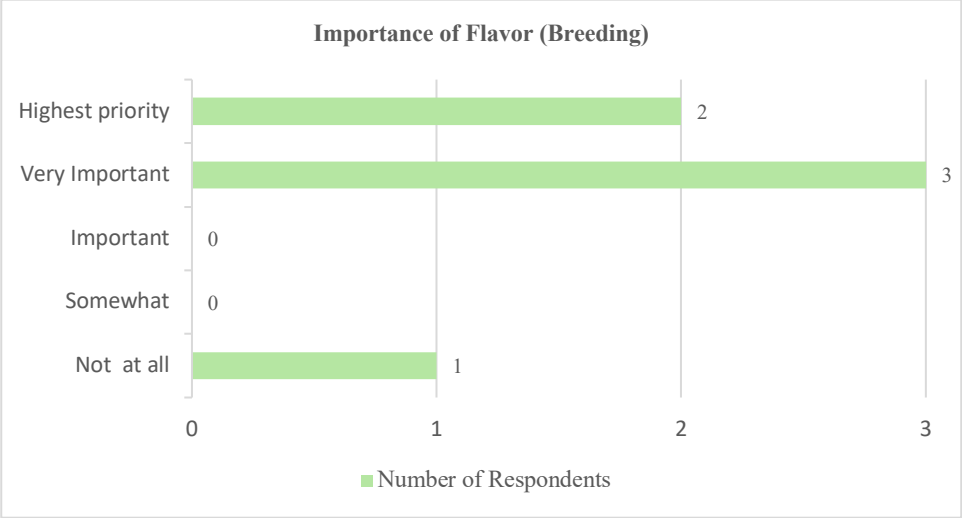
"Yes, especially as you start to get into high protein level type of products that the taste becomes the limiting factor. So certainly, anything that can be done to reduce that might allow for a higher percentage and use in a final product."

"…one of the biggest downfalls of peas specifically, is the inherent bitterness of peas."

The survey asked respondents to indicate the importance of improving flavor through plant breeding. Consistent with the comments made about taste in the interviews, five of the six respondents rated this as very important or highest importance (**Figure 19**). One respondent indicated this was not at all important and this low prioritization may be an indication that flavor is not a concern for the products produced by this processor or that this processor is employing technologies that address flavor issues within the products.

Figure 19: Importance of improving flavor through plant breeding

For the products that your company produces, what importance/priority do you place on improving flavor through plant breed? Provide a rating from "not at all important" to "highest priority/importance".



Price was mentioned as key to remaining competitive in the food ingredient market. The survey asked respondents to indicate the importance of improving price as a priority in plant breeding. All six respondents rated it as at a minimum as important, and three respondents indicated it was the highest priority (**Figure 20**). This is consistent with the interview findings that the price of peas was an important consideration for processors given the price sensitivity of the food ingredient market.

Figure 20: Importance of improving price through plant breeding

For the products that your company produces, what importance/priority do you place on improving price through plant breeding? Provide a rating from "not at all important" to "highest priority/importance".

New Variety Development

To better understand the requirements of the high value pea market, processors were asked about the constraints they faced in the industry and what role they felt plant breeders could play in helping to maintain and grow the competitive advantage of the Canadian pea processing sector. Respondents were asked at the end of the interview what they would like plant breeders to know or consider in developing new pea varieties. In response to these questions participants talked about the importance of understanding and focusing on the needs of the market in setting priorities. They were aware of the significant investment of resources that goes into plant breeding and felt it was important to consider the implications for the entire supply chain of any varietal developments. Past breeding efforts that have focused on attributes of value to producers had occasionally led to the release of varieties that proved difficult to process or market because of undesirable traits. Processors felt it was important to understand the needs of the entire supply chain and be aware that those needs were becoming increasingly specialized. Several respondents referred to growing competition in global markets and felt plant breeding had the potential to play a role in helping Canada maintain its competitive advantage by continuing to supply the quality of peas needed to meet market demands.

"…we have good varieties, we have consistent production, we have consistent quality. We have the infrastructure around it and investment around it to produce a good product. In the pea protein space, there's a little bit more variability right now, but I think we will get there in due course. …the growers are good stewards of the land."

"I mean we are getting displaced by a lot of these places like Russia, Ukraine, Kazakhstan, before we had a competitive advantage for many things, but those countries are catching up quickly in terms of their ability to handle and execute and clean and produce product comparable to us."

"The state of the Russian and Ukrainian exports today could completely change, and ultimately, they will invest, they will do more. They will do all the things that eventually catch up to us, because they'll have to."

Moving Forward

Several respondents cited the importance of seed breeding to the future of the industry. Processors believe the competitive advantage of the industry is dependent on the quality of the crops produced.

"This is where you get into the strategy perspective… Are you trying to raise the bar that everybody else has to meet too? Or are you just trying to be competitive in the current standards? And I think from that perspective, we need to keep raising the bar. I think some of that is an investment in seed varieties. I think some of its farming practices and those types of things."

"*Our farmers are fantastic farmers and so our competitive advantage, …I think our quality of the product coming off the field is just, it's so stellar… We have a very high level of quality."*

"I would say the quality and the consistency of that quality… And I am sure some of that comes from a very steady incoming source of peas."

In reflecting on the role of plant breeding in supporting the high value pea market, the importance of ensuring the gains were sufficient to warrant the investment was discussed.

"My main comment to them would be that whatever they are focusing their main energy and resources on is truly going to be worth it and accepted by the end consumer."

Processors noted the attributes of most benefit to producers were not necessarily the same as those that food manufacturers and final consumers valued. Several examples of varieties developed in the past that did not meet the needs of end users were identified. If new varieties were to be successful in the market, it was important to consider whether the attributes developed to address production issues would also meet the needs of the entire supply chain.

"…so sometimes it gets pushed to a farmer because of certain things whether it is mildew resistance or standability or whatever but that particular varietal, I am thinking green peas for example we send it to the buyers overseas and they don't like the shape, they don't like the color, there are other attributes in it that they don't like, so sometimes there is the odd varietal that will come to market that aren't vetted properly through customer acceptability. All of a sudden, a new variety comes out and you send it to the customer, and they say what is this, we don't like this."

"…the issue I see is who is going to be responsible for telling the plant breeders what the focus is? If you grow it, they will not necessarily buy it. It is not like if you build it, they will come. The companies we were selling to were the ones that were putting it into retail. They had their pulse on the market."

Processors were aware of the trade-offs that occur with plant breeding. There was often a price to pay for any attributes gained. In the past, breeding for specific attributes had resulted in gains and losses in terms of the other traits the new varieties offer. Yield drag was an important example of these trade-offs.

"I would want them to be cautious on the trade-offs. Be very aware of the trade-offs. Higher protein means what? What is the trade-off. Be very, very, very cognizant of what that tradeoff is, because it is a ripple effect. What we've seen is a ripple effect. … And when they remove the bitter taste, what is the trade off? There's always something on the other side.."

Producer Adoption

Many of the processors interviewed contracted directly with producers to supply peas to their facilities. The interviews provided the opportunity to ask about producer adoption of new varieties, specifically what processors felt influenced a producer's decision to grow newer, improved varieties. Several processors indicated that they do make recommendations to producers regarding the varieties of peas to grow and which seed dealers to work with. Factors thought to influence the producer's decision to adopt new varieties include the price of buying new seed, concerns about the regional accuracy of trial information provided in the seed guide, overall crop planning considerations such as maturity and adjustments to production practices, risk and uncertainty associated with growing a new variety, and the relative economic importance of peas as part of the entire farm income.

"All else being equal, a farmer is only going to switch to a different variety if the yield is better."

Processors talked about producer's having concerns with new varieties not performing as indicated in the seed guide specifically related to yield, standability, splitting, and disease resistance. This experience has led to a certain skepticism and mistrust of the information provided on new varieties. Producers prefer to wait and observe the experience of other farmers in their region before trying new varieties. More detailed and accurate regional information was identified as important for producer adoption.

"There are always new varieties. There are all these new things, and unfortunately some of them are better than others. And so, there's this apprehension from your side to try something new. They'd rather be the third person to do it than be the first person…even if all of the information they're being presented supposedly tells them that they're going to get paid for it and it's going to have all these positive things. … unfortunately, there have been some varieties that didn't meet

the attributes that the grower was sold. So that's been a challenge… and unfortunately the negative press is louder always than the positive press. …They want to know that other people have had success…the next thing is availability. What is the scale of the availability of supply?"

"Some of the breeders are breeding just for yield and pea size. The last round that they came out with was Forester, I think. Supposed to be a great yielder. Well, they don't. They all bleach."

Risk and loss aversion were other explanations for the tendency to stay with varieties that work and avoid taking what is considered a "chance" on new unproven varieties regardless of the expected benefits. Regional growing conditions, stable yield, and earlier maturity are encouraging producers to stay with varieties they have had success with rather than adopt new higher yielding varieties.

"Some of the new varieties are coming up to 26-27 %. Getting a little bit of trouble getting growers on board with it because the yield is a little less on some of these new varieties, so they have to weigh the constraints of yield versus premium on their harvested product"

"…there is a protein premium up to a dollar a bushel…. I don't even know if it always like, if it's worth it to go to a new seed for a dollar or a dollar fifty a bushel when you have a seed that you really like and you're familiar with. And you know what you're going to yield."

"Peas are very adaptable to climatic conditions. So, there's some areas certain varieties do better in than others. So, if they've got a locale that a variety is working very well. They're not very interested in changing because of that."

"If they've got something that they know is working, are they going to go and spend a bunch of extra money on pedigreed seed in order to take a chance. If they're not happy with the way things are going different story, then they'll look around."

Another consideration that was raised by a processor is that planting pulses has historically been more about soil health and crop rotation rather than as a profit center for the farm. In addition to this, disease pressures have resulted in peas becoming over time a smaller percentage of the entire crop planting, with producers only growing peas once every eight to ten years in a crop rotation. As a result, producers may not spend as much time researching new varieties and choose instead to return to varieties that are known to them. Familiarity with a variety reduces the search costs and transaction costs associated with acquiring and growing peas which can be relevant to the decision-making process when the pea crop was not as profitable as canola and a small percentage of the planted acres. Economic drivers for change have not been as pervasive as they need to be to switch varieties in the past, but this may change if a greater portion of the crop can be seeded to peas and prices remain high. Some processors have included retaining seed in contracts with producers to encourage growing of new varieties.

"...seems to be the resistance is the yield reduction and yellow peas especially, growers keep a lot of their own product for seed back so to get them to pay for seed is sometimes difficult...reduces their cost quite a bit."

"...we have growers that we've been talking to about new varieties. ... they want a production contract set now, so they know what they're going to get for them, and they want to be able to keep the seed at least the amount of seed that they put in this year"

"So I think the option of having those varietals higher protein should be there for those producers who want to chase that higher protein and try to chase that premium, but you know what we have found with this type of thing is that it is very similar to canola for example, like Nexera, when the canola price is low, we don't have a problem getting guys to sign up for Nexera, but when canola prices are high, #1 standard canola, that premium is not really worth chasing for a lot of producers. It is really market driven."

"...these farms that are being more run like a corporation. They look at the math and they look at those calculations a lot more closely. They probably trust those things a lot more ...who we're selling to will be changing, and it already is ...just the approach to things will likely benefit more adoption of these types of things."

Improving Communication and Collaboration

Processors felt improved communication and collaboration amongst the supply chain stakeholders would be beneficial in ensuring the quality and marketability of future pulse varieties. Several participants indicated a willingness to be more involved in the plant breeding process, offering input and feedback as varieties were being developed. As a more informed participant in varietal development, processors felt they could also play a role in promoting new varieties to growers for adoption.

"...If you have the best product? It's really easy to market. …We very much want you to be there and want you to be giving the information and hearing the information. So no, it's not an inconvenience for you to be reaching out earlier in the process. We would actually appreciate it."

"There is a lot of poor communication or miscommunication within our industry on what we need and that is nobody in particular's fault. …Put a picture up on the website, notified their clients, all the companies that are registered with them. Hey, this is potentially a new variety of peas, that would have stopped all the pain and suffering …if they had done at that stage and sent it to the buyers, and they knew who we were. We would all have said, hmmm, no thanks."

"We get asked all the time what varieties we like. We'll promote the varieties if there's something that's worthwhile."

"If they can continually educate in a simple way on their websites about what they are doing, and how that benefits us in the end. I think that's a great help."

Policy Considerations

Through the interview process a few issues were raised related to the regulatory environment for crop production and processing in Canada, as well as gene editing in global markets. Areas where policy interventions might be beneficial included financial support for the industry, supporting producer adoption of new pea varieties, industry standards for climate-smart programs, reducing regulatory roadblocks, and public education on gene editing.

When asked about the competitive advantage of the Canadian pea processing industry, most respondents referred to Canada's reputation as being a trusted and reliable supplier of agricultural products to the world. Canada's agricultural sector was described as producing quality, safe, environmentally friendly, and clean crops. Reference was made to the integrity of the supply chain and the important role all supply chain members play in maintaining a safe food supply. The regulatory environment has a key role to play in ensuring the safety and quality of the crops produced as well as the efficiency and reliability of the supply chain.

"This is where you get into the strategy perspective… Are you trying to raise the bar that everybody else has to meet too? Or are you just trying to be competitive in the current standards? And I think from that perspective, we need to keep raising the bar. I think some of that is an investment in seed varieties. I think some of its farming practices and those types of things."

"Canada is a large producer, so we have that benefit of scale, consistency of supply. Reputable people for the most part. We are a country that honors contracts, so there are some benefits there in terms of the actual product that's being shipped. Whether you talk about protein, starch, seed size. We have the history because of the breeding that has already been done…we have good varieties, we have consistent production, we have consistent quality. We have the infrastructure around it and investment around it to produce a good product. In the pea protein space, there's a little bit more variability right now, but I think we will get there in due course…"

"We have some of the toughest regulations in the world as far as how we grow them, what used to be a competitive advantage, but it's really hard to get paid for that. …Competition is tough."

As already discussed, one of the challenges identified by smaller, independent processors was accessing financing for the development of the capital-intensive technology required for fractionation. The need for more financial support going forward for the sector to grow was discussed. One respondent identified that grants were not sufficient and that what was required was an actual investment and financial backing from the government.

"This takes an extreme amount of money. This takes extreme capital, and the government just pats me on the head and says way to go. They don't support… The United States is calling, and they have a lot of money down there."

"Hands down, it's financing. …I think right now the money isn't coming into the industry largely because it is in its infancy. It's unproven and it's an if you build it, they will come, which to an investor are swear words."

"I would like to see underwritten loans by the provincial governments. They can get federal backing or whatever and take ownership in the companies they are loaning to until they get it paid back, like they did with Ford, Chrysler, and GM."

Two of the respondents referred specifically to the financial and administrative burdens of Canada's food manufacturing regulatory environment. When compared to the U.S., Canada was thought to be more tightly regulated and costly for processing facilities to operate in. The U.S. was referred to as more industry friendly with fewer regulatory hurdles and operational requirements for building a processing facility. Concern was raised that these disparities created a competitive advantage for U.S. processors and drive investment in value-added processing south of the border.

"This is not easy. The barrier to entry into this market is horrific. …It's very hard."

"So, I am looking at building the plant in the United States. It is so much easier. They've rolled out the red carpet. It is so much easier than the regulatory and red tape in Alberta and Canada. …I have to pay $185,000 for a class 4 Steam boiler engineer. I don't have to do that down in the States. We're out own worst enemies. We're chasing this environmental thing. …when I ran the numbers for carbon tax in five years, I'm bankrupt."

The issue of international market access for both commodity peas and value-added pea ingredients if gene editing was introduced into plant breeding in Canada was raised through the interview process. The global regulatory environment for gene-edited plants varies based on country and several major markets for peas and pea products regulate gene-edited crops like GMO crops. Concern that gene editing could become a trade barrier that would shut Canada out of key export markets was brought up in the interviews. The regulatory environment was acknowledged as evolving over time and that market acceptance of gene editing could change abruptly.

"This is a pretty dangerous topic actually. …whatever happens in our industry in terms of anybody starting to and I know that is starting to come down the pipes, anybody starting to have specific varieties grown for specific attributes , flavor attributes or high protein or isoflavones or whatever they are having it grown for, if any of that enters into the regular food chain and however possible some of those get picked up and tested, that could be a pretty significant trade barrier for us into a lot of markets. So that is something we need to be very, very, very careful about how to approach this."

One of the barriers to producer adoption of new varieties was thought to be the lack of information about new seed breeds. Concerns were raised about the reliability of the information provided in the seed guide as well as the level of detail and type of information provided. Related to this is the importance of how the information is presented to risk and loss averse producers. Plant breeders, industry groups, and government bodies could play a role in improving the quality and quantity of information provided on new varieties developed.

"Plant breeders giving good data is the most important. If you can confidently say hey this variety the results are here and its pretty accurate, that is always a good start. The first thing growers do is look at the seed guide. ...How does it compare to this one? So that kind of data is always really valuable to farmers, makes it easier for us to promote as well."

"… and I think that the one other big thing that we sometimes forget is we have a very diverse climate and growing conditions across even Western Canada. I mean what works in the south does not work the same in the north, but really the growers are kind of presented the same bill of goods across all of the geography…"

There was general agreement that industry-wide standards would be needed for a viable climate-smart certification program in Canada. One of the challenges related to this was the ability to get consensus on the standards, and definitions within those standards, for any environmental certification programs. Industry leaders have an important role to play in guiding and coordinating the development of climate-smart programs to ensure consistency and acceptance not only within the Canadian market but also in international markets that domestic suppliers sell into.

"…in order to charge for it, or for it to mean anything, everybody has to recognize it."

"*The problem is with sustainability. …everybody's got an idea about sustainability. And what are you comparing it to. It has to be measurable. It has to be verifiable. …May as well get the good old government involved…"*

When asked about the use of gene editing in plant breeding, most processors raised concerns about the public acceptance of it and suggested that more needed to be done to ensure that consumers understand gene editing as safe and distinct from GMO. Education through trusted sources about gene editing and the value it brings to crop production was needed and an important prelude to adopting it in pea breeding.

"Consumers do not understand the difference between GMO and gene editing…and especially the big markets in the United States and Europe."

"The government should be saying gene editing is the new, wonderful thing, because it is not GMO, it saves the world, …they should be doing that to prepare the way."

"As long as I guess you can continue to say non-GMO, and you don't have to put gene-edited on your packaging. But if you have to start saying it is gene edited I think there's going to be some pushback. …There would have to be a massive amount of education to the public."

Conclusion

The high-value pea processing sector was described as competitive and very price sensitive. Many processors indicated they compete based on technology and product differentiation, focusing on developing functional pea ingredients that add value to the products that food manufacturers want to create for their markets. The very competitive nature of the industry helps explain the interview findings that processors value pea attributes that improve the efficiency of processing or the functional value of peas as a food ingredient, and the importance processors placed of improving yield through plant breeding.

Some processors are paying small price premiums to producers for high protein peas but there were concerns that newer high protein varieties have been associated with yield drag, limiting the profitability for producers growing these varieties. One pea buyer who dealt in the export of commodity peas indicated that the entrance of larger processors into the Canadian market seemed to have raised the basis price slightly suggesting there has been a supply and demand price effect for all pea producers associated with the growth in the pea processing sector.

Processors saw the functionality of peas as an important strength that could be exploited in the ingredient market. As a functional ingredient pea may have benefited from the recent price inflation of other food ingredients, making peas a more affordable alternative as well as one that is perceived by consumers as adding "health" value to the final food products they are added to. Processors are anticipated to continue to focus on exploiting this unique positioning of peas in the food ingredient market into the foreseeable future. However, faba beans are already emerging as a contender in the protein ingredient market and only time will tell if they eclipse peas as the functional pulse ingredient of choice.

While processors saw the value of gene editing in advancing pea breeding for desired attributes such as flavor and disease resistance, they had concerns about the consumer response to employing this technology in pulses that were marketed based on being non-GMO. The image of pulses as being natural and healthy was important to the sector and any technology that might jeopardize this image would be resisted. Research into consumer acceptance both domestically and in international markets along with an assessment of the implications for the pea commodity market would be needed before processors would be willing to endorse gene editing.

Processors identified climate-smart certification as something that their customers might be interested in but not willing to pay a premium for in the current market environment. There was

disagreement on whether there might in the future be value in terms of a price premium for producers in developing a climate-smart program, or if in the future participation is such a program will simply be a requirement to sell into the market. It was clear that an industry-wide program was not something that had economic value right now and until consistent global industry standards and definitions for sustainability and climate-smart were established, not even feasible.

The take-away message for plant breeders regarding high-protein peas was that although more protein is always welcome and is a priority for those engaged in product differentiation based on this attribute, most are looking to improve attributes that would facilitate separation of the elements of the pea, reduce variability to achieve increased processing efficiency and consistency in the final products, or augment specific attributes of the pea such as a particular protein needed for current product development. The challenge in breeding for these specialized attributes is that they are often specific to the product and food manufacturer, and so not necessarily of benefit to the industry in general, and as the processors readily admit, the product innovation and market focus are evolving very quickly. What is of value today may not be tomorrow.

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Appendix 1: Online SurveyMonkey questions

1. How many tonnes of peas does your company currently purchase and process in a year?
   - In Canada
   - Globally (excluding processing in Canada)

2. How many tonnes of peas does your company currently have the capacity to process in a year?
   - In Canada
   - Globally (excluding processing in Canada)

3. How many tonnes of peas does your company plan to have the capacity to process in Canada per year?
   - 5 years from now
   - 10 years from now
   - 15 years from now

4. Based on your company's projected market/demand growth for products containing peas, what, if any, percentage increase in the amount of peas processed do you project for the next 10 years (we are looking for the average annual increase)? [% increase each year over 10 years (2024-2035)]

5. The current average protein content of Canadian yellow peas produced in Canada is about23%. What if any is the highest price premium (choose only one) you anticipate your company would be willing to pay for a pea variety that consistently provided a protein content of 27%?

1-5%	6-10%	11-15%	16-20%	None

   - Other. Please indicate both (1) what percentage of protein content would be required for your company to consider offering a price premium (relative to the price paid for peas offering 23% protein) and (2) what that percentage price premium would be

6. For the products that your company produce, what importance/priority do you place on the following attributes when sourcing peas to buy and process. Provide a rating of importance from "Not at all important" to "Highest priority/importance". If the attribute is not one you consider when purchasing peas give it a rating of "Not at all important".

Attribute	Not at all Important	Somewhat Important	Important	Very Important	Highest priority/ Importance
Flavor					

Size					
Color					
Seed Weight					
Protein Content					
Protein Quality					
Price					
Functionality					
Micronutrients					
Non-GMO					
Non-GE					

7. For the products that your company produce, what importance/priority do you place on improving through plant breeding the following attributes. For each attribute provide a rating of importance from "Not at all important" to "Highest priority/importance" for plant breeding. If you believe the attribute does not need to be improved (current quality is sufficient or it is not important to you) give it a rating of "Not at all important".

Attribute	Not at all Important	Somewhat Important	Important	Very Important	Highest priority/ Importance
Flavor					
Size					
Color					
Seed Weight					
Protein Content					
Protein Quality					
Price					
Functionality					
Micronutrients					
Non-GMO					

Non-GE					

8. On a scale of 0 to 5 with 0 being not at all interested and 5 being very interested, would your company be interested in purchasing gene-edited peas if this technology was used to improve attributes of value to you as a processor?

9. On a scale from 0 to 5, with 0 being not at all interested and 5 being very interested, would your company be interested in purchasing low-emission peas (relative to a global or Canadian average) supported by detailed, farm-level emission data?

Appendix 2: Qualitative interview questions

1. What types of innovations are you seeing in the industry?
2. What constraints do the current pea varieties available pose for the processing sector?
3. What are the most important attributes you consider when purchasing peas for processing?
4. Are you considering or interested in a Climate-smart certification program for any of your products? What are your thoughts about the development of an industry -wide framework/standards for a certification program? What do you think would be the issues/barriers in developing these programs? Is there market value in such a program and who do you think would benefit from it? What are your thoughts on the MRV framework that PIC is looking to develop for the industry?
5. Do you foresee gene editing being used to address specific attributes of pea ingredients being used in the food market such as flavor? Israeli Plantae Biosciences has used CRISPR to remove the bitter taste from yellow peas. Do you anticipate the plant-based food sector will be quick to adopt gene-edited technology?
6. Going forward as pulse breeders look to address various production and market issues, do you anticipate there is a willingness to trade-off gene editing for highly desirable attributes related to sustainability and palatability?
7. What percentage of pea protein does processing allow you to extract? Is improving the extraction technology a focus for your company? Is the fractionation process/technology an important source of competitive advantage in the pulse processing industry?
8. Considering that it takes seven to ten years for new pea varieties to reach the market, what attributes do you think plant breeders need to focus on now to address the future needs of the pulse food industry (2030)?
9. What do you think is Canada's current competitive advantage for global marketing of pulses and pulse products, specifically peas? What role if any does/can plant breeding play in maintaining /growing that competitive advantage?
10. What are the biggest issues/constraints the processing sector is currently facing in Canada?

This information gathering is to support the work of plant breeders so is there anything else you would like them to know?