VOLUME 1

PulseResearch

WHAT'S INSIDE

SASKATCHEWAN pulse Growers

LETTER FROM THE EXECUTIVE DIRECTOR

Since Saskatchewan Pulse Growers (SPG) was established in 1984, research and development (R&D) has always been at the core of SPG's mandate. For the 2014/15 fiscal year, the SPG Board of Directors continues to emphasize the importance of research in pulse crops by investing more than $10 million in R&D.

Within this publication, SPG has compiled for pulse growers a snapshot of the breadth of research that is currently being funded with their check-off dollars. Each story within the publication highlights the expected impact to growers of research investments in these areas. The articles are grouped into the areas of genetic improvement, agronomy, health and nutrition, and end-use processing.

SPG investments in the area of genetic improvement, breeding, and agronomy are aimed at keeping pulses competitive in rotation with other cropping alternatives Saskatchewan growers have. Breeding investments through our strategic breeding agreement with the Crop Development Centre (CDC) at the University of Saskatchewan continues to generate new pulse varieties with improved yield potential, disease resistance, and end-use qualities valued by markets around the world. Investments in agronomy research help to ensure growers have the knowledge and tools to achieve as much of the inherent yield potential in pulse crops as possible. Among others, agronomy investments help ensure growers have access to crop protection products to combat herbicide resistant weeds, optimize rotations, and manage diseases effectively.

In order to continue strong growth in the pulse industry, we need to ensure that demand for pulses increases faster than our production capacity. R&D investments in the areas of health outcomes and processing and utilization aim to generate solid science to support market development work to drive more consumption of pulses globally. Through our grower survey in early 2014 and at our regional meetings, growers told us that more investment in developing new demand for pulses is an important priority. We continue to build strong programs in these areas.

Throughout this magazine, growers will be able to read about projects that are made possible because of the investment of their check-off dollars, as well as areas in which we have been able to leverage their dollars through co-funding of projects with a multitude of partners across the agriculture industry.

Carl Potts

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Mapping Out a Better Route

New iMAP technology allows for faster and more efficient pulse breeding

SPG investment: *$2,678,508*
Project lead: *Dr. Bunyamin Tar'an, Associate Professor at the University of Saskatchewan and Breeder at the Crop Development Centre, Dr. Andrew Sharpe, of the National Research Council – Plant Biotechnology Institute*

Traditional plant breeding is a time-consuming process, requiring breeders to evaluate hundreds of thousands of individual plants across agro-climatic environments to identify the ones with the desired characteristics. Because of this rigorous process, it takes approximately seven to 10 years to develop a new pulse cultivar.

Due to the rapid expansion of pulse acreage in Canada and the demand for more intense rotations, there is a constant need for new pulse varieties. This is why Saskatchewan Pulse Growers (SPG) invested in research in 2010 that would allow breeders at the University of Saskatchewan's (U of S) Crop Development Centre (CDC) to adopt Implementation of Markers in Pulses (iMAP) technology, a process which, according to Dr. Bunyamin Tar'an, Associate Professor at the CDC and Plant Breeder at the CDC, expedites the breeding process while also enhancing the effectiveness of it.

"The iMAP project has allowed us to analyze thousands of DNA 'landmarks' in plant genomes to understand the genetic architecture of each pulse crop, to extract biological meaning from those DNA variations, and to eventually identify the candidate genes responsible for economically important traits," he says.

"In other words, iMAP developed new approaches that augment conventional breeding practices and are necessary to facilitate the rapid incorporation of traits into pulse crop cultivars."

The project also allowed researchers to use genome sequencing to identify and implement DNA diagnostic tools that are predictive of specific plant characteristics such as disease resistance, early maturity, and improved productivity and quality. This allows breeders to accelerate the development of new varieties that better suit grower and end-consumer needs.

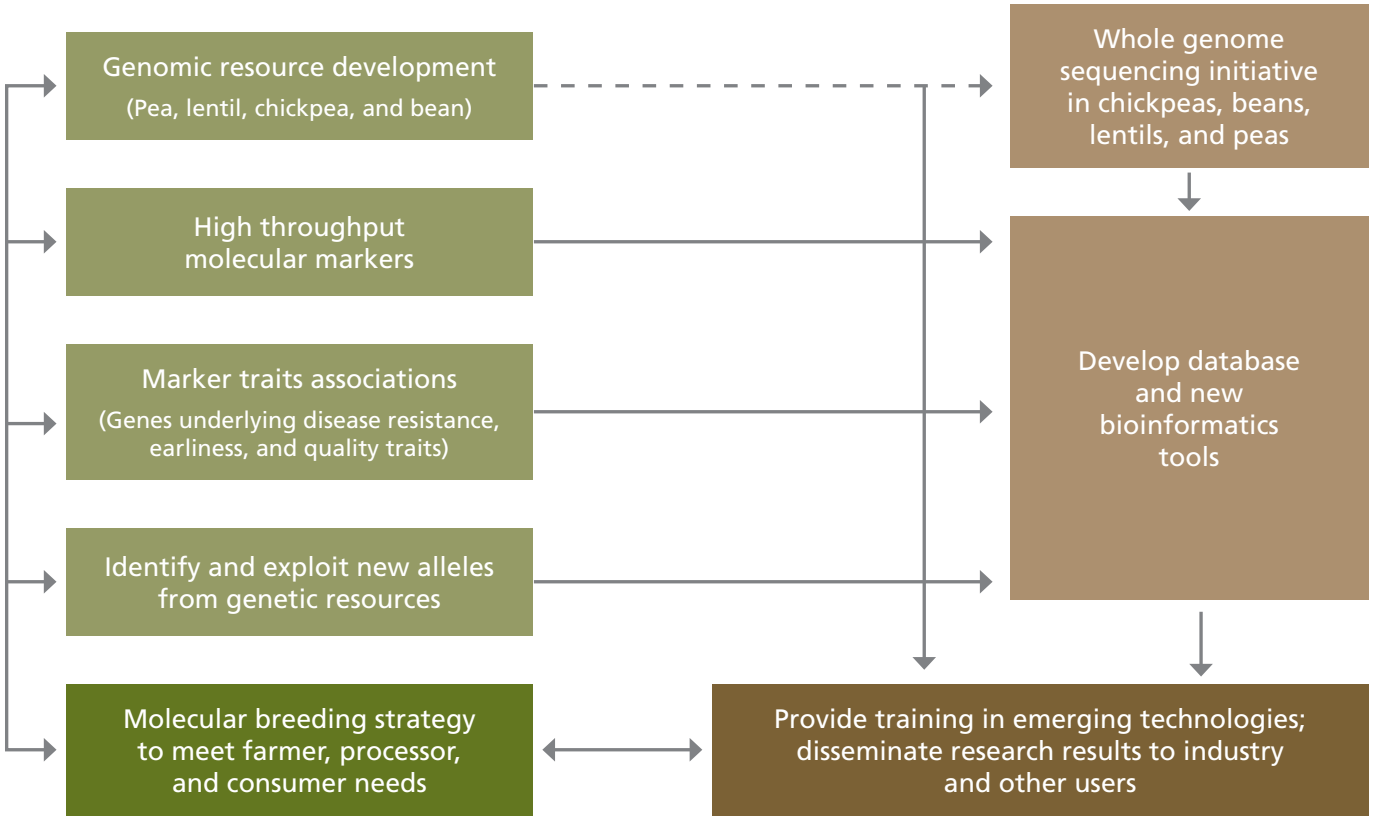
> "iMAP technology will allow growers to improve their production systems, decrease production costs and risks, increase the stability of the crops, and move commercial yields forward."
>
> **– Dr. Bunyamin Tar'an, Lead Researcher**

"One of the practical applications from iMAP is in the selection of chickpeas and lentils for resistance to IMI-herbicide and disease resistances in the common bean," Tar'an says. "We are continuing testing and confirmation of the outputs of iMAP for other traits that would expand the scope of the selection."

The project, now complete, allowed for the sequencing of the entire CDC Frontier kabuli chickpea genome, an effort which involved 49 scientists from 23 institutions around the globe and helped set the foundation to do similar work for lentils and peas, efforts that are currently underway. For more information on this ongoing project, flip to page 10.

"These achievements are monumental for the research community, but also for pulse growers in Saskatchewan, who will benefit in a number of ways," Tar'an says. "In the long run, iMAP technology will allow growers to improve their production systems, decrease production costs and risks, increase the stability of the crops, and move commercial yields forward."

iMAP Roadmap



Blight Future

Research takes us one step closer to controlling ascochyta blight in chickpeas

SPG investment: *$186,000*
Co-funders: *Agriculture and Agri-Food Canada – Canadian Crop Genomic Initiatives ($135,000)*
Project lead: *Dr. Lone Buchwaldt, Research Scientist, Agriculture and Agri-Food Canada, Saskatoon Research Centre*

Ascochyta blight in chickpea continues to be a serious problem worldwide for a number of reasons. Not only is there a lack of sources of resistance to the disease, but there is limited genetic variation in chickpea material currently used for plant breeding. That means that only small improvements can be expected in the fight against ascochyta blight.

One Saskatoon researcher expects to improve the odds. Dr. Lone Buchwaldt, a Research Scientist with Agriculture and Agri-Food Canada's (AAFC) Saskatoon Research Centre, has done extensive research in the area of ascochyta blight in chickpeas and just completed her most recent research project, funded by Saskatchewan Pulse Growers (SPG), on the issue earlier this year. In order to suggest better ways to control the disease, she set out to identify and understand the type of resistance to ascochyta blight through genetic markers in the chickpea genome.

"The first linkage map of molecular markers in chickpeas was developed by a group in Germany in 1999 and was based on simple sequence repeats (SSR), serving as a reference map for many years," Dr. Buchwaldt says. "More SSR markers were gradually added by other scientists, but the SSR map remained sparse. At AAFC we began development of another marker system based on single nucleotide polymorphisms, or SNPs. Since then, scientists have developed more than a thousand SNP markers and produced a dense linkage map of these markers, many of which were designed in actual genes with known functions including different defense mechanisms against pathogens."

This breakthrough helped Dr. Buchwaldt and other researchers at AAFC to identify specific genes associated with ascochyta resistance, partly because they were able to exchange both published and unpublished data with other scientists outside Canada, and partly because they had a leaf assay from which they could accurately determine the interaction of specific chickpea lines with different pathotypes of the *Ascochyta rabiei* pathogen.

"The most significant outcome of this research was the discovery of the presence of receptors in chickpea host cells that are able to recognize different pathotypes of the pathogen, which trigger different defense mechanisms," Dr. Buchwaldt says. "The classic outcome in most host-pathogen recognition systems is a high level of resistance. However, in the chickpea-ascochyta system, the resistance is often intermediary, and that has confused the interpretation of results in the past."

In another part of their research, the research team at AAFC chose chickpea germplasm that had not been looked at by other scientists for screening against the ascochyta blight pathogen, *Ascochyta rabiei*. They were able to identify new sources of resistance in chickpea accessions from 15 countries, information that will help expand the repertoire of resistance available for plant breeding. "We were fortunate to identify several chickpea lines from countries not previously known as sources of ascochyta resistance," Dr. Buchwaldt says.

Dr. Buchwaldt also built on previous research done by scientists from other chickpea-growing areas of the world such as India, Syria, Spain, Germany, Canada, Australia, and the United States. Her group was able to consolidate information about the location of ascochyta resistance loci in the chickpea genome using 10 of their own chickpea mapping populations in combination with 16 populations from the literature. This approach allowed the group at AAFC to consolidate information into 13 loci, conferring ascochyta resistance found in chickpea lines already known to the research community.

In Buchwaldt's research over the years, she has come across a few chickpea lines that have low-level resistance against several ascochyta blight pathotypes and other lines with a high level of resistance to some pathotypes, but not all. "I think it would be prudent to combine the general and the specific types of resistance into adapted varieties by traditional crossing and selection," she says. "In addition, varieties with different sources of resistance should be rotated to reduce the likelihood that resistance is overcome by changes in the pathogen population. This approach could, in the long term, provide growers with more durable disease resistance."

Additional research will be required to capitalize on the possibilities for new varieties and to extend the scope of this research. For now, these results mean we are one step closer to controlling the disease. They also mean we are one step closer to chickpea breeders having the capability to include the new chickpea lines with ascochyta resistance identified in this project by crossing into adapted varieties. "This would give growers the opportunity to select new varieties with a higher level of ascochyta resistance," Dr. Buchwaldt says.


CHICKPEA LEAF ASSAY SET UP


SUSCEPTIBLE REACTION


RESISTANT REACTION

A Novel Idea

Identifying and understanding novel sources of resistance to major lentil diseases

SPG investment: *$297,820*
Co-funders: *Saskatchewan Ministry of Agriculture – Agriculture Development Fund, Western Grains Research Foundation, and Natural Sciences and Engineering Research Council (collectively $675,881)*
Project lead: *Dr. Sabine Banniza, Plant Pathologist at the University of Saskatchewan's Crop Development Centre*

As most lentil growers in Saskatchewan know, fungicides are a major portion of production costs. However, they are necessary, as lentil diseases threaten to severely reduce seed yield and quality. For example, yield losses from anthracnose, one of the major diseases in Canadian lentil crops, can cause financial losses and that does not include losses from poor seed quality.

> "Disease resistance breeding is, in most cases, a never-ending story."
>
> **– Dr. Sabine Banniza, Lead Researcher**

According to Dr. Sabine Banniza, Plant Pathologist at the University of Saskatchewan's Crop Development Centre (CDC), lentil breeders are constantly working on increasing disease resistance within new varieties, but it is a challenge given the rapid pace at which pathogens evolve.

"Disease resistance breeding is, in most cases, a never-ending story, because pathogen populations co-evolve with resistant host plants and, in most cases, eventually manage to increase their virulence, which results in what we refer to as resistance breakdown," she says.

Because of this problem, Dr. Banniza is currently leading research, funded by Saskatchewan Pulse Growers (SPG), that aims to identify and understand novel sources of resistance to the major lentil diseases using an innovative new approach. This approach involves mapping the plant genes associated with resistance to anthracnose, ascochyta, and stemphylium blights in *Lens ervoides*, a wild relative of lentil chosen because of its resistance to several diseases. Researchers will then clone the genes, analyze them, and develop markers that will allow them to be tracked once they have been moved into cultivated lentil species. Finally, these markers would be applied for marker-assisted selection in hybrid populations.

"We will mine Lens ervoides for new resistance genes to anthracnose, ascochyta blight, and stemphylium blight and develop markers that we can then use in the interspecific hybrids to trace the genes through the generations of the breeding program," Dr. Banniza says.

Fungal Diseases	L01-827A	PI72815	Checks
Anthracnose	5.69±0.47	3.68±0.47	10±0.00 (E & R)
Ascochyta blight	1.12±0.40	2.19±0.41	5.44±0.50 (E) 2.12±0.33 (R)
Stemphylium blight	5.81±0.40	3.56±0.50	6.69±0.46 (E) 7.24±0.55 (R)

Checks: Lentil cultivars Eston (E) & CDC Robin (R)

IMAGE 1.
Wild relatives of lentil. *Lens ervoides* accessions L01-827 and PI72815 contain resistance genes with potential to combat fungal diseases of lentils grown in the Canadian prairies. Disease severity scores shown in the table are on a scale of 0 (highly resistant) to 10 (highly susceptible).

The outcome of this research, slated to be completed in February 2019, will create the foundation needed to develop elite lentil cultivars with superior resistance to fungal pathogens at a much faster pace than conventional breeding allows.

"We hope to eventually have better resistance for these diseases. With the markers and a few other bits and pieces of technology, like the fast generation protocol that has been developed here, that should be achievable much faster," says Dr. Banniza.

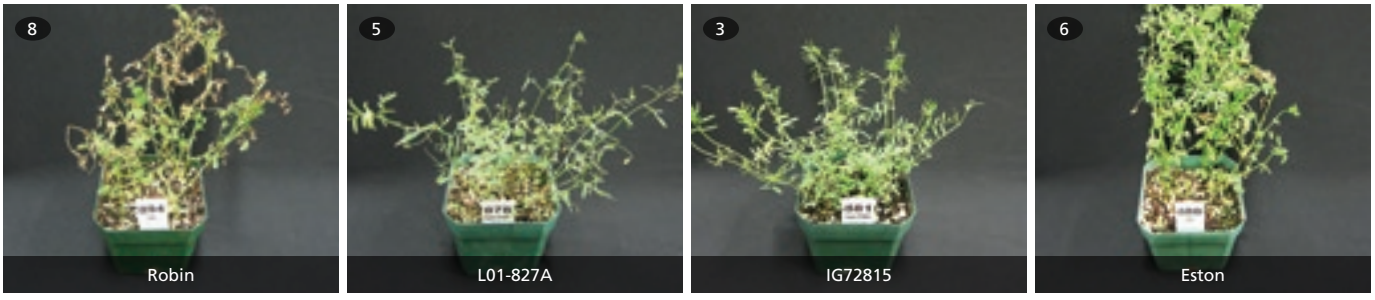
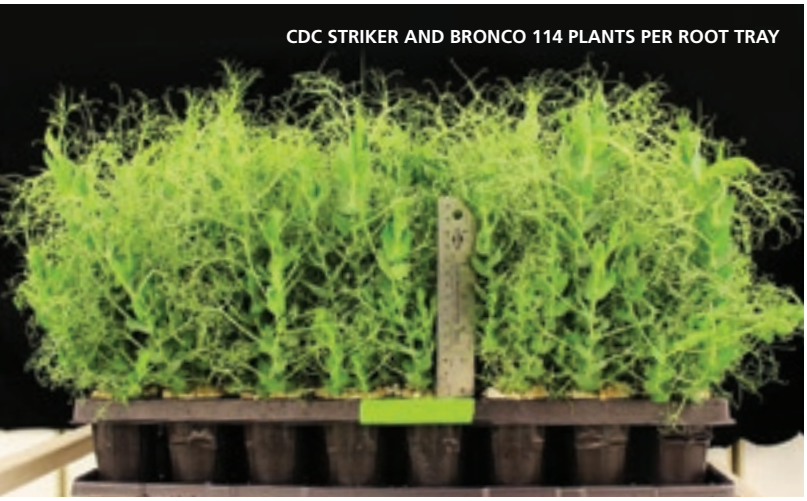


IMAGE 2.
Stemphylium blight severity score on wild lentils (*Lens ervoides* accessions L01-827A and PI72815) compared to cultivated lentils (*Lens culinaris* cv. CDC Robin and L01-827A). Disease severity scores (shown in white circles) are on a scale of 0 (highly resistant) to 10 (highly susceptible).

Pulse Evolution

Research helps increase the speed of developing better, stronger pulse varieties

SPG investment: *$791,142*
Researchers: *University of Saskatchewan's Crop Development Centre researchers Dr. Kirstin Bett, Dr. Monika Lulsdorf, Dr. Saeid Mobini, Shermy Mudiyanselage, Dr. Bunyamin Tar'an, Dr. Susan Slater, and Dr. Bert Vandenberg*



CDC STRIKER AND BRONCO 114 PLANTS PER ROOT TRAY

METRIBUZIN SCREENING

As global demand for pulses increases, so too does the demand for higher-quality and better-performing pulse varieties. Pulse breeders are tasked with developing new pulse varieties to meet this constant demand.

Fortunately, the technology and research involved with breeding is continually evolving as well, and researchers and breeders at the University of Saskatchewan's Crop Development Centre (CDC) are on the leading edge of this trend. For example, Dr. Tom Warkentin, a Plant Breeder at the CDC, spoke of recent research facilitated at the CDC that oversaw the development of Rapid Generation Technology (RGT), a series of protocols that employs genetics and advanced technology to accelerate the pulse breeding process.

"With RGT, plants are grown under conditions that result in miniature plants which flower and mature earlier than under normal growing conditions," Dr. Warkentin says. "Miniaturization is achieved by growing the plants in crowded conditions and/or by applying plant hormones that shorten plant internodes. Before the resulting seeds are fully mature, they are excised and replanted to start the next generation."

Dr. Warkentin, along with fellow CDC researchers Dr. Kirstin Bett, Dr. Monika Lulsdorf, Dr. Saeid Mobini, Shermy Mudiyanselage, Dr. Bunyamin Tar'an, Dr. Susan Slater, and Dr. Bert Vandenberg, developed basic RGT protocols for faba beans, lentils, peas, chickpeas, and dry beans by optimizing procedures for these crops including seed sterilization, germination, plant hormone treatments, and culture media using CDC varieties or breeding lines. According to Dr. Warkentin, the main benefit of the RGT protocols is the rate at which it accelerates breeding times. "Generation time can be reduced from over 100 days, under typical field or greenhouse conditions, to approximately 50 days, using rapid generation techniques," he says. "Meaning, for special crosses, we can advance them through six generations in a year. This can be useful when developing populations for specific genetic studies or for advancing high priority breeding populations."

Once the basic RGT protocol research had been completed, there was still more work to be done. CDC researchers began a follow-up research project in 2012, funded by Saskatchewan Pulse Growers (SPG), which is currently looking at how to best adapt and optimize RGT specifically to each pulse crop. For example, one part of the research is focusing on optimizing the RGT protocol in lentils in order to help produce varieties with resistance to multiple herbicides at a quicker speed. Other parts of the research are focusing on optimizing RGT procedures for dry beans, integrating marker-assisted selection and embryo rescue to enhance resistance to anthracnose and common bacterial blight. The project also aims to optimize RGT protocols for faba beans, field peas, and chickpeas to speed up the breeding process without affecting end quality.

Once complete in 2015, it is hoped that this research will accelerate the development of populations for genetic studies and gene markers, which will assist breeders in addressing important traits that growers are looking for in new varieties.

It is in the Genes

Lentil and pea genome sequencing research will maintain Saskatchewan's position as a world leader in the pulse industry

SPG investment: *$2,915,000*
Project leads: *Dr. Kirstin Bett, Professor, University of Saskatchewan Department of Plant Sciences, Dr. Doug Cook, Professor, Plant Pathology, University of California, Davis, Dr. Tom Warkentin, Professor, University of Saskatchewan, Crop Development Centre*

Although the lentil industry has seen tremendous success in terms of production and exports in Canada in the past decade, from a research perspective, the crop is behind in the area of genome sequencing.

Genome sequencing, a scientific process that traces an organism's entire DNA makeup, has been successfully completed for other major crops such as corn and soybean, resulting in faster development of new and improved varieties. Due to the comparatively small production of lentil crops globally and the substantial costs associated with genome sequencing, there has been less research done in this area and consequently there are fewer genetic and genomic resources available for lentils and peas.

"Current Saskatchewan Pulse Growers (SPG) funded research aims to sequence the lentil and pea genomes, which will make it easier to produce competitive pulse varieties faster, as well as maintain Saskatchewan's position as a world leader in the pulse industry," says Dr. Kirstin Bett, one of the lead researchers and a Professor at the University of Saskatchewan's Department of Plant Sciences.

"This research will help us stay at the forefront of lentil and pea genetics and breeding and, perhaps more importantly, help us continue to compete in the landscape with larger crops and maintain or increase lentil production in Saskatchewan," she says.

According to Dr. Bett, genome sequencing is a complex process. It allows researchers to better understand the DNA of an organism, which better allows them to manipulate it when breeding. "The genome is like the instruction manual for a species," she says. "It is written in four-letter code, some of which contains the genes that contribute to what an individual looks and performs like. If we can work out the 'words' in the manual then we can better understand the species and be more efficient at breeding."

Ultimately, the genetic sequencing information allows breeders to integrate genomic technologies into the breeding process so that new lentil cultivars can be tailored to overcome emergent production constraints, like disease and climate patterns, as well as meet requirements for market demand, like seed types or nutritional quality.

> "This research will help us stay at the forefront of lentil genetics and breeding."
>
> **– Dr. Kirstin Bett, Researcher**

The genetic information will also help breeders accelerate the rate of breeding, although speed is not the main goal. "The idea is not to increase the rate of varietal development so much as to maintain or increase the gains from selection. For example, having a marker for a trait like disease resistance or herbicide tolerance means we no longer have to screen in multiple generations with the pathogen or herbicide," Dr. Bett says.

Once complete, this will mean greater precision in breeding, an accelerated rate of variety development, and ultimately, a new paradigm in crop breeding, where crops are designed with specific genome content and pre-determined trait values. The resulting superior pea and lentil varieties will help position Saskatchewan growers to overcome current and future production challenges and help our province maintain its position as a world-leading producer and exporter of pulse crops globally.

COMPARING RED LENTIL VARIETIES

AGRONOMY

Growing Green

Research aims to measure the environmental benefits of growing pulses

SPG investment: *$77,587*
Co-funders: *Saskatchewan Ministry of Agriculture – Agriculture Development Fund ($67,468)*
Project Researchers: *Dr. Richard Farrell, Associate Professor, College of Agriculture and Bioresources, University of Saskatchewan, Dr. J. Diane Knight, Professor and Ministry of Agriculture Strategic Research Chair, University of Saskatchewan, and Dr. Reynald Lemke, Agriculture and Agri-Food Canada*

The carbon dioxide footprint of agricultural products has become an important factor in gaining and maintaining market access. Because of this, it is now critical to be able to accurately determine the magnitude of emissions from crop residues and to understand the controls on these emissions so their overall contribution can be accurately reported. It is also important to be able to identify effective options for mitigating emissions.

This is what Dr. Richard Farrell, an Associate Professor in the College of Agriculture and Bioresources at the University of Saskatchewan (U of S), aimed to do through recently completed research conducted in collaboration with Dr. Diane Knight, a Professor at the U of S, and Dr. Reynald Lemke of Agriculture and Agri-Food Canada.

"The greenhouse gas intensity of agricultural products has become an important criterion for maintaining or gaining market access," says Dr. Farrell. "Thus, results from this research will help build the case that in addition to agronomic and human health benefits, growing pulses also provides a strong environmental benefit."

The motivation for this Saskatchewan Pulse Growers (SPG) funded research came from the fact that default emission factors for Western Canada are not necessarily accurate. Research specific to the Western Canadian prairies has shown that the nitrous oxide (N_2O) emission factor for nitrogen (N) sources in this region averages about 0.4 to 0.6 per cent. However, the current default emission factor for N sources added to soils is one per cent. "Current procedures for estimating emissions assume that the proportion of nitrogen emitted as nitrous oxide is the same regardless of the nitrogen source, i.e. synthetic fertilizers, animal manures, or the nitrogen crop residues," Dr. Farrell says. "There is good reason to think that this may not be the case, but not enough evidence to affirm or refute that speculation."

In order to better determine what these rates should be, Dr. Farrell's research looked at soils from the Black, Dark Brown, Brown, and Gray Zones with both 50 per cent and 70 per cent water-filled pore space. These soils were amended with ^{15}N-labeled residues of wheat, pea, canola, and flax, and then analyzed for N_2O (both total and $^{15}N_2O$) using a Picarro G5101-i isotopic N_2O analyzer – cutting-edge technology that allows for the measurement of the isotopic signature of N_2O in the air. One of the major successes of the research was determining that this tool was a relatively simple, low-cost, analytical platform for research of this type." Having the analytical capacity to detect labelled nitrous oxide provides us with an important tool to identify the source of emissions, thereby providing a better understanding of how nitrogen is being cycled and, hopefully, developing more efficient crop management strategies," Dr. Farrell says.

> "Results from this research will help build the case that, in addition to agronomic and human health benefits, growing pulses also provides a strong environmental benefit."
>
> **– Dr. Richard Farrell, Researcher**

Results from the field research showed that, while both water content and soil type had an impact on N_2O production, there was a clear and consistent trend showing that emission factors for pea were intermediate compared to other crops researched.

Results also showed that emissions for pulse crops were comparable to cereal crops, which were both quite low in Saskatchewan growing conditions. This information will help support any warranted changes to the Canadian greenhouse gas inventory and the quantity of greenhouse gases assigned to prairie crop production. It will also be useful in helping Saskatchewan pulse growers effectively mitigate their emissions and report them accurately, so that they may avoid marketing risks going forward.

Finally, this information acts as scientific evidence of something that most of us already suspected – that there are environmental benefits to including pulses in your rotation. "Previous work has suggested that overall greenhouse gas emissions are lower from rotations that include pulse crops compared to those that do not, but a number of uncertainties remained – particularly regarding the impact of the pulse residue on nitrous oxide emissions during the following crop year," Dr. Farrell says. "This work will help to eliminate some of that uncertainty."

The Battle of Resistance

Developing management options for herbicide-resistant weeds in pulse crops

Growing Forward 2

SPG investment: *$80,490*
Co-funders: *Alberta Pulse Growers and Agriculture and Agri-Food Canada (collectively $221,472)*
Project lead: *Eric Johnson, Weed Biologist with Agriculture and Agri-Food Canada*

In a recent phone survey undertaken by Saskatchewan Pulse Growers (SPG), famers indicated that weed management was a top concern for their pulse crops, specifically those with Group 2 herbicide resistance.

The prevalence of these weeds is a known problem in the Canadian prairies, stemming from an overreliance on Group 2 herbicides due to a lack of alternative product options. This has caused weeds to develop resistance much quicker than they usually do and, according to Eric Johnson, Weed Biologist with Agriculture and Agri-Food Canada, there are now more than 20 weed species in the Canadian prairies identified as being resistant, with the most concerning ones being kochia, wild mustard, and cleavers.

Johnson is currently working on a solution to the problem via a two-part research project, funded by SPG, which aims to identify alternative modes of action for weed management and to help make them available in Saskatchewan. The first phase of the project, now complete, investigated potential herbicide candidates, including flumioxazin (Group 14), fluthiacet-methyl (Group 14), pyroxasulfone (Group 15), and propyzamide (Group 15) for alternative modes of action in weed control, taking into consideration the impact of soil type and climatic diversity on the herbicide's performance. From this research, Johnson made some valuable discoveries including that a fall application of flumioxazin helped to control winter annual weeds (including narrow-leaved hawksbeard) and early spring flushes of kochia, indicating it could be effective in managing glyphosate-resistant kochia that emerges prior to seeding pulses. It was also determined that fluthiacet-methyl, a post-emergence product, worked with tank-mixes including imidazolinone herbicides to control resistant kochia and wild mustard in Clearfield® lentil and other pulses. Johnson also discovered that pyroxasulfone demonstrated activity on wild oats and cleavers, and that propyzamide demonstrated good control of kochia and wild oats with acceptable crop tolerance in lentils and field peas; this effect improved when combined with ethalfluralin.

The second phase of the research, now being carried out, involves two objectives. The first is to obtain the information necessary to register these compounds for use on pulse crops in Saskatchewan, including the best timing, adjuvants, and formulation for treatments. The second is determining a pre- and post-emergence herbicide strategy for controlling cleavers in field peas in the black soil zone, as well as identifying tank-mix options to control glyphosate-resistant kochia before seeding.

> "Our research will provide pulse growers with additional herbicide modes of action to control resistant weeds."
>
> **– Eric Johnson, Lead Researcher**

"Our goal is to determine a combination pre and post-strategy to provide consistent cleavers control in higher organic matter soils," Johnson says. "In terms of the pre-seed burnoff of glyphosate-resistant kochia prior to seeding pulses, we are trying to introduce another mode of action, so we are not just reliant on Group 14s as tank-mix partners."

Johnson's goal is to have the project completed by 2017 and to be able to offer growers alternative solutions to their herbicide problems as a result. "We hope that, by that time, registrations for flumioxazin, pyroxasulfone, and fluthiacet-methyl will be submitted or approved for registration," he says.

PYROXASULFONE (GROUP 15) SYMPTOMS ON EMERGING WILD OAT

AUTHORITY (GROUP 14) CONTROLLING GROUP 2 RESISTANT KOCHIA

A Study in Sulfur

Research aims to help growers choose the best sulfur fertilizer source for their rotation

SPG investment: *$40,738*
Co-funders: *Saskatchewan Ministry of Agriculture – Agriculture Development Fund, Saskatchewan Canola Development Commission, and Western Grains Research Foundation (collectively $109,300)*
Project lead: *Dr. Jeff Schoenau, Professor of Soil Science, Department of Soil Science, University of Saskatchewan*


SULFUR TRIALS NEAR MELFORT


HARVEST OF SEED PLACED S RESPONSE PEA PLOTS AT CENTRAL BUTTE


SAMPLING SOIL FROM SEED ROW FOR CHEMICAL AND SPECTROSCOPIC ANALYSIS

Sulfur fertilizer is becoming more widely recommended for pulse crops as an important part of the fertilizer mix. However, there are still some unknowns for pulse growers about the long-term effects of these products.

While previous research has examined the end result of sulfur fertilizer on crop yield response and plant sulfur uptake, there is little information available about the transformations that different sulfur fertilizers undergo in the soil from the time of application to crop uptake. "This is important information for growers to have access to in order to predict the relative performance of these products for different crops under varying application conditions," says Dr. Jeff Schoenau, a Professor of Soil Science in the Department of Soil Science at the University of Saskatchewan.

Dr. Schoenau is leading a research study, funded by Saskatchewan Pulse Growers (SPG), which aims to answer these questions and, ultimately, help pulse growers choose the best sulfur fertilizer source for their short and long-term needs for plant-available sulfur in their rotation.

"Sulfur fertilizers are available in different chemical forms that behave differently in the soil," he says. "Some fertilizers, such as sulfur, require microbial oxidation to sulfate to become plant-available. Other fertilizers, such as calcium sulfate, are only partially soluble, while others, such as ammonium sulfate and potassium sulfate, are completely soluble."

Dr. Schoenau's research, which will be conducted in different soil-climatic zones in Saskatchewan under controlled environment and field conditions, will focus on canola, pea, and wheat crops. "While canola is generally recognized as the crop most responsive to amendment with sulfur fertilizers, the response of other crops like pea and wheat to sulfur fertilization also needs to be investigated to develop better nutrition plans for these crops."

The research will follow the fate of the fertilizers from the time of application to the uptake and recovery in the plant, as well as their effects on yield. To facilitate this research, Dr. Schoenau will use a soft x-ray microcharacterization beamline (SXRMB) from the Canadian Light Source, cutting-edge technology that facilitates microanalysis of various materials. "For the first time, we are using synchrotron spectroscopy at the Canadian Light Source to successfully follow the conversion of the fertilizer sulfur to different chemical forms in the soil," he says.

> "The response of other crops, like pea and wheat, to sulfur fertilization also needs to be investigated to develop better nutrition plans for these crops."
>
> **– Dr. Jeff Schoenau, Lead Researcher**

This research will rely on previous research Dr. Schoenau has done in the areas of tolerance to various rates and forms of sulfur and phosphorus fertilizer placed in the seed-row of different canola species and varieties. "This research builds on previous work by expanding into other crops like pea and wheat, and takes the impact of sulfur fertilization beyond seed-row placement tolerance, to transformations of the sulfur in the seed-row that take place throughout the growing season, and interaction with other seed-row placed nutrients like phosphorus," he says.

Dr. Schoenau hopes that the conclusion of the research will produce valuable new information for pulse growers about using sulfur fertilizer products in our province. He also hopes to be able to provide recommendations as to the most appropriate sulfur fertilizer for different crops, considering factors such as cost effectiveness and plant availability over the time period needed. "The new information on crop response to fertilization will be used by the industry to refine sulfur fertilizer recommendations to growers," he says.

Getting to the Root of the Problem

Examining the best ways to control soybean root rot in Western Canada

Growing Forward 2

Funders: *Manitoba Pulse Growers and Agriculture and Agri-Food Canada (collectively $683,908)*
Project lead: *Debra McLaren, Research Scientist, Agriculture and Agri-Food Canada, Brandon Research Centre*
Co-researchers: *Drs. R.L. Conner and B.D. Gossen, Agriculture and Agri-Food Canada, S.F. Hwang and K.F. Chang, Alberta Agriculture and Rural Development, and Dr. S.E. Strelkov, University of Alberta*

Considered to be a green alternative for conserving non-renewable resources, soybeans are seeing increasing market demand nationally and internationally for human consumption and animal feed markets. As a result, the seeded area in Canada has grown significantly over the last five years and is only expected to keep growing as market demand increases and cultivars with early maturity and improved cold tolerance become available.

However, root diseases could undermine the success of soybean production for Canadian growers. "Soybean root rot affects root development, nitrogen fixation, and ultimately, yields," says Debra McLaren, Research Scientist with Agriculture and Agri-Food Canada's Brandon Research Centre.

"Fusarium root rot is a major disease of soybeans in Canada and can cause significant yield reductions due to reduced plant stands, stunted seedlings, and weakened root systems," she says. "Controlling Fusarium root rot is difficult and cultivars with high levels of resistance are not yet available. In addition, little information is available in Western Canada on the prevalence, incidence, and pathogenicity of Phytopthora root rot, which is one of the most destructive diseases of soybeans in Ontario."

Because of the lack of options for preventing this disease, the best path forward is developing strategies to manage it. This is why McLaren is currently leading research that aims to ensure that soybean growers in Western Canada have the best disease management and prevention options to nurture this up-and-coming crop. "This research aligns with current industry priorities of ensuring that soybean growers have access to high yielding, disease resistant varieties that are adapted to growing conditions in Western Canada," she says.

INOCULUM PREPARATION

In order to achieve the desired results, McLaren is gathering information to add to the currently lacking database on this disease in Western Canada through research being carried out with collaborating scientists at facilities across Western Canada over a five-year period. Information will be collected on the major root rot pathogens of soybean, their impact on yield loss, genetic variation within the populations of root rot pathogens, and soybean cultivars with improved resistance/tolerance to the most prevalent root rot pathogens. In addition, the impact of soil salinity on root rot development and the aggressiveness of predominant root rot pathogens across different regions will be assessed.

PATHOGENICITY TEST GREENHOUSE

Research is expected to wrap up in 2018, at which time McLaren expects to have prepared the foundation needed to create strategies to improve root rot management. This information will also serve to create specific recommendations for soybean growers in Western Canada, which will be communicated through a variety of grower-focused communication channels. Finally, the information will be used in plant breeding programs for the development of high yielding, disease-resistant soybean varieties that are adapted to growing conditions in Western Canada.

> "This research aligns with current industry priorities of ensuring that soybean growers have access to high-yielding, disease-resistant varieties that are adapted to growing conditions in Western Canada."
>
> **– Debra McLaren, Lead Researcher**

In the end, managing root rot in soybean will have far-reaching impact. "It will also improve the efficiency and consistency of soybean production in Western Canada, increase the competitiveness of soybean production under prairie conditions, and ultimately increase profits for growers through increased yields and reduced risk," McLaren says.


HEALTH AND NUTRITION
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Baby Steps

Research tests link between pulse consumption and female fertility

Growing Forward 2

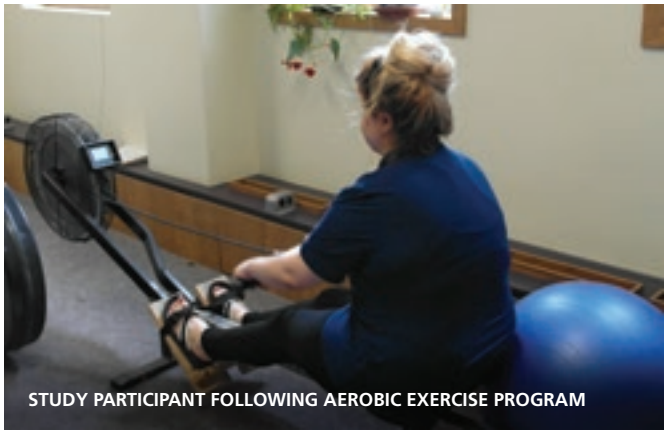
SPG investment: *$76,100*
Co-funders: *Agriculture and Agri-Food Canada ($271,900)*
Project lead: *Dr. Gordon Zello, Head of the Division of Nutrition and Dietetics & Professor of Nutrition, University of Saskatchewan*

We already know that pulses are good for human health for a number of reasons, but one research team at the University of Saskatchewan (U of S) suspected they could also help treat women who suffer from polycystic ovarian syndrome (PCOS), an endocrine disorder that affects approximately 10 per cent of women and is characterized by excessive body weight, polycystic ovaries, an increased risk of Type 2 diabetes, and even infertility.

It is generally thought that lifestyle modifications, including diet and exercise, can play a big role in improving PCOS. Previous research by Dr. Gordon Zello, Professor and Head of Nutrition and Dietetics at the U of S, and Dr. Phil Chilibeck, Professor of Kinesiology at the U of S, showed positive effects from including pulses in diets of people at risk for metabolic syndrome. Putting these two ideas together, Dr. Zello and Dr. Chilibeck suspected the same thing could be accomplished with pulses and PCOS.

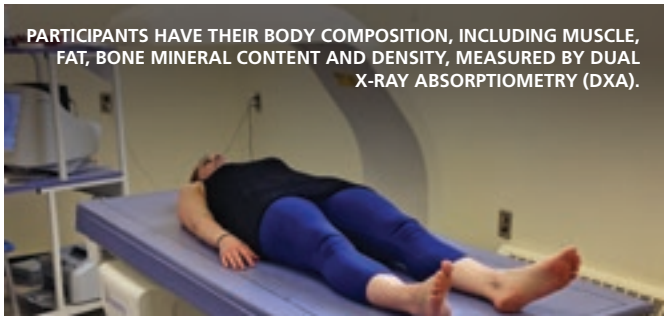
"Metabolic complications such as metabolic syndrome and diabetes are higher among women with PCOS," Dr. Zello says. "This led us to the idea of investigating a pulse-based diet in women with PCOS. It is thought that many of the clinical features of PCOS are a result of insulin resistance and hyperinsulinemia, and it is known that pulses have an insulin lowering effect."

The first phase of the study, already complete, had women with PCOS participate in a 16-week lifestyle intervention program. They were required to eat a healthy diet featuring pulse-based meals and follow an aerobic exercise program; they were monitored during and after the four months. Results showed reduced fat mass and waist circumferences, signs of improved blood glucose levels, reduced cholesterol, balanced hormone levels, and a reduced number of cysts in their ovaries. Research also showed lower levels of fasting insulin and glucose, which is important as hyperinsulinemia (excess levels of insulin in the blood) is thought to be a key-contributing factor to many of the characteristics associated with PCOS. Most significantly, many women reported more regular menstrual cycles and some even left the study because they became pregnant.



STUDY PARTICIPANT FOLLOWING AEROBIC EXERCISE PROGRAM

The second phase of the research, which is ongoing, will assess other health parameters, such as levels of liver fat, which is a factor in PCOS, and apolipoprotein B, which can be used to determine the risk of developing cardiovascular disease. This phase will also involve testing for genetic determinants that could improve individual responses to dietary intervention, as well as individuals' responsiveness to interventions designed to affect blood lipid levels.



PARTICIPANTS HAVE THEIR BODY COMPOSITION, INCLUDING MUSCLE, FAT, BONE MINERAL CONTENT AND DENSITY, MEASURED BY DUAL X-RAY ABSORPTIOMETRY (DXA).

Set to wrap up within the next year, Dr. Zello expects this research to lead to sound scientific outcomes linking pulse-based diets to treating PCOS, information that could also be used to support a health claim for pulses in Canada. However, another critical component of the research will be creating educational resources for people affected by PCOS about how pulse-based diets can help them make positive lifestyle changes.

"Although several studies have determined that diet and exercise interventions resulting in modest weight loss can lead to improvements in lipid profile and fertility measures in women with PCOS, there is currently no recommended optimal diet for this population of women," says Laura McBreairty, a Post-Doctoral Fellow at the U of S and coordinator for this project. "The information obtained from this study will provide support for the recommendation of pulses to be incorporated into the diets of women with PCOS."

Dr. Zello and the research team, which also includes Dr. Donna Chizen, a gynecologist at the U of S, will produce a cookbook of pulse-based recipes that will make it easier for people who are not used to cooking with pulses to include them in their everyday diets. In addition, this information will not be specific to people affected by PCOS – it will also be pertinent for anyone affected by chronic metabolic disorders or those that are just generally interested in leading healthier lives.

"A significant portion of the population shares many of the features associated with PCOS, such as insulin resistance and obesity, and we expect that our results will help promote the use of a pulse-based diet for both women with PCOS and the general population," Dr. Zello says. "We hope to find new ways for Saskatchewan pulse growers to increase awareness and interest in consuming pulses as part of a regular diet."

Pumping Iron

Investigating the role of lentils in treating iron deficiency

SPG investment: *$37,100 USD*
Project lead: *Dr. Kimberly O'Brien, Cornell University, New York, USA*

Iron deficiency, caused by a lack of iron in the body, is the most prevalent nutrient deficiency worldwide, and not just in developing countries. According to the World Health Organization, it is considered to be "among the most important contributing factors to the global burden of disease."

"Iron deficiency occurs when people do not receive enough iron from their food sources, which is especially common among women and young children," says Dr. Kimberly O'Brien, a researcher at Cornell University.

"Humans must absorb iron from their diets to offset the small amounts of iron that are lost each day," she says. "When women are pregnant or when children are growing, much larger amounts of iron are needed to support this growth."

Adding to the problem, in countries in which iron deficiency levels are highest, people do not commonly eat as many highly bioavailable sources of iron, such as meat, and instead favour plant-based diets, which tend to have limited bioavailability of iron.

For this reason, Dr. O'Brien, and co-researchers Dr. Diane DellaValle and Dr. Ray Glahn launched a first-of-its-kind study, funded by Saskatchewan Pulse Growers (SPG), to measure iron absorption from lentils among women. To facilitate this research, they recruited a sample group of 19 healthy women and served them a supplemental iron source, as well as a 117-gram serving of lentils in the form of dal, a lentil-based dish that is common in South Asia, one of the areas most affected by iron deficiency and Canada's biggest export market for lentils. The women then gave blood samples so that Dr. O'Brien could measure the levels of iron absorbed from the lentils and the supplements and compare them to normal levels.

"We found that, while high in iron concentration, the iron bioavailability, which is measured as the amount of iron absorbed from the food, of lentils is rather low but comparable to that of other non-heme iron sources, like soybeans, black beans, and sweet potatoes," Dr. O'Brien says. "We also found, as have other studies, that women with lower iron status absorb more iron from this non-heme iron source."

> "Trying to improve the iron content of plant-based foods that can be purchased or grown in many areas of the world may be an effective way to improve iron status."
>
> **– Dr. Kimberly O'Brien, Lead Researcher**

These results are an important first step for further research aiming to improve the iron absorption from plant-based foods such as lentils. "Knowing the amount of iron absorbed from this food as it is consumed helps us to determine how many people we need in a community-based study to see improvements in body iron status with the goal of impacting functional outcomes of iron status," Dr. O'Brien says.

This type of work is especially important right now as plant-based foods and food security, which the Saskatchewan lentil industry plays an important role in, is the most practical and sustainable option for improving iron levels worldwide. "Supplement-based interventions are often expensive and difficult to sustain without government support," Dr. O'Brien says. "Trying to improve the iron content of plant-based foods that can be purchased or grown in many areas of the world may be an effective way to improve iron status."

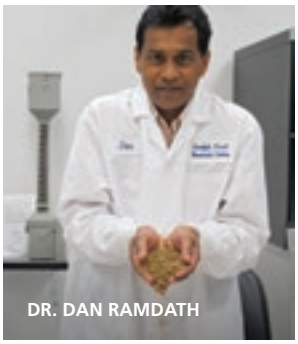
ANION EXCHANGE CHROMATOGRAPHY COLUMN THAT THE DIGESTED BLOOD IS LOADED INTO

RESEARCH SUBJECT EATING A PREPARED MEAL OF LENTILS

Staking a Health Claim

Growing Forward 2

Research on pulses, satiety, and blood glucose levels aims to help secure health claims for pulses in Canada


DR. DAN RAMDATH

SPG investment: *$281,747*
Co-funders: *Agriculture and Agri-food Canada ($766,614)*
Project lead: *Dr. Dan Ramdath, Research Scientist, Agriculture and Agri-Food Canada, Guelph Food Research Centre, and Adjunct Professor, Nutrition and Dietetics Centre, University of Saskatchewan*

Pulses are generally known to be a major component of any healthy diet. They are an excellent source of fibre, carbohydrates, protein, and vitamins. There has also been consistent scientific evidence demonstrating a link between pulse consumption and a decreased risk of diabetes and cardiovascular disease. This is especially important at a time when approximately two million Canadians are affected by Type 2 diabetes – a number that is only expected to rise.

Despite all we know about the health benefits of pulses, they still lack a health claim in Canada. This is because of the lack of data involving pulses and human health, information that is required to meet Health Canada's regulations and substantiate health claims.

Researchers like Dr. Dan Ramdath, a Research Scientist for Agriculture and Agri-Food Canada (AAFC) Guelph Food Research Centre, are working to remedy this situation. Along with his collaborators at AAFC, the University of Guelph, and the University of Manitoba, Dr. Ramdath is currently leading research funded under the AAFC Agri-Innovation Program that aims to establish a link between pulse consumption, satiety, and blood glucose management. More importantly, he aims to test this link in a way that meets Health Canada's guidelines for research that supports health claims by combining compositional and physiochemical investigations of pulses with research that involves human trials and measures defined human response to pulse consumption.

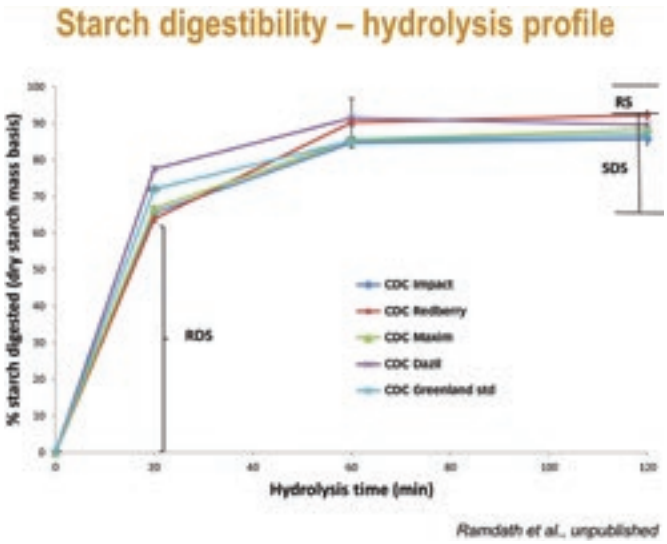
"It is important to relate food structure and contents to their biological outcome. This has been highlighted by Health Canada as a major gap in the advancement of health claims in Canada," Dr. Ramdath says. "The proposed human studies are consistent with Health Canada's guidelines for producing high-quality studies for health claims. Research involving testing on humans is an important component to any study that aims to support health claims."

Dr. Ramdath's two-phased research will focus on common red lentil, green lentil, and yellow pea market varieties. In the first phase, he will analyze the nutritional composition of the chosen varieties and characterize their starch fractions and digestion profiles using established laboratory methods. These results will be used to select 16 varieties that have the best potential for blood glucose lowering and satiety in humans. The selected varieties will be tested in healthy human volunteers to assess their relative effectiveness in reducing blood glucose levels, which will be related to the nutritional composition of the chosen pulses. These results will provide a better understanding of how lentils and yellow peas lower blood glucose levels.

In the second phase, Dr. Ramdath will incorporate four of the 16 varieties into food matrices, which will then be tested in human volunteers to determine if the blood glucose lowering characteristic of yellow peas and lentils is maintained when they are incorporated into a food. He will also test satiety levels in humans as related to the different pulse varieties. "Satiety properties of lentils and yellow peas are important because this can influence the amount of food people consume, which in turn can influence dietary energy intake and weight loss," he says.

Once all the research is complete, Dr. Ramdath is optimistic that there will be substantial, high-quality evidence to support a health claim submission for lentils and yellow peas in Canada. "If the chosen pulse varieties lower blood glucose by more than 20 per cent, this data could be included in a petition for a health claim on the blood glucose lowering of lentils and yellow peas."

Beyond health claims, the research will also benefit pulse growers in Saskatchewan by identifying pulse varieties with the most enhanced health benefits, information that will be valuable when it comes time to make cropping and marketing plans for future years. "Pulse growers in Saskatchewan will benefit not only from increased domestic consumption from an approved health claim and commercialization of pulse-based foods with health benefits, but also from informed guidance for production of yellow pea and lentil market varieties," Dr. Ramdath says.



Ramdath et al., unpublished

A Gut Feeling

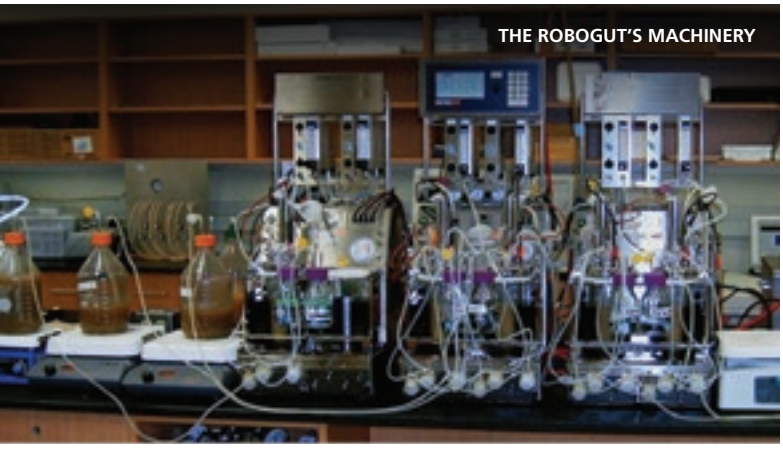
Research examines the link between pulse consumption, gut health, and chronic disease

Growing Forward 2

SPG investment: *$329,563*
Co-funders: *Agriculture and Agri-Food Canada ($912,125)*
Project lead(s): *Dr. Krista Power, Research Scientist, Agriculture and Agri-Food Canada Guelph Food Research Centre and Dr. Emma Allen-Vercoe, Associate Professor, University of Guelph*

It is already known that chronic human illnesses such as inflammatory bowel disease (IBD), cancer, diabetes, and neurological disorders are related to imbalances in gut health. It is also generally known that the regular consumption of pulses has an effect on chronic diseases in humans and can reduce the risk of diabetes, obesity, cardiovascular disease, and cancer.

What is not as clear is the mechanism behind the link between pulse consumption and gut health. This is the question at the centre of ongoing research currently led by Krista Power, Research Scientist at Agriculture and Agri-Food Canada, Guelph Food Research Centre, and Dr. Emma Allen-Vercoe, Associate Professor at the University of Guelph. Funded by Saskatchewan Pulse Growers (SPG), this research aims to determine exactly how different pulses affect gut health and what the impact of these effects are on humans, specifically in relation to chronic disease.



THE ROBOGUT'S MACHINERY

"The gut plays an important role in various human chronic diseases, not only those in the gastrointestinal tract, such as IBD and colon cancer but also those external to the gut, including obesity, neurological disorders, and diabetes, to name a few," Dr. Power says. "Identifying a clear link between pulse consumption and gut health will reveal opportunities for the use of pulses and pulse-based foods in the effective treatment and prevention of many chronic diseases."

In order to establish this link, Dr. Power and Dr. Allen-Vercoe will look at the nutritional components of pulses, how they are metabolized in the large intestinal tract, and how they modulate the structure and activity of microbes in the human intestine. In order to obtain this information, they will use something called the Robogut model, a complex recreation of the lower intestinal tract which makes the intricate study of human microbiota possible.

"The Robogut is a chemostat system set up as a life-support system for the microbes that live in the human gut," Dr. Allen-Vercoe says. "Many of these microbes are very difficult or even impossible to culture using traditional microbiology techniques, which focus on isolation, so the Robogut allows us to culture them as part of a microbial ecosystem. The benefit of this is that this is much more physiologically relevant."

"Identifying a clear link between pulse consumption and gut health will reveal opportunities for the use of pulses and pulse-based foods in the effective treatment and prevention of many chronic diseases."

– Dr. Krista Power, Research Scientist

They will also examine how pulse processing and cooking alters the effects of pulses on gut health. For example, cooking methods affect the relative proportions of starches, fibre, and composition of pulses, therefore influencing their potential to impact gut health. "Since pulses differ in terms of their levels and types of gut health promoting bioactives, we also hope to highlight which pulses are optimal for promoting gut health and reducing disease risk," Dr. Allen-Vercoe says.

The research is expected to wrap up by March 2018, at which time Dr. Power and Dr. Allen-Vercoe hope to have a more concrete understanding of the relationship between pulses and gut health, which they hope will influence consumers and the food industry about how to best prepare pulse foods to achieve optimal gut health benefits. On a larger scale, they expect the research will stimulate more action within the pulse industry as a whole.

"Our results may stimulate the potential development of new pulse varieties that are rich in important gut health bioactives and impact functional food research to optimize pulse incorporation into foods designed to modulate gut microbiota and promote gut health," Dr. Power says. "They might also stimulate more human health research and have an overall impact on pulse food consumption."

Pulses for Your Pets

Exploring the benefits of pulse-based pet food

SPG investment: *$207,000*
Co-funders: *Natural Sciences & Engineering Research Council, Alliance Grain Traders, and Horizon Pet Foods (collectively $387,000)*
Project lead: *Dr. Lynn Weber, Associate Professor, Veterinary Biomedical Sciences, University of Saskatchewan*

How can you make pet food healthier and cheaper to produce, while also lowering the risk of glucose toxicity or diabetes in pets?

By making it with pulse starch instead of corn starch. That is the hypothesis of Dr. Lynn Weber, who is leading Saskatchewan Pulse Growers (SPG) funded research that aims to build scientific evidence showing that pet food made from pulse starch instead of corn starch is healthier for your pets, particularly carnivores.

"The slower digestibility of pulse starches allows more time for the body of any species, but particularly carnivores, to deal with glucose before levels get too high, thereby reducing or erasing glucose toxicity," she says. "Carnivores have evolved to eat low starches, primarily meat, in their diet."

> "We think that pulse-based foods will be healthier for all species."
>
> **– Dr. Lynn Weber, Lead Researcher**

Dr. Weber's research will explore the use of slowly digestible pulse starches from pea, lentil, and faba bean in pet food, with the intention to prove that these starches will produce lower glycemic index levels in carnivores, lower insulin levels, and fewer adverse health effects compared to corn starch, which is more rapidly digested.

"Since corn starch is digested much more rapidly than pulse starches, leading to great spikes in blood glucose after a meal rich in corn starch, it presents a greater risk for glucose toxicity," Dr. Weber says.

In order to investigate, the research will involve carnivorous species, including cats and rainbow trout, and omnivorous species, including dogs and tilapia, and will compare their ability to digest carbohydrates, their glycemic responses to single feedings, and their health effects in feeding trials. Although the research aims to show health benefits for carnivorous pets, Dr. Weber also thinks results will be positive for omnivores.

"We think that pulse-based foods will be healthier for all species, because even in an omnivore (although they generally control glucose well) lower peaks in glucose after eating pulse starch will still be healthier," she says.

The research will also look at how the commercial food manufacturing process affects the health benefits of pulse starches. "Because the extrusion process to produce pet food in dry pelleted form involves treating the starch with heat and moisture and then rapidly cooling it, it can affect the structure and digestibility of the starches," Dr. Weber says. "What we do not know, and are intending to find out, is to what degree the pulse starches lose their beneficial starch structure during cooking and to what degree it can be regained during rapid cooling," she says. "We suspect that both processes will be better than corn starch."

CATS SAMPLE PULSE-BASED FOOD IN THIS STUDY

Dr. Weber's research, which aims to be completed in the summer of 2016, will provide the pulse industry with the information it needs to better market pulses in the pet food and aquaculture markets. Given that the pet food market in the United States was worth an estimated $21.26 billion USD last year, this is an investment that will have high long-term value for all stakeholders, with pet food already being a significant and growing market for pulses.

"If pulse starches are shown to be healthier for pets or allow good aquaculture production compared to corn starch, this will be used as marketing support for pulse starch use in pet foods and aquaculture feeds," Dr. Weber says. "A greater share of this market for Saskatchewan-grown pulses would benefit all of Saskatchewan, not just the growers."


END-USE

Gaining Momentum

Pulse flour milling project poised to meet growing consumer demand for pulse ingredients

SPG investment: *$346,000*
Co-funders: *Agriculture and Agri-Food Canada – Canadian Agriculture Adaptation Program, Alberta Pulse Growers, and The Canadian Special Crops Association (collectively $1,573,750)*
Project lead: *Heather Maskus, Project Manager, Pulse Flour Milling and Food Applications, Canadian International Grains Institute*

At a Canadian food industry event in Toronto, Galen Weston Jr., Executive Chairman of Loblaws, called pulses "the food of the future," confirming something that those within the industry already know – that demand for pulses is taking off.

The pulse research industry has been anticipating this and is poised and ready to meet the demands of food companies in Canada and abroad by increasingly looking for ways to provide consumers with healthier and more diversified food products.

Recently, at the Canadian International Grains Institute (Cigi), researchers completed a multi-year research project aimed at determining and demonstrating how pulse flours can be optimized to best meet the needs of commercial food manufacturers. "Four years of work has culminated into valuable knowledge and expertise in the area with potential opportunities in this area beginning to gain momentum," says Heather Maskus, Project Manager in Pulse Flour Milling and Food Applications at Cigi.

"The pulse milling project has enhanced Canada's knowledge about the use of pulse ingredients as value-added food products, and this is exactly the kind of innovative initiative that the global grain and food industry is interested in hearing about," she says. "The increased exposure of this project in Canada is piquing the interest of the global food industry, which is interested in trying these new applications using Canadian pulses and Canadian pulse flours."

The research itself was focused on creating pulse-based products that meet the needs of commercial food companies. The Cigi team facilitated this by first getting feedback from food companies about their specific requirements for food ingredients and then applying in-house expertise and cutting-edge milling technologies to create flours from Canadian peas, lentils, chickpeas, and beans that meet these requirements. They also tested these pulse flours in a variety of food products including noodles, pasta, baked goods, batter coated chicken nuggets, and snacks. "The end result was pulse flours of a specific quality, possessing the unique functionality that food companies are looking for, but the most important takeaway was realizing the potential of pulse flours in specific markets," Maskus says.

"Within a commercial realm, for instance, there is strong potential for pulses within the snack food market. This is not only because pulses are a versatile ingredient in products like puffed extruded snacks, crackers, or cereal bars, but also a result of the conditions of the snack food market here in North America. We see consumers interested in diversifying their snacking with more selection in grains but also wanting a healthy component to their snack, with added protein or fibre."

Cigi has shared research results with Canadian food companies and industry associations such as the American Association of Cereal Chemists, the Institute of Food Technologists, and the Chinese Cereals and Oils Association, as well as with all their program participants (there are approximately 1,000 participants/year) who are interested in learning more about Canadian field crop industries and innovative activities taking place.

> "This is exactly the kind of innovative initiative that the global grain and food industry is interested to hear about."
>
> **– Heather Maskus, Lead Researcher**

Beyond sharing knowledge, the project has had another important outcome – spurring spinoff research in a variety of related areas that has the potential to unveil more untapped markets for Canadian pulses. One example of this is a current Saskatchewan Pulse Growers (SPG) funded research project that is looking at using Canadian pulse flours in Asian noodles, steamed buns, and Chinese biscuits (see page 26). "This is just one example of the long-lasting effects this research will have on the continued development of the pulse ingredient industry," Maskus says.

"We are also seeing interest in applied research and development with several companies and are continuing to partner with industry leaders in baking, milling, equipment manufacturing, and food industry worldwide. Cigi's expertise will continue to support the research work in China to optimize these products, and open other avenues for Canadian pulses all over the world," says Maskus.


PULSE FACILITY LABWORK


CIGI'S DR. SUN HUI DEMONSTRATES HOW THE QUALITY OF STEAMED BUNS IS AFFECTED THROUGH THE ADDITION OF PULSE FLOURS

Binding Together

Growing Forward 2

Research tests pulses as meat binders in commercial food products

SPG investment: *$19,818*
Co-funders: *Agriculture and Agri-Food Canada and InfraReady Foods Ltd. (collectively $188,912)*
Project lead: *Dr. Phyllis Shand, Professor and Department Head, Food & Bioproduct Sciences, University of Saskatchewan*

As we see more and more consumer demand for healthier food options made with plant-based protein sources and gluten-free ingredients, the opportunities for pulses as ingredients in commercial food products continue to grow.

One opportunity is in the use of binders, which are used in processed meats to hold ingredients together while also enhancing the juiciness and texture of the product, making it thicker. Binders are commonly made with soy, wheat, and dairy products, so pulses offer the potential to serve as a nutritious alternative as they are naturally gluten-free, act as meat extenders, and are high in protein and carbohydrates.

The idea of pulse binders is a relatively new concept to the commercial food industry and is an area in which the industry lacks knowledge of how to best use pulses. Saskatchewan Pulse Growers (SPG) funded research, led by Dr. Phyllis Shand, Professor and Head of the Food and Bioproduct Sciences Department at the University of Saskatchewan (U of S), aims to fill that knowledge gap. Dr. Shand's research will build scientific knowledge on why and how to use pulses as consumer-friendly binders in commercial meat products and will then share this information with commercial food partners.

"The ultimate goal of this research is to showcase the commercial possibilities for this ingredient and encourage consumers to consider lentils and other pulses as part of their healthy diet," Dr. Shand says.

In the first part of the study, now complete, Dr. Shand and her collaborators evaluated a variety of pulse flour options to determine which would work best as binders and colour stabilizers in two types of processed meats, beef patties and low-fat bologna. The pulse flours were evaluated for characteristics that best predicted how they would perform in food systems, including their composition, emulsifying abilities, lipid-water holding capacities, colour, and gelatinization/pasting properties. The research team also experimented with using a variety of infrared thermal heat-moisture treatments (micronization) on the pulse flours to determine the best process for improving their beneficial properties and inactivating detrimental enzymes. Finally, consumer evaluation panels were run at the U of S and University of Manitoba on the final prototype products to determine the attractiveness of the final product from a marketing perspective.

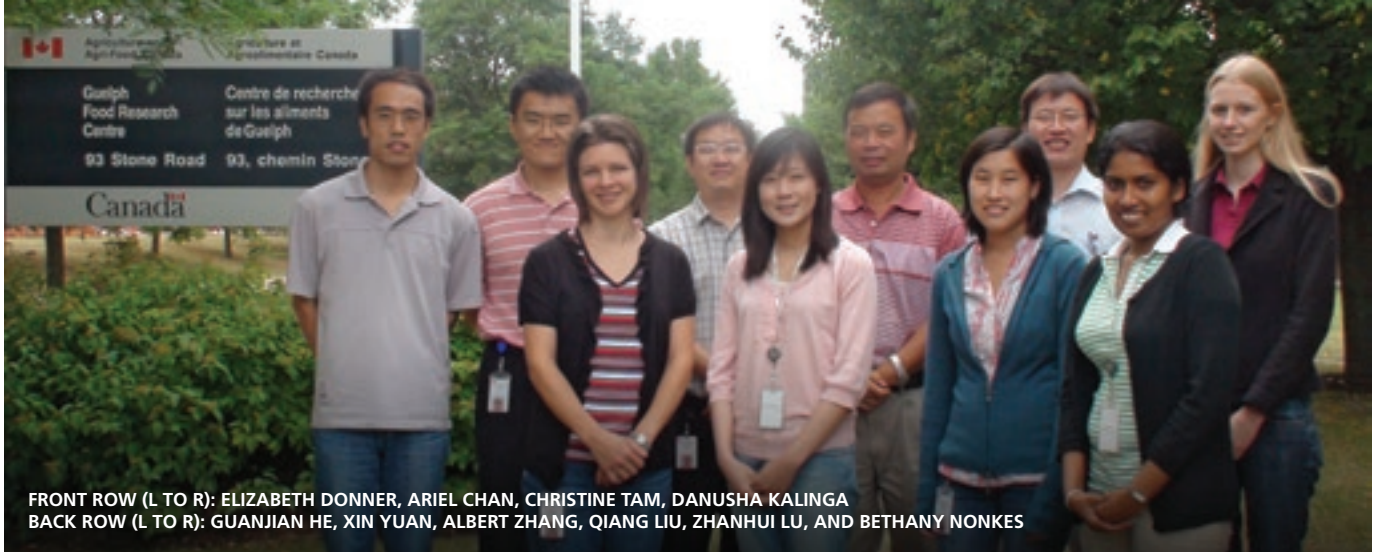
Results showed that micronized lentil and chickpea flours were the best candidates as ingredients in processed meat products, as a binder and colour stabilizer, and as a healthy, low-fat, and gluten-free alternative to traditional binders. Most importantly, the products made with lentil and chickpea flours also appealed to consumers in panel evaluations. "We consistently observed that consumers liked the taste and texture of low-fat beef burgers with added micronized lentil and chickpea flours and rated them at least as high as burgers containing toasted wheat crumb as a binder, which is commonly used in Canada," Dr. Shand says. "In addition, adding pulses likely would raise the 'healthy quotient' of burgers in the eyes of the consumer, as over 75 per cent of consumers in an earlier study considered lentils to be a good source of nutrition."

BURGERS MADE WITH PULSES AS A BINDER

The next stage of this research, which will be carried out in 2015, aims to increase the use of pulse ingredients internationally. In order to facilitate this, Dr. Shand and her team are developing prototypes of lentil-enhanced consumer products designed for international markets, including frozen burgers, meat or fish balls, and various sausages. These products will be tested locally, and then in different regions chosen for the research.

"Once we confirm the region for our consumer trial, we will use local consumers to help us fine-tune the regional meat, poultry, or fish products that will be developed as a platform to introduce this concept to that region," Dr. Shand says. "Then we will explore consumer responses there to help open up these new markets."

Once this research is complete, the outcome will have several effects on the pulse industry in Saskatchewan. At a local level, an increased demand for high-value, lentil-based ingredients in commercial food products means an increased demand for Saskatchewan-grown lentils and for value-added products from our province. "But the success of the project will be measured more tangibly in the form of new pulse-based food products on the market," says Dr. Shand, She is confident this will happen, as her team has been in touch with several food companies to share results of the research. Although she is not at liberty to say which companies specifically, due to client confidentiality, some major Canadian meat companies and food ingredient suppliers are currently doing pre-market evaluations on products containing micronized lentil flour. "We are eagerly awaiting the first commercial release of these products on the market," she says.



FRONT ROW (L TO R): ELIZABETH DONNER, ARIEL CHAN, CHRISTINE TAM, DANUSHA KALINGA
BACK ROW (L TO R): GUANJIAN HE, XIN YUAN, ALBERT ZHANG, QIANG LIU, ZHANHUI LU, AND BETHANY NONKES

Putting Pulses on the Daily Menu

Growing Forward 2

Research aims to get more pulse starch ingredients into commercial food products

SPG investment: *$238,878*
Co-funders: *Agriculture and Agri-Food Canada ($647,232)*
Project lead: *Dr. Qiang Liu, Research Scientist, Agriculture and Agri-Food Canada, Guelph Food Research Centre*

Pulse starch ingredients represent huge opportunities for the future of the pulse industry, however, they currently have fewer commercial applications than other plant starches.

This is something that Dr. Qiang Liu, Research Scientist, Agriculture and Agri-Food Canada, Guelph Food Research Centre, wants to change. He is currently working on research that ultimately aims to make pulse starches a more practical and viable ingredient for commercial food companies by addressing the current reasons pulse starches are not commonly used commercially, and there are a number of them. For example, some pulse starches are characterized by restricted swelling power, impurity, high gelatinization temperatures, and high water loss, all factors which make them unsuitable candidates for commercial inclusion. In order to meet industrial needs, starches need to be able to withstand high shear rates and forces during processing, have low acidity, and endure high and low temperatures, which many pulse starches cannot.

There are currently chemical and biochemical approaches available to modify pulse starch to meet these requirements, but these approaches generally do not meet environmental and food safety requirements. Dr. Liu's research aims to develop a novel type of modification technology that would meet environmental and food safety concerns, but also still produce consumer-friendly pulse starches.

"The current procedure for starch isolation from pulse seeds is very time consuming, taking approximately two or more days, and involves many steps to purify starch," Liu says. "We will develop a novel technology, with a combination of enzymatic, carbon dioxide, and alkali treatment that takes place during the isolation. This will result in maximizing starch yield and purity while minimizing damage."

This research will also identify Canadian pulse starches that have potential to be a good fit within commercial food products by analyzing their chemical composition, granular and molecular structure, and functional and nutritional properties, as well as experimenting with them in extrusion and other conventional processing technologies. From there, Dr. Liu will create a new database of knowledge about Canadian-grown pulse starches, which will serve as an educational resource for the food processing industry. Dr. Liu's research will also produce a quick and efficient analytical method for screening existing, new, and speciality pulses to determine which ones are the best candidates for food ingredients, considering factors such as starch digestibility, glycemic response and glycemic index, validation of *in-vitro* and *in-vivo* digestion testing, chemical composition, granular and molecular structure, functionality, and nutritional properties.

> "This research will generate substantial information and advanced knowledge on starch chemistry in pulses and pulse food products."
>
> **– Dr. Qiang Liu, Lead Researcher**

"This research will also address several fundamental questions on starch structure, retrogradation, and interaction on digestibility," Dr. Liu says. "It will also generate substantial information and advanced knowledge on starch chemistry in pulse and pulse food products."

"Once the project is complete in 2018, research findings will be shared with the food processing industry, creating a partnership that will be instrumental in driving the Canadian pulse industry forward at a much quicker speed," Dr. Liu says.

"The development of new technologies and products in this research will open new opportunities and markets for Canadian pulse products and pulse cultivars."

Toxic Environment

Examining the role Saskatchewan lentils can play in treating chronic arsenic toxicity

SPG investment: *$233,923*
Co-funders: *National Science and Engineering Research Council ($205,423)*
Project lead: *Dr. Judit Smits, Department of Ecosystem and Public Health, Faculty of Veterinary Medicine, University of Calgary*

Chronic arsenic toxicity, a condition caused by elevated levels of arsenic in the body due to drinking contaminated water or eating contaminated foods, has been estimated to affect more than 137 million people worldwide, according to 2007 research from the University of Cambridge. When contracted, the condition, also called arsenicosis, causes a variety of short and long-term health effects that can include heart and arterial diseases, cancer, hyperpigmentation of skin, diabetes, and even death.

However, it is thought that the effects of chronic arsenic toxicity can be either slowed down or reversed to a significant degree through a selenium (Se) rich diet and one researcher set out to test the role that Saskatchewan-grown lentils can play in treating the condition.

Dr. Judit Smits, a professor in the Department of Ecosystem and Public Health, Faculty of Veterinary Medicine, at the University of Calgary, led research that involved feeding lab rats that had been exposed to arsenic in water either Se-rich Saskatchewan-grown lentils or Se-deficient lentils from another region in North America. Dr. Smits was interested in exploring the benefits of using natural sources of Se-rich foods (such as lentils) instead of Se-enhanced manufactured diets.

"In lentils, the major form of selenium is selenomethionine, which is readily absorbed across the gut wall and retained in the body to contribute to antioxidant activity," she says. "In manufactured foods, the selenium is generally added as selenite. This is absorbed reasonably well too, but according to some work, not as well as selenomethionine, and it is not retained in the body as well as selenomethionine," says Dr. Smits.

The first part of Dr. Smits' study found it was possible to reverse the health effects of arsenic toxicity with commercial diets fortified with selenium. "We found that in the biological responses we could measure, there was a significant benefit to the higher selenium diets in counteracting arsenic damage and body burdens of arsenic," she says.

The second part of the research found that the rats that were fed diets made from 50 per cent Saskatchewan lentils for 14 weeks (half their lives) saw an increased amount of arsenic being lost from their bodies through urine and feces, lower levels of arsenic trapped in their kidneys, and decreased liver damage seen with arsenic exposure in rats.

DR. SMITS EXAMINES A SLIDE

"The next step will be to do testing on humans who have been exposed to arsenic," Dr. Smits says. "We are currently working on plans to achieve this, including applying for funding and identifying research partners in countries where chronic arsenic toxicity is a massive problem."

These initial results are good news for lentil growers in Saskatchewan, who are fortunate to have unique soil quality on their side, allowing them to grow high quality lentil crops. "The high selenium content of Saskatchewan lentils is largely because of the good fortune of having farm land where an ancient seabed existed, and therefore the soil naturally contains good levels of selenium," says Dr. Smits.

These initial results are also good news for the Canadian lentil industry as it seeks to build new and diverse agricultural export markets through unique research initiatives such as this one.

"If we can prove the health benefits of Saskatchewan lentils to counteract arsenic toxicity in affected human populations, lentil growers will have an additional and extremely valuable quality in their lentils that ought to give a market advantage," Dr. Smits says.

International Flavours

Research aims to get more pulse flours in Chinese staple food products

SPG investment: *$339,090*
Co-funders: *Alberta Pulse Growers ($106,167)*
Project lead: *Chinese Cereals and Oilseeds Association*

China is a substantial export market for pulses. In 2013, it surpassed India as Canada's largest importer of yellow peas, importing just under one million tonnes. With growing consumer demand among the country's 1.4 billion people for healthier and more diverse food products, the opportunities within China will only continue to grow.

In order to capitalize on these opportunities, the Canadian pulse industry first needs to address the lack of information available on using pulse ingredients in Chinese staple foods, which up until now has meant that soy and wheat gluten ingredients have been predominantly used instead. This is why Saskatchewan Pulse Growers (SPG) is currently funding research, facilitated through Pulse Canada, which aims to position pulse flours as a functional and nutritious ingredient for Chinese staple foods, such as dry noodles, cookies, biscuits, and steamed buns.

"Food companies are interested in exploring the use of pulse flours to enhance the nutrition and health profiles of their product lines," says Tanya Der, Manager of Food Innovation & Marketing for Pulse Canada. "This is part of a growing global interest in developing food products that combine pulses and cereal products like rice and wheat, offering consumers new food products that address weight management and improved nutrition."

The research aims to inform this growing area of interest by gathering information through two phases. The first phase will look at the best ways to include pulse flours in commercial Chinese food products to improve fibre and protein levels, while still maintaining the proper physical and chemical properties of the dough. Specifically, researchers will test pulse flour incorporation levels of up to 50 per cent in Chinese-style dry noodles, up to 40 per cent in biscuits and cookies designed for the Chinese snack market, and up to 20 per cent in two types of Chinese steamed breads that are largely consumed in the country's northern and southern provinces.

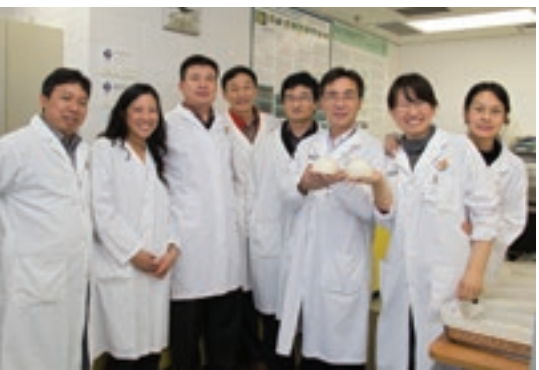
Once researchers have determined the optimal formulations and procedures for creating products with pulse flours, the second phase of research will test the products with Chinese food industry partners. This will include a bakery in Tianjin, a noodle manufacturer in Shandong province, and a yeast company in Beijing. These partners will perform production trials in their own commercial processing environments to test how pulse flours interact with Chinese wheat varieties and other local ingredients, how the dough performs with local processing equipment, and the general economics of adopting pulse flours into their ingredient portfolios. Each commercial partner will also be able to contribute their own expertise to the process, advising on aspects such as consumer acceptance criteria for new products, regional marketing strategies, and more.

The research is expected to be completed by April 2015, at which point Der expects to have conclusive information about how to successfully incorporate pulse flours into commercially produced Chinese staple foods. She also expects the research will have laid the foundation to work with local partners to get these products adopted into the country's commercial food industry. "With these food studies being conducted in China, local researchers will begin forming a network of expertise in pulse ingredient functionality and be able to transfer technical knowledge to local food industries that have the capacity to commercialize and market new food products," she says. "Overall, the prototypes will be used to stimulate further interest in pulse innovation, helping to create greater awareness for pulse ingredient applications in China."

An end result of new and healthier food products for Chinese consumers would also translate into significant benefits for the Canadian pulse industry. In 2009, China's annual sales of locally produced biscuits and cookies alone was approximately $10 billion CAD, which means that capturing even part of the Chinese staple food market could dramatically increase demand for Canadian pulses and value-added flour products, especially given Canada's strong export partnership with the country.

"China's imports of peas have increased from 50,000 tonnes per year to just under one million tonnes in recent years. During this growth, Canada has been able to maintain more than 90 per cent market share in China's pea imports," Der says. "So we know that Canadian growers and exporters are very well positioned to capture incremental market demand resulting from this research."

CHINESE RESEARCHERS LEARNING ABOUT THE PROPERTIES OF PULSE-BASED FLOURS IN PRODUCTS



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