Enhancing World Markets for Canadian Pulses through Secondary Processing and Value Added Research

SPG Project # PRO1008

Final Progress Report: Year 5 (August 1st, 2014 – July 31st, 2015)

Submitted to:

Saskatchewan Pulse Growers and Manitoba Pulse and Soybean Growers

By:

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1. Introduction

In 2006, Cigi partnered with the Saskatchewan Pulse Growers and the Manitoba Pulse and Soybean Growers to undertake processing and value-added research on pulses. The overall goal of this research is to enhance Canada's image as a supplier of quality pulses and to support the domestic industry in value-added initiatives. In 2010, funding for the Enhancing Market Opportunities for Canadian Pulses Project was renewed for an additional five years. The project is designed to include applied research and responsive industry support activities that is focused on the assessment of pulse quality, processing and the utilization of pulses as ingredients in processed food products. Direction and feedback on project activities are provided by an Industry Advisory Committee comprised of pulse grower groups, academia, pulse breeders and representatives from the pulse and food processing industries. Results from this project provide technical information that can be used to support not only value-added initiatives and breeding efforts, but the promotion of Canadian pulses in domestic and international markets. By undertaking market-responsive applied research it is possible to diversify markets and promote Canadian pulses on the basis of their intrinsic quality characteristics.

This document represents a final report under the current funding agreement with SPG and MPSG however, partial funding for the activities in this report is secured until 2018 under the AAFC – Agricultural Innovation Program. Additional industry funding will need to be secured to continue most applied research outlined in this report and future pulse value chain support and technical marketing efforts.

2. Abstract/Summary

Since 2006 the Canadian International Grains Institute (Cigi) has been providing support to the Canadian pulse value chain by leading applied research and value added initiatives with pulse crops under the Enhancing Market Opportunities for Canadian Pulses Project. On an annual basis Cigi conducts activities with a focus on assessing pulse quality, pulse processing methods and also conducts investigations in the utilization of pulse ingredients in processed food products. The overall objectives of these activities are to enhance Canada's image as a supplier of quality pulses and to support the domestic industry in value-added initiatives.

In the current year, dedicated Cigi staff in the pulse department have focused on applied research activities that assessed the effects of growing location and variety on the quality of peas and lentils. Through this activity Cigi was able to provide information to pulse breeders and stakeholders on the quality of peas and lentils produced in Canada and those grown in a competitors market. Information on the quality of Canadian pulses is of importance and has an effect on the marketability and subsequent demand of Canadian pulse crops.

Cigi has been investigating the effects of pre-milling seed treatments such as micronization and partial germination on the end product quality of processed food products. This work has generated information that is directed to the end users of pulse ingredients. The results provide food processors with the knowledge on how the pre-treated pulses will function in their food product formulations. This work directly benefits the end users of pulses by providing

information on how to harness additional benefits of pulse ingredients through the use of pre milling seed treatments and increases the awareness, confidence and demand for high quality Canadian pulse ingredients. Additionally, the Cigi pulse research team is in the second year of a four year research project that is focused on positioning pulses and pulse ingredients in the growing gluten-free processed food industry. As part of this activity Cigi is using pulses to create nutritionally improved high quality gluten-free processed food products to meet the needs of both consumers and manufacturers.

Over the years Cigi has transferred knowledge gained from pulse research activities throughout the entire pulse value chain to increase the efficiency of domestic pulse production and processing to creating opportunities for value added initiatives for Canadian pulses. Continued support from SPG and MPSG over the past decade has enabled Cigi to maintain a high level of pulse research activity in direct support of Canadian producers and the pulse industry.

3. Industry Advisory Committee

The Industry Advisory Committee meeting was held on January 12th, 2015 in Saskatoon, SK. Committee members in attendance included:

R. Newkirk, Cigi (Chair)
J. Buth, Cigi
P. Frohlich, Cigi
G. Boux, Cigi
C. Potts, SPG
A. Fletcher, SPG
L. Mascarenhas, SPG
T. Warkentin, CDC
R. Tyler, University of Saskatchewan
G. O'Hara, Parrheim Foods
M. Pickard, Infraready Products Ltd
M. Tulbek, Alliance Grain Traders
M. Hughes, Best Cooking Pulses (via conference call)
L. Fischbuch, APG (via conference call)
T. Der, Pulse Canada (via conference call)

4. Progress Report on Project Activities:

Note: Activities for which work will continue following this reporting period are documented using a project progress section. These activities have current but partial funding secured through the
AAFC – Agricultural Innovation Program.

4.1 Quality assessment of extruded snacks, pasta and noodles made with pre-cooked (micronized) pulse flours

(Additional funding for this project was obtained from AAFC – Agricultural Innovation Program)

Background and Objectives

Infrared cooking technology, also referred to as micronization, is a process designed to improve the nutrition, palatability and flavour profile of cereal grains and pulses. However, the effects of this treatment on the end quality of processed food products is unknown. The overall objectives of this activity are to test the effects of micronization on the end product quality of spaghetti, extruded snacks and Asian noodles. During the current reporting period various pulses were micronized and then milled into flour. Micronized and untreated pulse flours were blended with durum semolina, extruded into spaghetti, dried and then assessed for quality

Purpose

Micronization has become a pre-treatment of interest within the food industry due to the numerous compositional and functional benefits the treatment imparts on the raw grains. This specific heat treatment effects flour functionality and can reduce the undesirable flavours often found in raw pulses. This is of a specific interest to the food industry as flavour serves as one of the largest barriers to the increased utilization of pulse ingredients. Results from this activity provide food processors with current knowledge on how micronized pulses will function in their food product formulations and what the effects are compared to the untreated flours, increasing awareness, confidence and demand for high quality Canadian pulse ingredients.

Materials and Methods

Flour Preparation

Yellow peas, red and green lentils, chickpeas and navy beans were sourced from commercial suppliers. Pulses were micronized at InfraReady products in Saskatoon using commercial settings and methodology. Micronized and untreated pulses were pin milled at Cigi using a Hosakawa Alpine 100 UPZ pin mill set to 22,000 rpm.

Spaghetti processing

Pulse flours were blended with durum semolina at a ratio of 30:70. Spaghetti was extruded using a Namad Lab Scale Extruder and dried using a high temperature drying cycle using a Buhler batch drier. Colour of dried spaghetti was determined using a Minolta CR-310 Colorimeter. Cooking time, coking loss and cooked spaghetti firmness were determined according to the AACCI Method 66-50 Pasta and Noodle Cooking Quality. Statistical analysis of spaghetti samples was carried out using the ANOVA and Tukey – Kramer Multiple Comparison Test. A 100% durum semolina spaghetti was used as a reference.

Results and Discussion

Flour Analysis

Functional and compositional characteristics of micronized and untreated pulse flours are presented in Table 1. Differences between the functional properties of untreated and micronized flours were detected. Micronized flours exhibited unique pasting profiles and emulsifying capacity values when compared to untreated samples. Analytical properties in the micronized flours exhibited a lower moisture content compared to the raw flours due to the applied dry heat treatment. Increased peak viscosity was also observed in the micronized flours and could be attributed to the larger flour particle size and starch gelatinization during the thermal processing. A decrease in emulsion and foaming capacities in the micronized flours indicate denaturing of the protein during micronization.

Table 1. Compositional and functional properties of untreated and micronized pulse flours.

	Untreated Flours					Micronized Flours				
	Yellow pea	Red lentil	Green lentil	Chickpea	Navy bean	Yellow pea	Red lentil	Green lentil	Chickpea	Navy bean
PULSE FLOUR (db)										
Moisture, %	9.3	10.3	9.4	9.1	9.4	7.2	8.2	7.6	7.6	7.4
Protein Content, %	22.4	28.4	29.3	24.1	26.0	22.5	28.4	28.7	23.6	26.0
Ash Content, %	2.6	2.7	2.9	3.2	4.0	2.6	2.7	3.0	3.3	4.0
Total Starch Content, %	48.5	44.9	44.8	36.5	36.5	49.2	43.5	43.4	34.7	35.7
Minolta Colour - L*	74.7	58.8	64.4	66.0	75.2	74.3	60.2	63.3	66.6	75.7
a*	1.0	7.6	-0.5	4.7	1.7	2.5	7.7	0.3	3.4	1.6
b*	31.0	19.3	26.3	21.6	13.3	33.5	19.5	24.8	22.7	15.4
RVA Pasting profile										
Peak Viscosity, RVU	128.0	141.0	146.0	85.0	102.0	183.0	202.0	168.0	88.0	139.0
Hot Paste Viscosity, RVU	115.0	132.0	137.0	82.0	99.0	155.0	168.0	144.0	81.0	135.0
Breakdown, RVU	13.0	9.0	10.0	2.0	3.0	28.0	34.0	24.0	7.0	3.0
Final Viscosity, RVU	181.0	218.0	222.0	109.0	145.0	267.0	259.0	232.0	108.0	218.0
Setback, RVU	66.0	86.0	86.0	27.0	46.0	112.0	91.0	87.0	27.0	83.0
Pasting Time, min	4.9	4.9	5.2	5.8	6.7	5.1	4.9	5.0	6.0	6.4
Starch Damage, AI										
Starch Damage, %	1.4	1.7	1.9	0.8	0.7	1.4	1.2	1.3	0.7	0.6
Water abs capacity (g water/g fl)	1.2	1.6	1.1	1.2	1.5	1.2	1.3	1.2	1.3	1.4
Oil abs capacity (g oil/g fl)	0.9	0.9	0.9	1.0	0.9	0.9	0.9	0.9	0.8	0.9
Foam capacity	51.0	33.0	27.5	32.0	30.0	29.0	38.0	14.5	11.0	26.0
Foam stability										
10 min	88.3	89.4	97.1	84.7	100.0	88.3	92.2	91.6	80.4	89.2
30 min	71.7	84.7	89.6	51.3	85.0	75.4	76.5	89.2	67.0	85.8
60 min	33.3	72.8	76.5	30.8	55.0	57.3	67.7	84.9	40.2	76.7
120 min	23.3	63.6	67.9	23.2	45.0	36.1	52.9	69.3	40.2	58.3
Emulsifying capacity										
Emulsifying activity	39.1	39.5	39.2	39.1	39.2	6.9	5.3	4.4	20.9	29.6
Emulsion stability	40.1	65.9	87.8	20.0	80.3	0.0	109.0	108.2	18.0	28.5
Mastersizer										
d(0.1) um	8.5	11.9	8.2	8.7	12.5	10.9	10.9	8.9	11.9	10.7
d(0.5) um	29.7	66.9	32.0	33.6	91.2	39.0	90.9	38.9	225.3	67.2
d(0.9) um	368.7	316.9	225.7	390.5	561.0	470.9	463.8	274.3	751.8	572.7
D[4,3] um	114.0	145.4	89.7	136.3	203.0	164.7	183.1	129.2	310.8	218.3

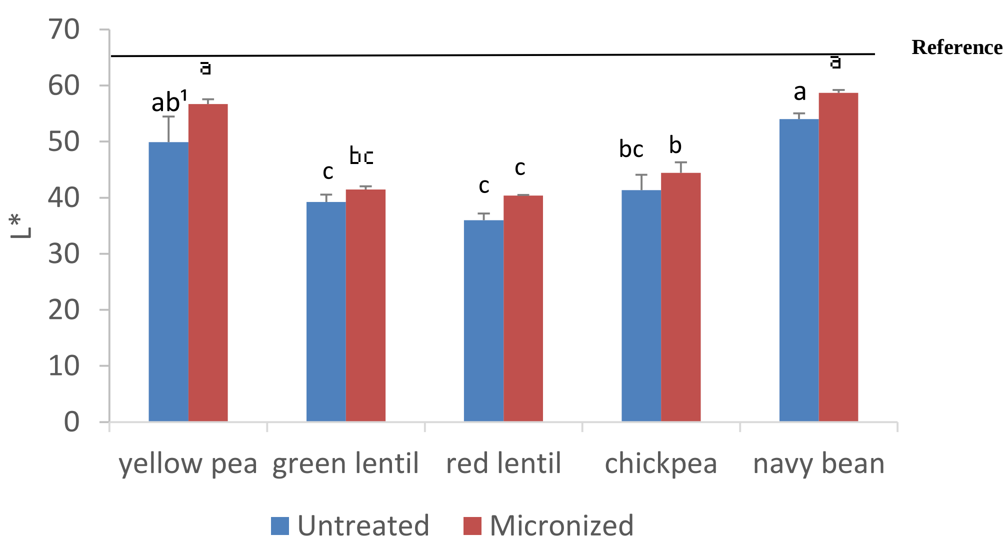
Spaghetti Quality Analysis

Colour

Figure 1. Dried untreated pulse flour spaghetti (top) with micronized pulse flour spaghetti (bottom) and a semolina control (center). L to R: yellow pea, green lentil, red lentil, chickpea, navy bean

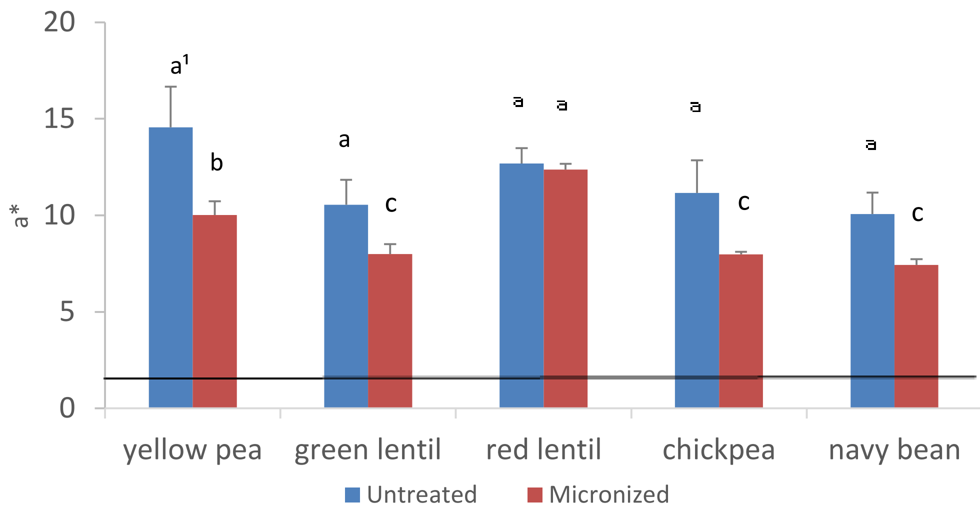
Spaghetti made using micronized pulse flours exhibited an increase in brightness represented by higher Minolta L* values following drying (Figure 2). Spaghetti redness values were lower for the micronized samples than the untreated samples (Figure 3). Spaghetti yellowness values, were lower for the untreated samples when compared to the micronized samples with the exception of spaghetti made using chickpea flour (Figure 4).

Figure 2: Minolta colour L* values of dry spaghetti made with 30% untreated and micronized pulse flours.



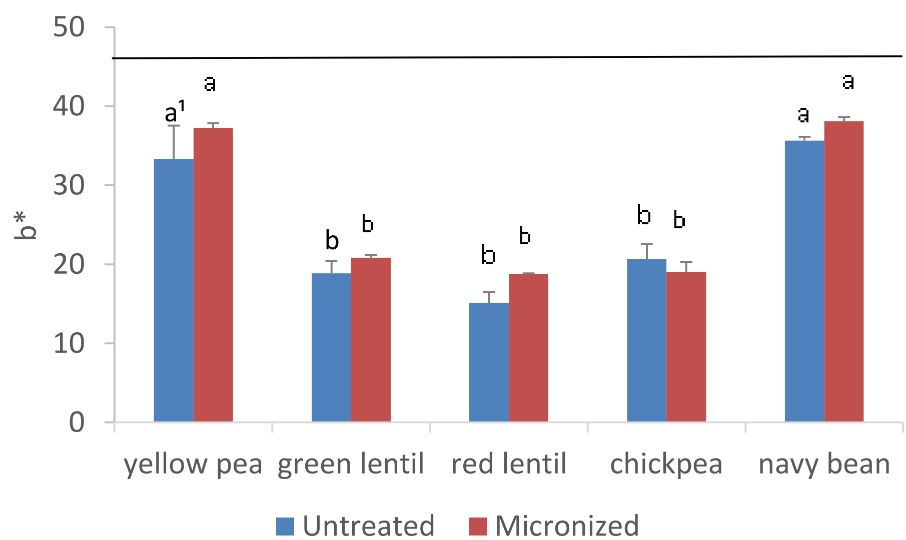
[1]Values with the same letter are not significantly different at ($p \leq 0.05$)

Figure 3: Minolta colour a* values of dry spaghetti made with 30% untreated and micronized pulse flours



[1]Values with the same letter are not significantly different at ($p \leq 0.05$)

Figure 4: Minolta colour b* values of dry spaghetti made with 30% untreated and micronized pulse flours.



[1]Values with the same letter are not significantly different at ($p \leq 0.05$)

Cooking Time

Differences in the cooking times of micronized and untreated pulse spaghetti were minimal and ranged between 9.9 – 10.5 minutes for the untreated spaghetti and 9.8 – 10.5 for the micronized samples.

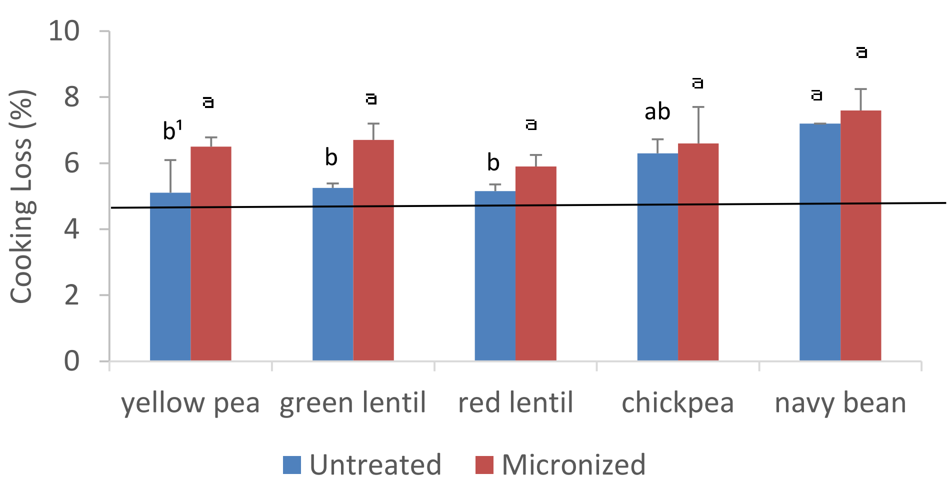
Table 2. Cooking time of dried spaghetti made with 30% untreated and micronized pulse flours

Cooking Time (min)	Untreated Pulse Flour	Micronized Pulse Flour
Reference	11.0 ± 0.35a	11.0 ± 0.35a
Yellow pea	10.5 ± 0.0a	9.8 ± 0.35a
Green lentil	10.3 ± 0.35a	10.0 ± 0.0a
Red lentil	9.9 ± 0.35a	10.5 ± 0.0a
Chickpea	10.5± 0.0a	9.8 ± 0.0a
Navy bean	10.5 ± 0.0a	10.3 ± 0.35a

[1]Values with the same letter are not significantly different at ($p \leq 0.05$)

Cooking Loss
Micronized spaghetti samples showed an increase in cooking loss when compared to untreated samples that ranged from 6.7-8.0% and 4.4-7.2% respectively. Highest cooking loss values were detected in spaghetti made using navy bean flour (Figure 5).

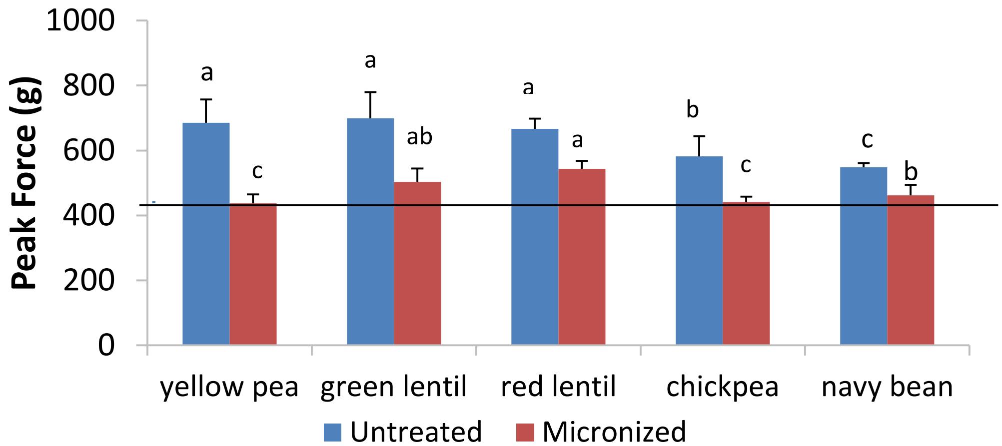
Figure 5: Cooking loss of spaghetti made with 30% untreated and micronized pulse flours



[1]Values with the same letter are not significantly different at ($p \leq 0.05$)

Instrumental Texture (Firmness)
Firmness of micronized spaghetti represented by peak force required to instrumentally shear the samples (following cooking for 10 minutes) was lower (437.2 – 543.3 g) compared to the untreated pulse spaghetti (548.3–699.2g). Within the micronized samples, spaghetti made using red lentils showed the highest firmness values following 10 minutes of cooking (Figure 6).

Figure 6: Firmness (g) of spaghetti made with 30% untreated and micronized pulse flours following cooking for 10 min



[1]Values with the same letter are not significantly different at ($p \leq 0.05$)

Conclusion

Results from this work show that pre-cooking or micronizing pulses using infrared technology prior to flour milling has an effect on the quality of spaghetti. Treating the pulses with infrared heat altered the functional properties of the flours specifically pasting profile and emulsifying capacity. Micronization improved spaghetti colour, specifically the brightness of the spaghetti. The amount of loss following cooking was increased for the micronized samples and the texture of the cooked spaghetti was decreased. Differences in cooking time between the treated and untreated spaghetti were not detected but as expected cooking times were lower for pulse spaghetti as compared to 100% durum semolina spaghetti.

Information generated by this activity will be transferred to the industry in a research poster at the 2015 AACCI meeting to inform potential end users of the effects of micronized pulse flours will have on the quality of spaghetti and other processed food products.

4.2 Characterization of pulse fractions derived from Canadian pulses

(Additional funding for this project was obtained from AAFC – Agricultural Innovation Program)

Background and Objectives

Protein isolates and concentrates are increasingly being used as ingredients in food products to increase nutrition and functionality of processed foods. Cigi's lab-scale air classifier is dedicated to processing pulse flours to understand processability of the flours and the function and composition of resulting protein and starch fractions. The objectives of this activity are to determine the processabillity of pulse flours during air classification with a current focus on pea and faba bean flours.

Purpose

Plant based protein fractions are important ingredients in the food industry as they increase the nutritional properties and improve functional characteristics of processed foods. Soy protein concentrates and isolates are heavily used in the food industry however processors are attempting to move away from these ingredients due to their allergenic properties. Pulse proteins are not considered allergenic ingredients and therefore have the potential to function in an increased capacity in processed foods. Pulse ingredients can potentially replace allergenic soy based ingredients in certain markets. Through this activity Cigi is building knowledge focused on the functional characteristics of pulse proteins as substitutes to soy proteins in order to increase the marketability of pulse ingredients.

Project Update

During the current reporting period pulses were sourced from commercial suppliers. Pulses were

pre-ground using a hammer mill and then milled to a fine flour using a pin mill. Pulse flours were air classified into coarse and fine fractions and assessed for composition and functional properties. Higher pulse protein fractions were achieved following air classification when compared to the original flours. However, protein contents of these fractions were much lower than expected and ranged between 28.0 to 31.5% protein. In this study, lower protein values were a result of the presence of hull fraction in the flour prior to air classification. It was concluded that the hull fraction needs to be removed prior to air classification to achieve higher protein concentration in the fine fraction.

In subsequent work, yellow peas and faba beans were dehulled, pre-ground and milled into a fine flour. The protein concentrate values for the pea and faba bean concentrates were increased to 48.4-68.7% respectively.

Table 3 shows the protein concentrations of the fine fractions following air classification of pea and faba bean flours. The data indicates that as the pin mill speed is increased the protein concentration increases in the fine fraction. However, with higher air classifier speeds the yields of the fraction decrease. Air speed settings at 46m^3/h during fractionation yielded higher protein concentrations for pea protein whereas a setting of 60m^3/h was more favorable for fractionating faba bean flour.

Table 3. Effect of air classifier speed and air flow on the protein content of the fine fraction from pea and faba bean flours

Sample	Pea Protein (%)	Faba Bean Protein (%)
Flour at start	22.8	33.5
46m^3/h 4k rpm Fine (F)	22.1	34.2
46m^3/h 6k rpm F	27.2	58.8
46m^3/h 8k rpm F	42.1	67.8
46m^3/h 10k rpm F	48.4	67.8
60m^3/h 4k rpm F	22.6	33.4
60m^3/h 6k rpm F	22.7	46.3
60m^3/h 8k rpm F	31.3	62.4
60m^3/h 10k rpm F	44.4	68.7

Future Activities

Additional work as part of this activity will include the assessment of compositional and functional properties of pea, faba bean and soy protein concentrates. Compositional properties that will be assessed will include protein, starch and total dietary fibre and functional tests will include RVA pasting profile, oil absorption capacity, foam capacity, foam stability, emulsification capacity and particle size analysis. Selected pulse fractions will be incorporated in food product formulations and assessed for end product quality. A focus will be placed on those products where the soy fraction can be replaced by a pulse fraction.

4.3 Influence of functional ingredients on the quality of extruded snacks made with pea flour

(Additional funding for this project was obtained from AAFC – Agricultural Innovation Program)

Rationale and Objectives

Processing pea flour using a twin-screw cooking extruder has been shown to produce an acceptable good quality directly expanded snack. Functional ingredients, when added to the existing water and pea flour based formulation can further improve the quality of the extruded snacks. The objectives of this study are to measure the effects of functional ingredients (salt, sugar, fibre and starch) on the end product quality of pea flour based snacks and to determine optimum levels of each functional ingredient in order to produce a high quality commercially viable directly expanded extruded snack product.

Purpose

Extrusion processing is a very efficient system to produce snacks, breakfast cereals and other ready to eat products. Using pulse flours to replace traditional corn ingredients is an excellent way to improve nutrition and functionality of these foods. The purpose of this activity is to provide information to food extrusion processors on how to effectively and efficiently use pea flour as an ingredient in extruded products and ultimately increase the level of utilization of pulse flours in these foods.

Project Update

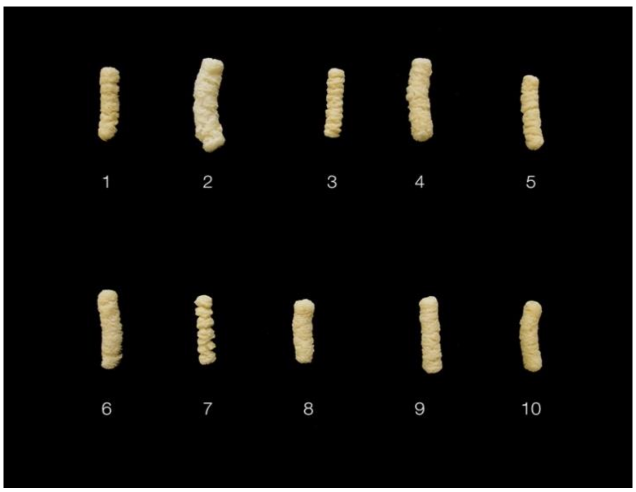
Dehulled yellow pea flour was sourced from a commercial supplier along with pea hull fibre, pea starch, sugar and salt. Treatments were prepared using 100% yellow pea flour blended with various combinations of functional ingredients as pre-determined by the Response Surface 2FI model. The treatments were extruded using a Clextral EV 25 cooking extruder and assessed for quality by measuring expansion ratio, bulk density, instrumental texture (assessed using a TA.HD plus texture analyzer where peak counts represent crispiness and linear distance between the peaks represents crunchiness of the snacks). Data was analyzed using the Design of Experiment Software and using ANOVA for Response Surface models.

Initial results using the Response Surface 2FI model indicate that expansion ratios of the snacks were decreased following the addition of sugar and fibre. Bulk density of the snacks was increased with the addition of fibre and sugar (there was an interaction between sugar and fibre in the model).

Addition of sugar to the formulation had a positive significant effect on the crispiness (peak counts) of the snacks. Products with a higher inclusion of sugar had a crispier texture than the

products with lower added sugar. Inclusion of starch and fibre have negative effects on crispness (There were no significant interactions found between any factors for crispness) Sugar was the only factor found to have a significant effect on crunchiness of the snacks (linear distance between the compression peaks measured instrumentally). With increased additions of sugar the snacks were crunchier. An interaction between sugar and fibre was also found on the crunchiness of the products.
Figure 7 represents selected images of extruded snacks with combinations of added salt, sugar, fibre and starch. The figure demonstrates the magnitude of the effects that the functional ingredients have on the end product quality of directly expanded extruded snacks.

Figure 7. Selected extruded snacks processed using pea flour and combinations of various amounts of salt, sugar, starch and fibre.



Future Activities
Future work on this activity will incorporate the findings from Response Surface 2FI model into a pilot processing exercise to optimize extruded snack formulation using functional ingredients. This knowledge will be transferred to the industry as a means to promote the use of pulse ingredients in extruded snack formulations. Additionally, Cigi will use optimized pea flour extruded products as promotional items during industry events to represent the benefits and versatility of Canadian pulses as ingredients in processed foods.

4.4 Effect of genetics and environment on the compositional, cooking quality and hydration characteristics of peas and lentils

(Additional funding for this project was obtained from AAFC – Agricultural Innovation Program)

Background and Objectives
This activity is a continuation of previous research that investigated the influence of seed composition on the sensory (odour and flavour) characteristics of peas and lentils. In collaboration with the Crop Development Centre (CDC) and Department of Environment and

Primary Industries (DEPI) in Australia, Cigi acquired Canadian and Australian pea and lentil varieties grown in different locations within the respective regions. Cigi's objectives in the current activity were to assess the cooking and hydration properties of the samples. DEPI in Australia was tasked with determining the composition of the pea and lentil varieties.

Purpose

Hydration and cooking time of peas and lentils are considered measures of pulse quality in certain markets. Understanding and optimizing these properties can have an effect on the marketability and demand for Canadian pulses. The purpose of this study is to investigate the effects composition and growing location can have on these quality characteristics. Additionally, assessing, understanding and addressing the quality differences between peas and lentils grown in Canada and Australia will help to gain a competitive advantage for Canadian pulses.

Materials and Methods

Canadian pea and lentil samples were provided by the CDC in Saskatoon, SK. The sample set included 20 varieties of peas and lentils (10 peas and 10 lentils) grown in Meath Park and Sutherland SK. Peas and lentils were seeded in May 2013 and harvested in September 2013. Australian pea and lentil samples were provided by DEPI in Horsham, Victoria. This sample set included 13 varieties of peas (not replicated) and 14 varieties of lentils grown in Horsham. Peas and lentils were seeded in May 2013 and harvested in December 2013.

Initial moisture content (MC), Water Hydration Capacity (HC), Unhydrated Seeds (US) and Firmness of Cooked Pulses was determined according to AACCI methods 44-15.02, 56-35.01 and 56-36.01 (firmness) respectively and 100-Seed weight was measured on all samples. Dehulled samples that included whole peas and whole red lentils were dehulled using a Satake Grain Testing Mill according to the method of Black et al (1998) with modifications . Hydration rate (HR) at set time intervals (30 min) was determined according to the method generated by An et al (2009) with modifications. Cooking time of peas and lentils was determined according to the Australian Pulse Quality Laboratory Manual (2001) method APQ 102.1 with modifications.

Results and Discussion

MC of peas ranged from 9.3 - 10.1% and no significant differences were found in the MC of samples in the yellow or green pea market classes. Seed weight ranged from 20.5 g (red pea, CDC 2710-1) to 27.3 g (green pea, CDC Striker) when assessing all pea varieties. Within the green pea market class, CDC Limerick had a significantly lower 100 seed weight than CDC Greenwater and Striker. Yellow pea variety CDC Golden and Meadow had a significantly lower seed weight than variety CDC Saffron which had the highest seed weight (Table 4).
Overall HC of peas ranged from 55.4% (green pea, CDC Striker) to 100.6% (red pea, CDC 2710-1). No significant differences were found within yellow pea market class for HC. Within green peas, CDC Greenwater hydrated significantly more over a 16 h period compared to CDC Striker and also had the least amount of US (Table 4).

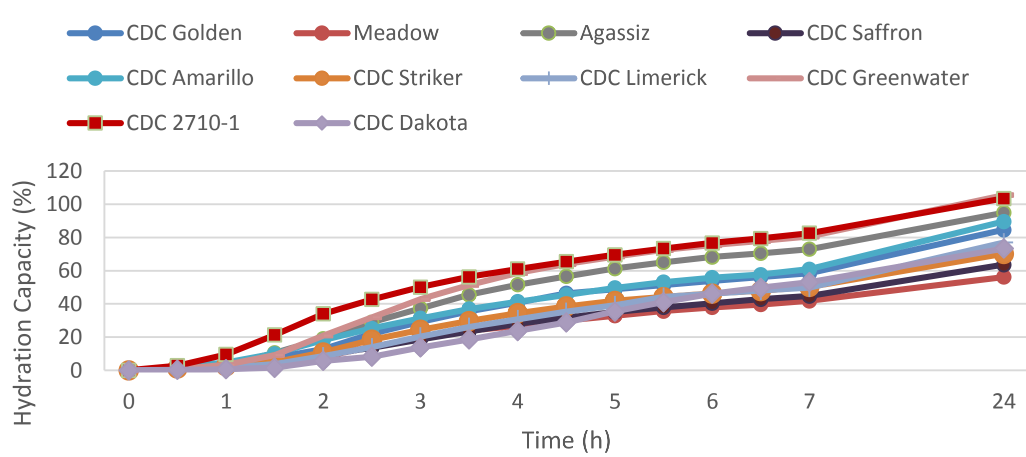
Table 4. Initial Moisture Content, 100-Seed Weight, Hydration Capacity and Unhydrated Seeds of Peas Grown in Canada

Type	Variety	MC (%)	100 Seed Weight (g)	HC (%)	US (%)
Yellow	CDC Golden	10.1 ± 0.4a[1]	23.6 ± 1.0b	79.4 ± 26.2a	29 ± 22.8a
Yellow	Meadow	9.8 ± 0.3a	23.1 ± 0.3b	66.9 ± 22.8a	33.8 ± 21.5a
Yellow	Agassiz	9.4 ± 0.2a	24.3 ± 0.3ab	93.0 ± 14.8a	14.5 ± 14.5a
Yellow	CDC Saffron	10.0 ± 0.3a	26.9 ± 2.7a	84.8 ± 21.7a	16.5 ± 11.1a
Yellow	CDC Amarillo	10.0 ± 0.4a	24.4 ± 1.1ab	78.2 ± 19.3a	21.5 ± 21.4a
Green	CDC Striker	10.2 ± 0.2a	27.3 ± 0.5a	55.4 ± 22.2b	41.8 ± 25.9a
Green	CDC Limerick	10.2 ± 0.2a	23.4 ± 0.6c	81.4 ± 19.7ab	17.3 ± 19.8a
Green	CDC Greenwater	9.7 ± 0.6a	24.7 ± 0.3b	92.8 ± 7.0a	10.8 ± 9.0a
Red	CDC 2710-1	9.3 ± 1.1	20.5 ± 0.7	100.6 ± 7.7	7.5 ± 9.6
Dun	CDC Dakota	10.1 ± 0.3	21.3 ± 2.1	69.4 ± 28.8	38.8 ± 26.0

[1]Values for samples from the same market class within a column and with the same letter are not significantly different at ($p<0.05$)

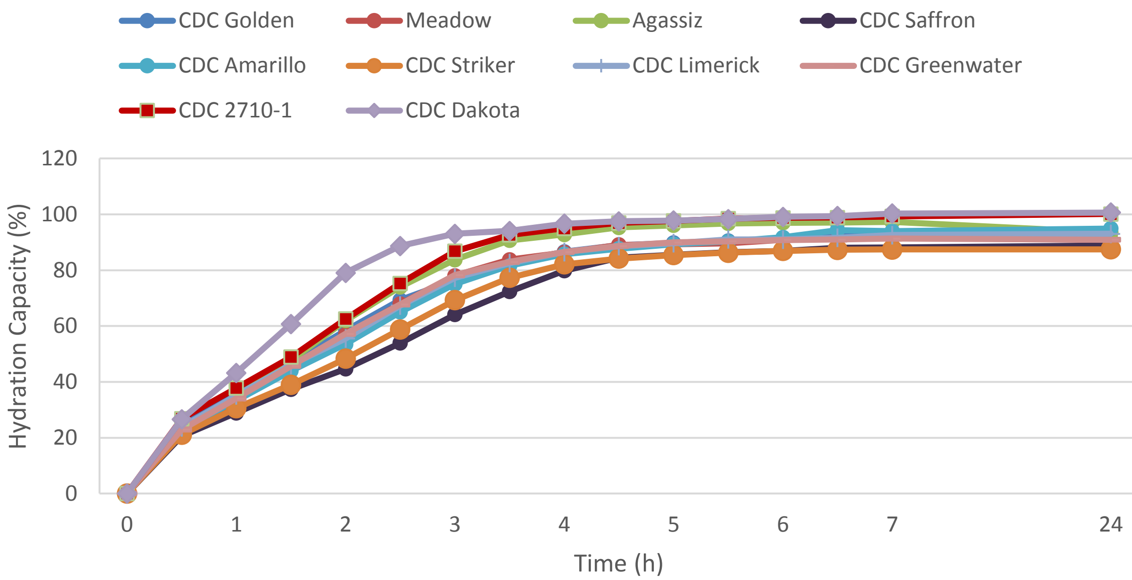
HR curves of whole peas are shown in Figure 8. Visual assessment of the curves indicates that the red pea, variety CDC 2710-1 exhibits higher HR values compared to all other varieties.

Figure 8. Hydration rate curves plotted as HC over time of whole pea varieties grown in Canada



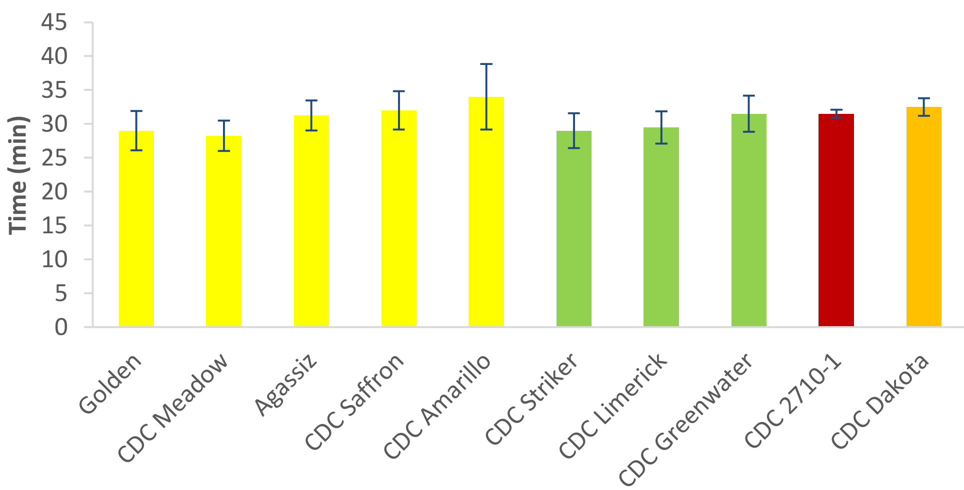
HR curves of dehulled peas are shown in Figure 9. Similar water absorbing trends for all pea varieties were detected with the exception of variety CDC Dakota. This variety exhibited a faster HR compared to all other dehulled pea varieties.

Figure 9. Hydration rate curves plotted as HC over time for dehulled pea varieties grown in Canada



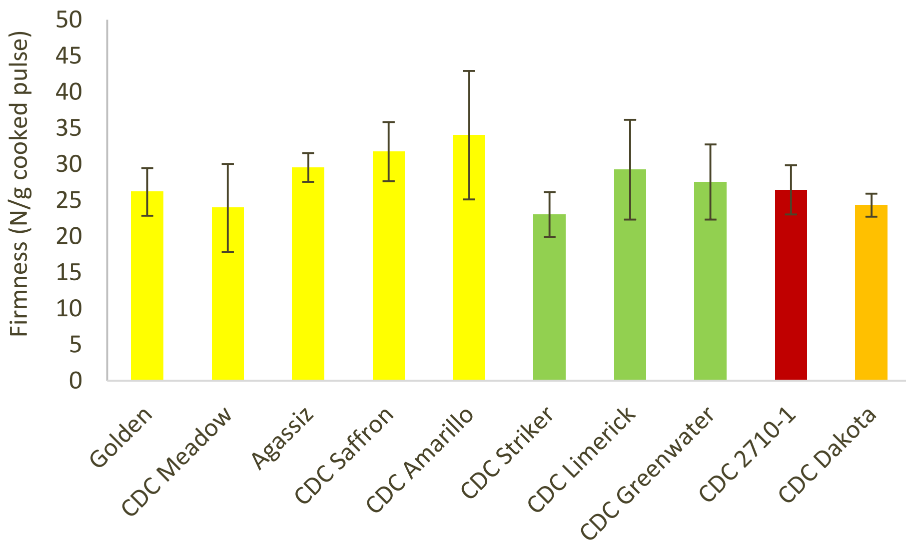
CT of split peas ranged from 29 min (CDC Golden and Striker) to 34 min (CDC Amarillo). No significant differences were found between CT any of the dehulled pea varieties (Figure 10).

Figure 10. Cooking times of dehulled pea varieties grown in Canada



Results of split peas cooked at 21 minutes and measured for texture (firmness) can be found in Figure 11. Firmness values ranged from 23.0 N for CDC Striker and 34.0 N for CDC Amarillo. No significant differences in cooked pea texture were found in the yellow pea or green pea samples.

Figure 11. Firmness of dehulled and cooked pea varieties grown in Canada



Location Effects

Peas grown in the Meath Park region of Saskatchewan had a significantly lower MC, HC, CT, cooked firmness values and a significantly higher amount of US compared to peas grown in the Sutherland region of Saskatchewan (Tables 5 and 6.)

Table 5. Effects of growing location on properties of whole peas grown in Canada

Test	Meath Park	Sutherland
Moisture Content	9.7 ± .5a[1]	10.1 ± .4b
100-Seed Weight	24.1 ± 2.4a	23.74 ± 2.3a
Hydration Capacity	64.8 ± 19.2a	95.6 ± 11.2b
Unhydrated Seeds	38.1 ± 17.8a	8.1 ± 8.0b

[1]Values within a row with the same letter are not significantly different at ($p \le 0.05$)

Table 6. Effects of growing location on properties of dehulled split peas grown in Canada

Test	Meath Park	Sutherland
Cooking Time	29.5 ± 2.8a[1]	32.3 ± 2.3b
Firmness	24.8 ± 3.8a	30.4 ± 5.7b

[1]Values within a row with the same letter are not significantly different at ($p \le 0.05$)

Canadian Lentils

MC values of all lentils ranged from 10.1- 10.9%. Seed weight of all lentil varieties ranged from 2.8 g (green lentil CDC Asterix) to 7.5 g (green lentil CDC Greenstar). Within the green lentils, Greenland and CDC Greenstar had a significantly higher seed weight compared to CDC QG-1 and CDC Asterix. Red lentil seed weight ranged from 3.0 - 5.2 g with CDC KR-1 weighing significantly more than all other red lentil varieties (Table 7).

HC for all lentil varieties ranged from 63.9% (red lentil, Ruby) to 97.9% (green lentil, Greenland). CDC Asterix had a significantly lower HC than the other green lentils and also the highest amount of US. Red lentil, CDC- KR 1 had a significantly higher HC than CDC Maxim, Redcliff and Ruby and the lowest amount of US, and Ruby had the lowest HC and highest amount of US (Table 7).

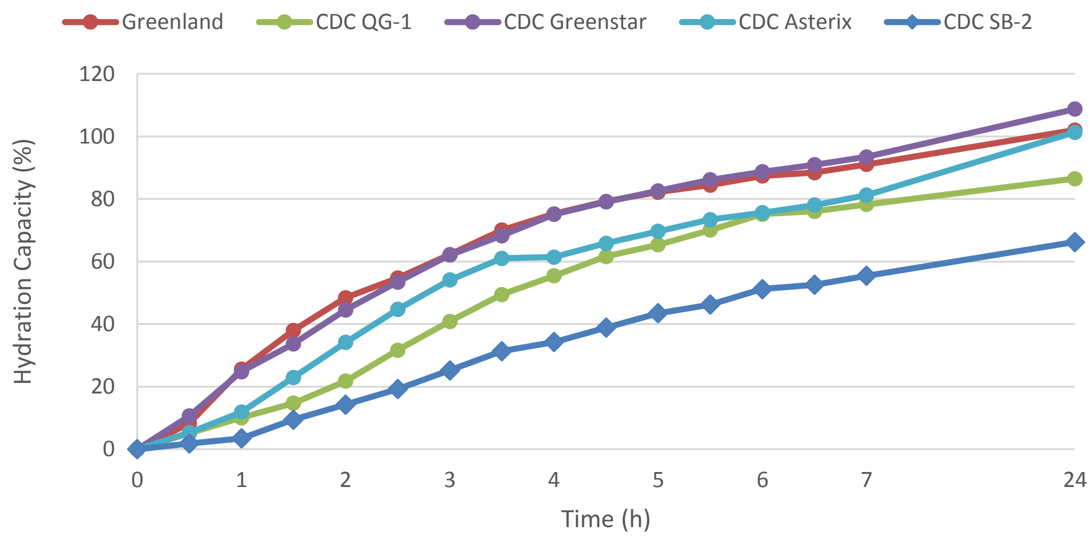
Table 7. Initial moisture content, 100-seed weight, hydration capacity and unhydrated seeds of Canadian grown lentils

Type	Variety	MC (%)	100 Seed Weight (g)	HC (%)	US (%)
Green	Greenland	10.2 ± 0.4a	7.0 ± 0.58a	97.9 ± 1.6a	1.0 ± 2.0a
Green	CDC QG-1	10.5 ± 0.2a	4.6 ± 0.24b	92.1 ± 6.1a	5.8 ± 4.1ab
Green	CDC Greenstar	10.4 ± 0.5a	7.5 ± 0.64a	96.8 ± 3.9a	0 ± 0ab
Green	CDC Asterix	10.1 ± 0.4a	2.8 ± 0.14c	75.5 ± 3.3b	13.0 ± 3.4b
Spanish Brown	CDC SB-2	10.5 ± 0.4a	3.83 ± 0.27	69.2 ± 5.2	23.8 ± 2.9
Red	CDC KR-1	10.6 ± 0.4a	5.2 ± 0.4a	72.2 ± 7.0b	18.5 ± 7.0a
Red	CDC Maxim	10.6 ± 0.6a	4.1 ± 0.1b	85.7 ± 2.9a	7.0 ± 6.8a
Red	Redcliff	10.9 ± 0.4a	3.9 ± 0.2b	71.7 ± 1.8b	14.5 ± 5.3a
Red	Ruby	10.4 ± 0.2a	3.0 ± 0.2c	63.9 ± 3.4b	29.1 ± 4.7a
Red	CDC Rosie	10.5 ± 0.4a	3.2 ± 0.1c	76.2 ± 9.8ab	15.2 ± 5.0a

[1]Values for samples from the same market class within a column and with the same letter are not significantly different at ($p<0.05$)

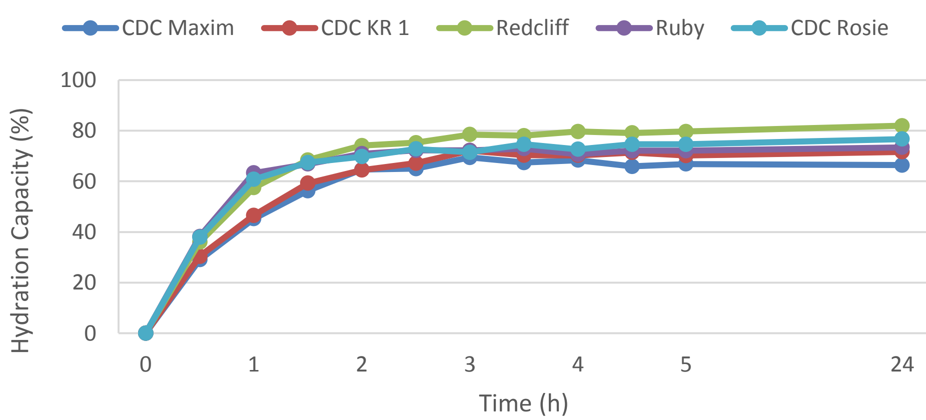
HR curves of whole lentils are shown in Figure 12. Green lentil varieties Greenland and CDC Greenstar exhibit curves with higher HR values when compared to the other lentil varieties.

Figure 12. Hydration rate curves of Canadian grown whole green and Spanish brown lentils



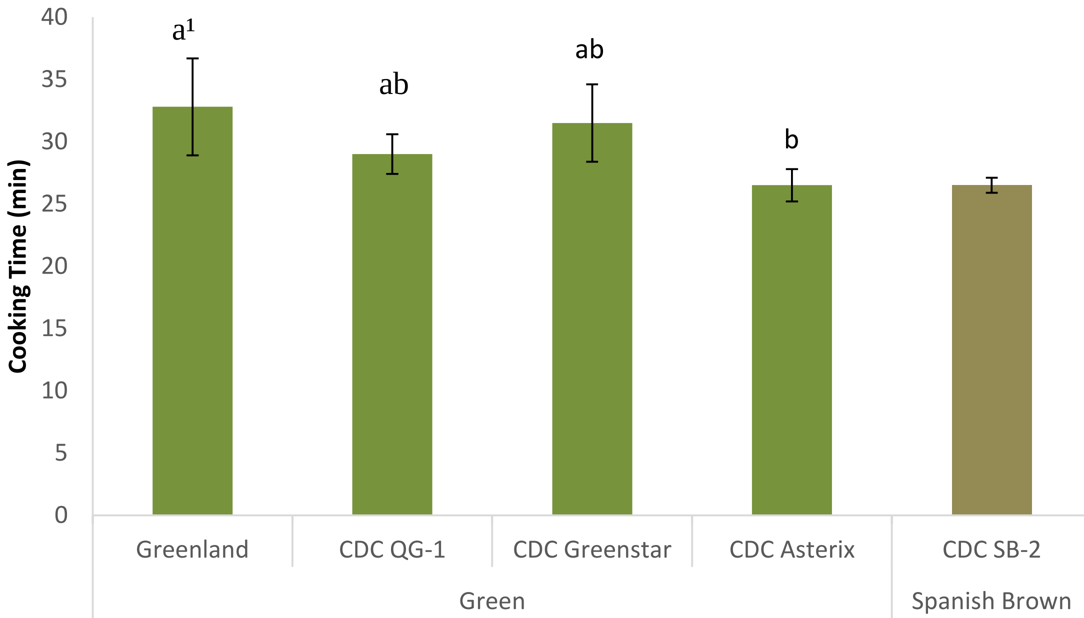
HR curves of dehulled red lentils are shown in Figure 13. The HR of dehulled red lentils show similar curves for all varieties.

Figure 13. Hydration rate curves of Canadian grown dehulled red lentils



CT of whole green and Spanish brown lentils ranged from 26.5 min (CDC Asterix and CDC SB-2) to 32.8 min (Greenland). Greenland had a significantly higher CT than CDC Asterix (Figure 14).

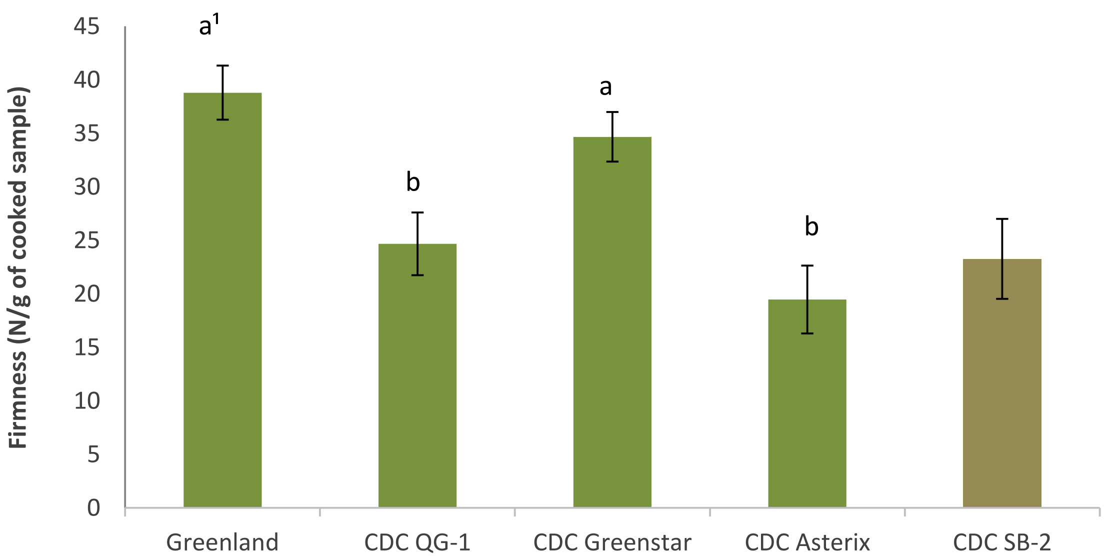
Figure 14. Cooking time of whole Canadian grown green lentils



[1]Values with the same letter are not significantly different at ($p \leq 0.05$)

Firmness of whole lentils was measured following 20 min of cooking. Firmness values ranged from 19.5 to 38.8 N. Greenland and CDC Greenstar were significantly more firm than CDC QG-1 and CDC Asterix and the Spanish brown lentil had a cooked firmness value of 23.3 N (Figure 15).

Figure 15. Firmness of cooked whole Canadian green and Spanish brown lentils



[1]Values with the same letter are not significantly different at ($p \leq 0.05$)

CT of dehulled red lentils ranged from 7.5 - 8.0 minutes. There were no significant differences detected among samples (Table 8).

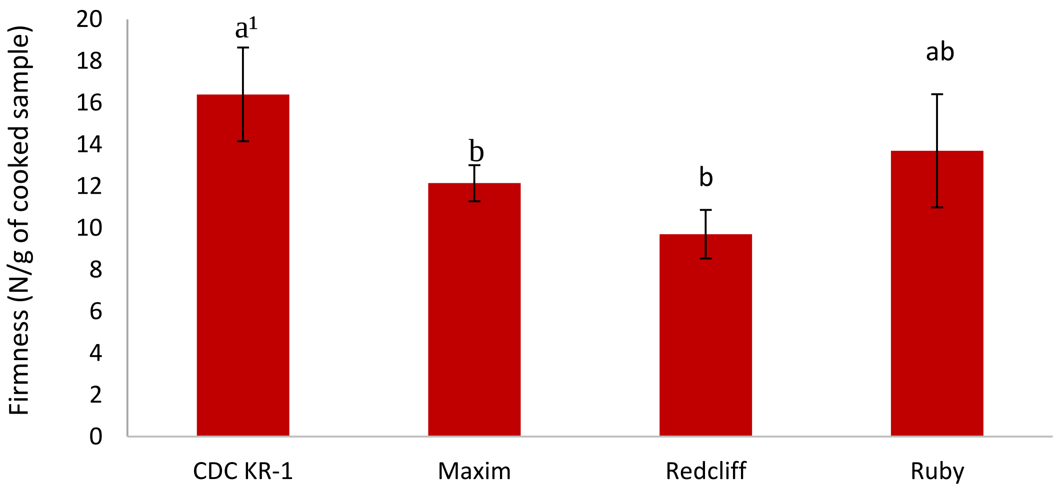
Table 8. Cooking time of Canadian grown dehulled red lentils

Type	Variety	CT (min)
Red	CDC Maxim	7.5 ± 0.6a[1]
Red	CDC KR 1	8.0 ± 0a
Red	Redcliff	8.0 ± 0a
Red	Ruby	7.8 ± 0.3a
Red	CDC Rosie	7.8 ± 0.5a

[1]Values within a row with the same letter are not significantly Different at ($p \leq 0.05$)

Firmness of split red lentils ranged from 9.7 to 16.4 N. CDC KR-1 was significantly more firm than Maxim and Redcliff following 20 minutes of cooking.
**Note: CDC Rosie was not assessed for cooked texture due to limited sample quantity*

Figure 16. Firmness of cooked dehulled Canadian grown red lentils



[1]Values with the same letter are not significantly different at ($p \leq 0.05$)

Location Effects

Lentils grown in the Limerick region of Saskatchewan had a significantly lower MC. Lentils grown in Sutherland had a lower seed weight, HC and US and higher CT and cooked firmness although values were not significantly different (Table 9).

Table 9. Effect of growing location on whole Canadian grown lentil characteristics

Test	Limerick	Sutherland
Moisture Content	10.3 ± .3a[1]	10.7 ± .3b
100-Seed Weight	4.7 ± 1.7a	4.3 ± 1.4a
Hydration Capacity	81.5 ± 12.0a	78.8 ± 13.1a
Unhydrated Seeds	12.3 ± 10.3a	13.2 ± 9.6a

[1]Values within a row with the same letter are not significantly different at ($p \leq 0.05$)

Table 10. Effect of growing location of whole and dehulled Canadian grown lentils on cooking time and firmness

Test	Limerick	Sutherland
Cooking Time	18.2 ± 10.5a[1]	18.9 ± 12.0a
Firmness	21.1 ± 10.0a	22.3 ± 10.1a

[1]Values within a row with the same letter are not significantly different at ($p \leq 0.05$)

Australian Peas

MC of peas grown in Australia ranged from 7.9 - 9.0%. Seed weight for all peas ranged from 20.0 g (green pea, CDC 2366-16) to 24.0 g (green pea, CDC Striker).
HC ranged from 93.0% (green pea, CDC Striker) to 103.3% (yellow pea, 2387-53). No US were observed among samples with the exception of PBA Wharton (Table 11).

Table 11. Initial moisture content, 100 -seed weight, hydration capacity and unhydrated seeds of peas grown in Australia[1]

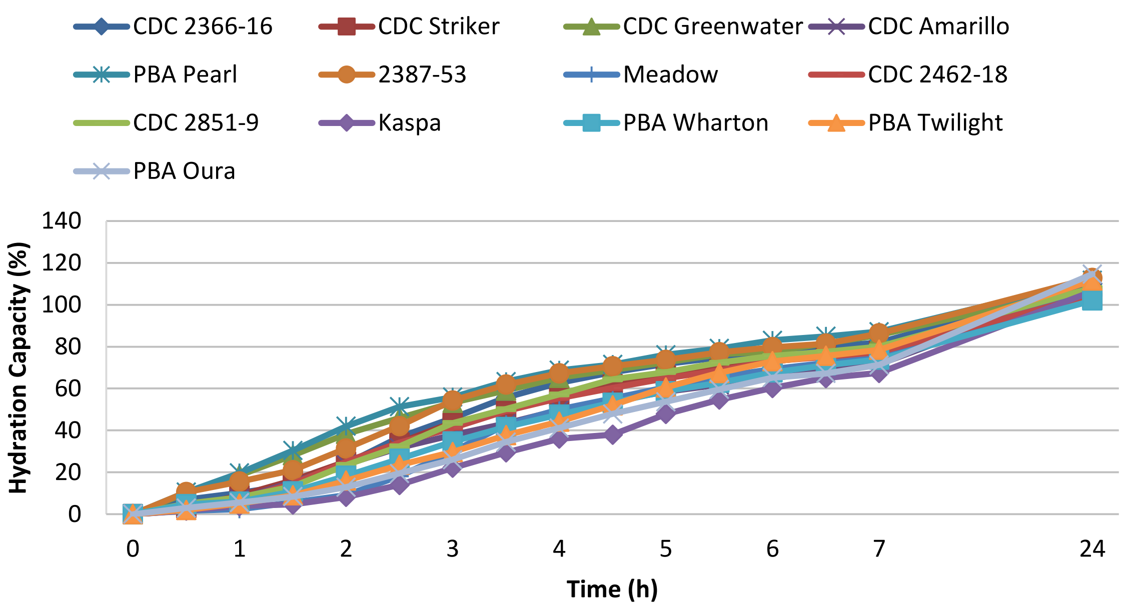
Type	Variety	MC (%)	100 Seed Weight (g)	HC (%)	US (%)
Green	CDC 2366-16	8.1	20.0	103.2	0
Green	CDC Striker	8.2	24.0	93.0	0
Green	CDC Greenwater	8.0	22.3	100.2	0
Yellow	CDC Amarillo	8.9a	22.8a	98.8ab	0a
Yellow	PBA Pearl	8.5a	23.0a	105.0a	0a
Yellow	2387-53	8.3a	21.3a	103.3ab	0a
Yellow	Meadow	9.0a	20.1a	100.5ab	0a
Yellow	CDC 2462-18	8.8a	22.7a	95.9b	0a
Yellow	CDC 2851-9	7.9a	21.9a	98.5ab	0a
Dun	Kaspa	8.2a	22.9b	100.3b	0a

Dun	PBA Wharton	8.8a	23.1b	99.2b	2.5a
Dun	PBA Twilight	8.9a	23.6b	102.5b	0a
Dun	PBA Oura	8.6a	26.1a	110.2a	0a

[1]Values for samples from the same market class within a column and with the same letter are not significantly different at ($p<0.05$)

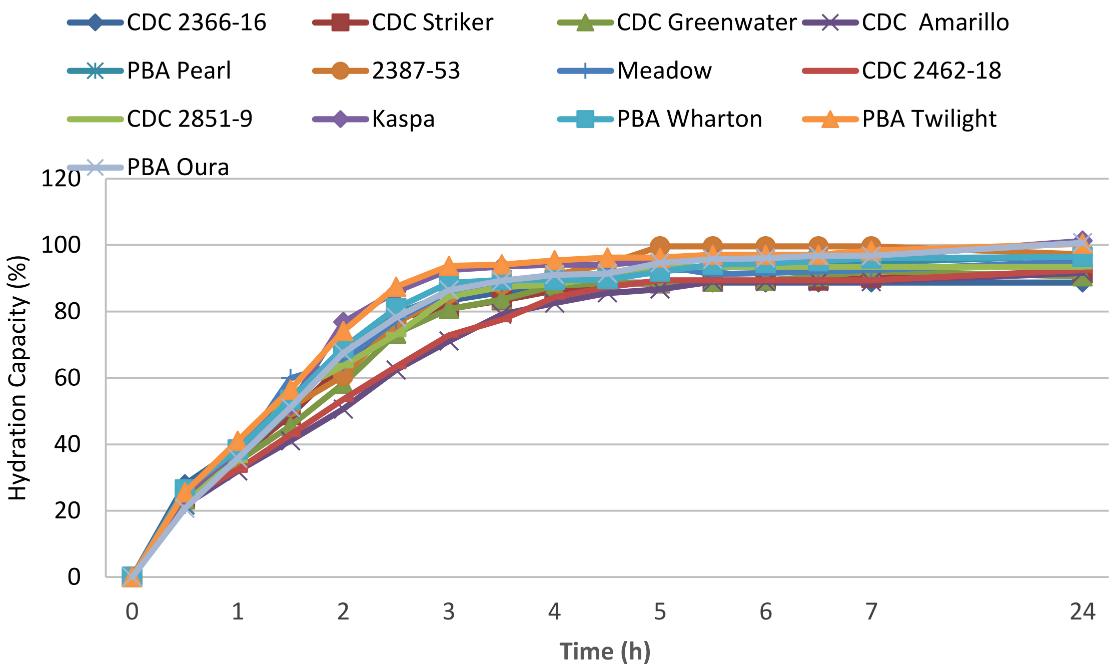
HR curves of whole peas are shown in Figure 17. Yellow peas PBA Pearl and 2387-53 absorbed the largest amount of water during testing and CDC Kaspa appears to have a delay in the onset and continuance of moisture absorption.

Figure 17. Hydration rate curves of whole Australian grown peas



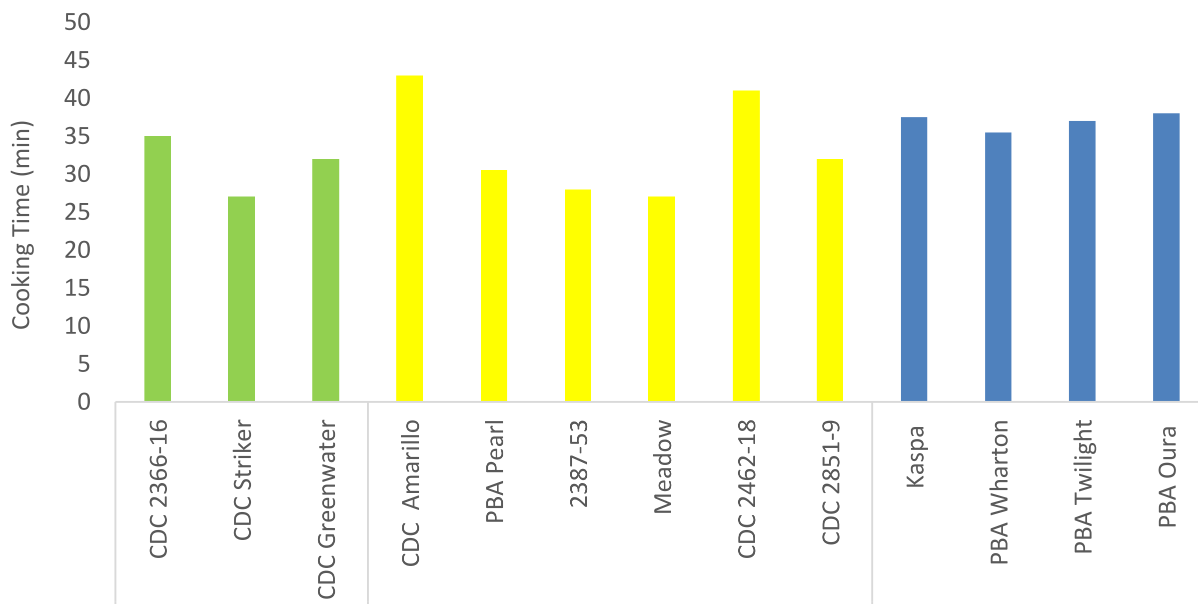
HR curves for Australian dehulled peas are shown in Figure 18. Australian grown pea varieties showed similar water absorption trends.

Figure 18. Hydration rate curves of dehulled Australian grown peas



CT of dehulled Australian peas ranged from 27 min (CDC Striker and Meadow) to 43 min (CDC Amarillo) (Figure 19).

Figure 19. Cooking time of Australian grown dehulled peas



Australian Lentils

MC of Australian lentils ranged from 7.8-8.9%. Green lentil CDC Sedley had a significantly higher MC than Matilda, although the difference was small. Red lentil Cassab had a significantly higher MC than CDC Rosebud, Rosetown or Northfield. Seed weight ranged from 2.0 g (Beluga lentil, Indian Head) to 6.3 g (green lentil, CDC Sedley) when observing all lentil varieties. Within the green lentils, CDC Sedley had a significantly higher seed weight compared to Matilda. Red lentil seed weight ranged from 2.4 to 4.3 g with CDC Redchief weighing significantly more than all other red lentil varieties, except Cassab, Cobber and CDC Redcoat (Table 12)

HC in all lentil varieties ranged from 72.1% (red lentil, CDC Rosetown) to 112.1% (red lentil, CDC Rosebud). Green lentil CDC Sedley had a significantly higher HC than Matilda. CDC Rosebud had a significantly higher HC than Northfield, CDC Blaze and CDC Rosetown. US were most prominent in the Northfield variety (7.0%) and were significantly higher than in red lentils CDC Ruby, CDC Robin, CDC Redcoat, Cassab, CDC Rosetown, Cobber and CDC Redchief (Table 12).

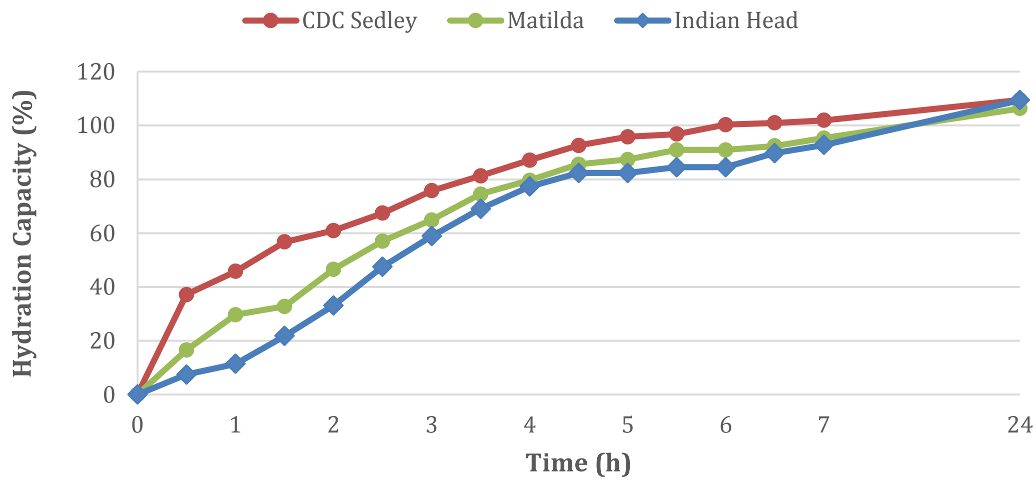
Table 12. Initial moisture content, 100 -Seed Weight, hydration capacity and unhydrated seeds of Australian grown lentils

Type	Variety	MC (%)	100 Seed weight (g)	HC (%)	US (%)
Green	CDC Sedley	8.2 ± 0.0a[1]	6.3 ± 0.11a	106.8 ± 0.12a	0.0 ± 0.0a
Green	Matilda	8.0 ± 0.07b	4.9 ± 0.04b	100.1 ± 0.72b	1.5 ± 0.7a
Beluga	Indian Head	7.8 ± 0.0	2.0 ± 0.04	98.8 ± 0.33	7.5 ± 0.7
Red	CDC Ruby	8.5 ± .21abc	2.5 ± 0.04f	96.4 ± 1.77a	2.5 ± 0.04ab
Red	CDC Robin	8.3 ± 0.35abc	2.4 ± 0.50f	104.5 ± 6.34a	2.5 ± 3.5ab
Red	CDC Redcoat	8.7 ± 0.35ab	3.8 ± 0.11abc	102.3 ± 3.23a	.5 ± 0.71b
Red	Cassab	8.9 ± 0.21a	4.2 ± 0.13ab	98.2 ± 2.14a	1.0 ± 1.41ab
Red	CDC Rosetown	8.1 ± 0.07bc	3.0 ± 0.11def	72.1 ± 8.70b	1.0 ± 1.41ab
Red	CDC Blaze	8.3 ± 0.14abc	3.5 ± 0.0bcd	89.4 ± 13.78ab	.5 ± 0.71b
Red	CDC Redbow	8.2 ± 0.0abc	2.8 ± 0.05ef	110.8 ± 5.94a	.5 ± 0.71b
Red	CDC Rosebud	8.1 ± 0.07bc	2.5 ± 0.07f	112.1 ± 4.7a	.5 ± 0.71b
Red	CDC Redwing	8.2 ± 0.21abc	3.3 ± 0.01cde	108.5 ± 4.86a	0.0 ± 0.0b
Red	Northfield (00-2,1)	7.8 ± 0.14c	2.8 ± 0.08ef	91.8 ± 3.96ab	7.0 ± 2.83a
Red	Cobber	8.1 ± 0.14abc	4.2 ± 0.16ab	101.0 ± 1.74a	1.5 ± 0.71ab
Red	CDC Redchief	8.5 ± 0.07abc	4.3 ± 0.13a	109.0 ± 3.0a	1.0 ± 1.41ab

[1]Values for samples from the same market class within a column and with the same letter are not significantly different at ($p<0.05$)

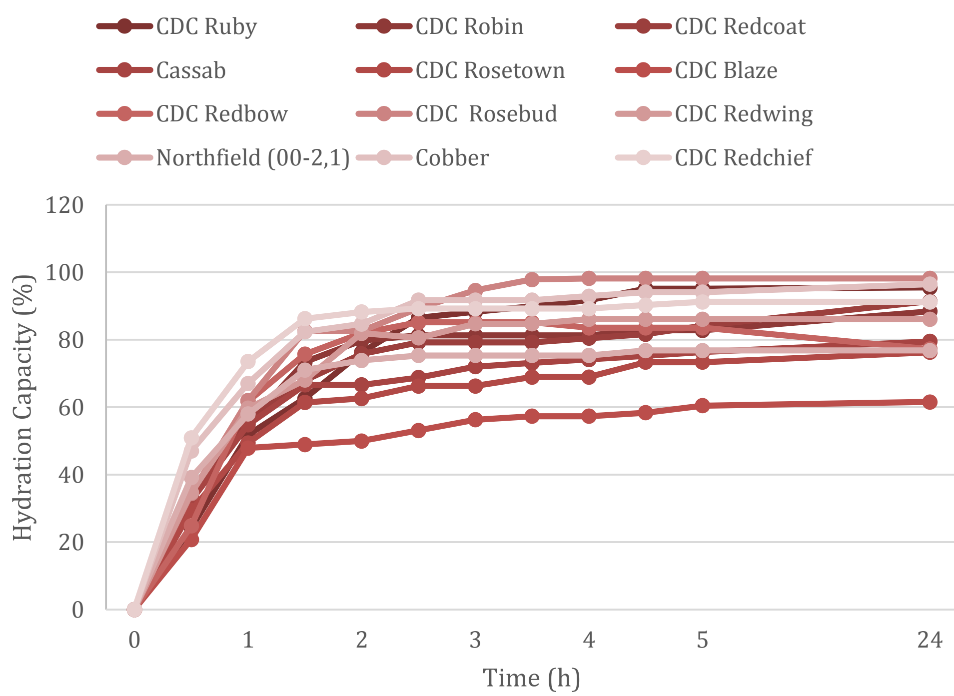
HR curves of whole lentils are found in Figure 20. CDC Sedley appears to have increased hydration rate during the first hour of soaking, compared to varieties Matilda and Indian Head.

Figure 20. Hydration rate curves of whole Australian grown green and Beluga Lentils



HR curves of dehulled red lentils are shown in Figure 21. Variety CDC Blaze absorbed less moisture and at a slower rate than the other red lentil varieties.

Figure 21. Hydration rate curves of split Australian grown red lentils



CT of whole green and Beluga lentils ranged from 21.5 min (Indian Head) to 34.5 min (Matilda) and no significant differences were found for CT within the green lentil varieties. The CT of split red lentils averaged 9 min and no significant differences were found among red lentil varieties (Table 13).

Table 13. Cooking Time of Australian Grown Lentils

Type	Variety	CT (min)
Green	CDC Sedley	31.0 ± 0.0a[1]
Green	Matilda	34.5 ± 2.12a
Beluga	Indian Head	21.5 ± 2.12
Red	CDC Ruby	9.0 ± 0.7a
Red	CDC Robin	8.0 ± 0.0a
Red	CDC Redcoat	9.5 ± 0.7a
Red	Cassab	9.0 ± 0.0a
Red	CDC Rosetown	9.5 ± 0.7a
Red	CDC Blaze	9.0 ± 0.0a
Red	CDC Redbow	9.0 ± 0.0a
Red	CDC Rosebud	9.0 ± 0.0a
Red	CDC Redwing	9.5 ± 0.7a
Red	Northfield (00-2,1)	9.5 ± 0.7a
Red	Cobber	9.0 ± 0.0a
Red	CDC Redchief	9.0 ± 0.0a

[1]Values for samples from the same market class within a column and with the same letter are not significantly different at ($p<0.05$)

Conclusions

Moisture contents of Canadian peas varied, depending on location and variety. Meath Park had slightly lower moisture content than Sutherland. Lower hydration capacities were seen in varieties with a high percentage of stone seeds (unhydrated seeds). The red pea variety CDC 2710-1 in the study had the highest hydration capacity, followed by Agassiz and CDC Greenwater. Hydration rate curves for whole peas were similar for all pea varieties. The red pea, however absorbed water more quickly than the other pea varieties. Hydration rate curves and cooking times of Canadian peas were similar.

Small differences were detected in moisture contents between varieties of Canadian lentils grown in different locations. Lower hydration capacities were seen in varieties with a high percentage of stone seeds. Stone seeds were most predominant in the Spanish brown lentil and the red lentil varieties. Green lentils, on average had the highest hydration capacities. Hydration rate curves for whole lentils were similar although the Spanish brown lentil absorbed less water throughout the 7 h testing period. Hydration rate curves of the split red lentils were similar. Longer cooking times of green and Spanish brown lentils were observed.

Moisture contents of Australian grown pea and lentil samples were similar between all varieties. Seed weight varied for all pea varieties, although Dun pea PBA Oura weighed the most, and also had the highest hydration capacity. CDC Striker had the lowest hydration capacity although this did not affect the cooking time, as the lowest cooking time was seen in CDC Striker. Hydration capacity for all other peas were similar in green, yellow and dun peas. Hydration rate curves for whole and split peas ranged 28-43 min; Yellow peas CDC Amarillo and CDC 2462-18 had longer cooking times compared to all other pea varieties.

Hydration properties of Australian green lentil varieties showed similar trends although the water uptake was higher in CDC Sedley within the first 30 minutes and cooking time was lower when compared to variety Matilda. Hydration properties of red lentils were similar for all varieties, with the exception of CDC Rosetown. CDC Rosetown had the lowest hydration capacity and a lower hydration rate curve compared to the other red lentil varieties but this did not affect the cooking time of the split red lentils.

Overall, results from this work show that the hydration and cooking characteristics of different varieties of peas and lentils can vary within pulse market class and between the locations and environment in which they were grown. The differences for unhydrated seeds found between Australian and Canadian samples are substantial. Australian samples had less unhydrated seeds when compared to Canadian samples. These findings should be investigated further as unhydrated seeds can influence the hydration characteristic and more importantly the cooking time of peas and lentils influencing the marketability of these crops. Next steps in this work will include a correlational analysis between the composition of peas and lentils and their respective hydration properties and cooking quality.

4.5 Development of gluten-free products using pulse ingredients

(Additional funding for this project is secured from AAFC – AIP program and Alberta Innovates Bio Solutions)

Background and Objectives

Gluten-free food products are typically formulated with ingredients that are high in starch and lacking in protein, fibre, vitamins and minerals. Incorporating pulses into these products creates an opportunity to not only increase the nutritional profile of gluten-free products but to improve their sensory acceptability and palatability. The current utilization of pulses as food ingredients in commercial gluten-free products is limited and greater understanding of the functionality of these ingredients in specific gluten-free food applications is required. Objectives of this activity are to develop high quality nutritious gluten-free foods using pulse ingredients including tortillas pan breads and cookies.

Purpose

The purpose of this activity is to assess the potential for pulses as ingredients in gluten-free processed food products. Successful completion of this work and subsequent technology transfer will result in access to a new market for pulses the novel ingredients in gluten-free products.

Materials and Methods

Tortilla processing

Five pulse flours sourced from commercial suppliers were tested in a tortilla formulation at 30% inclusion rate with a gluten-free flour blend containing brown rice, white rice, and tapioca flours. A control tortilla formulation was made using a blend of brown rice, white rice and tapioca flours (Table 14).

Table 14. Control and Pulse Flour Blends for Gluten-Free Tortillas

Flour Type	Control Flour Blend		Pulse Addition Flour Blend	
	Inclusion (%)	Amount (g)	Inclusion (%)	Amount (g)
Tapioca	30	60	21	42
Brown Rice	40	80	28	56
White Rice	30	60	21	42
Pulse	0	0	30	60
Total	**100**	**200**	**100**	**200**

Tortillas were processed using lab scale mixer and an electric griddle. Tortilla physical properties including colour, thickness and diameter were assessed. Colour was measured using a Minolta CR-310 Colorimeter. Tortilla firmness and cohesiveness was measured using a compression test using a TA.HD texture analyzer from Stable Micro Systems. Rollability was assessed by a subjective scoring method. Sensory characteristics were recorded using a subjective scoring method developed at Cigi. Statistical analysis of tortilla quality attributes was carried out using the ANOVA and Tukey – Kramer Multiple Comparison Test.

Pan bread processing
Gluten-free starches and flours were sourced from commercial suppliers. Based on results from previous work, a white rice flour/potato starch/tapioca starch blend was used to develop a formulation for a control gluten-free pan bread. To evaluate the effect of incorporating different pulse flours into gluten-free bread, the pulse flours were incorporated into the control formulation at either 30 or 50%.

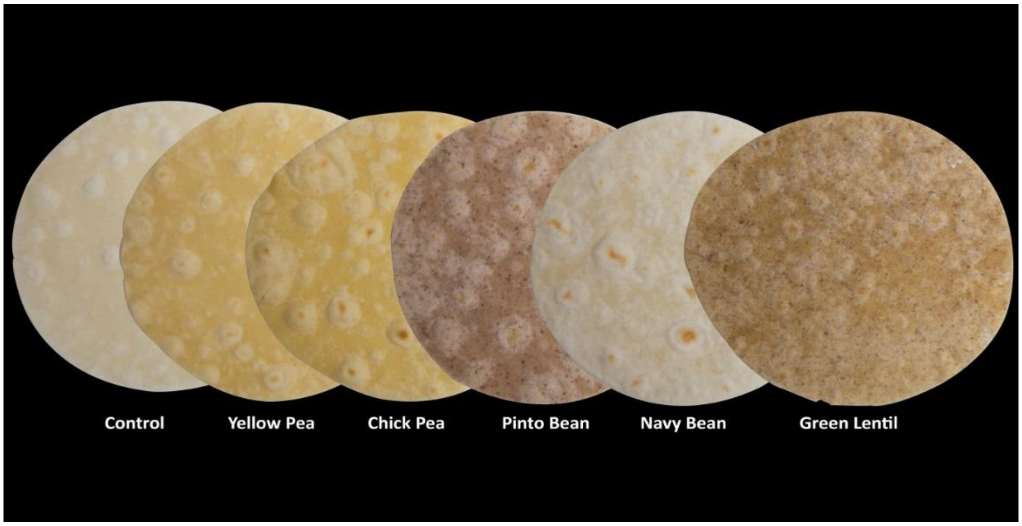
All analysis of the gluten-free bread presented in this report was completed on the day of baking after the bread cooled to room temperature. Crumb colour was evaluated using the Minolta Chroma Meter CR-310 (Konica Minolta, Japan) using a D65 illuminant. C-cell (Calibre Control Instruments Ltd, United Kingdom) imaging was used to measure internal crumb characteristics of the baked bread including number of cells, cell diameter, cell wall thickness and slice height were all measured. The BVM (Perten Instruments, Sweden) was used to measure both loaf and specific volume. Texture of the bread was evaluated with a compression test using the TA_HD Plus Texture Analyzer (Stable Micro System, United Kingdom) according to method 74-09.01 to evaluate bread firmness.

Cookie processing
Pulse flours were sourced from commercial suppliers. The flours were added to a gluten-free cookie formulation based on a traditional gluten-free flour mix with a portion of mesquite bean flour. Cookies were test baked in batches on a lab scale and assessed for their sensory attributes. A sensory panel assessed the cookies for their flavour, aroma, mouth feel, aftertaste and overall acceptability.

Results and Discussion (gluten – free tortillas)

Figure 22 shows gluten-free tortillas produced using non-pulse gluten free flour blend (control) and pulse flours

Figure 22. Control gluten-free tortilla and gluten-free tortillas with added pulse flours.



Dimensions and Physical Attributes
The dimensions considered for tortilla quality are the weight, diameter, and thickness. While all tortillas were cut to the same size, the ability of the tortilla to puff during cooking is dependent on the formulation. Puffing is a desirable quality attribute, which has an effect on the thickness of a tortilla. The thicker a tortilla, the more puffing is usually observed. In this experiment, it was seen that tortillas formulated with chickpea flour had the greatest thickness of all tortillas, and were significantly thicker than the control. No significant differences were seen for tortilla weight. Conversely, the navy bean flour tortillas were significantly smaller in terms of diameter when compared to the control (Table 15).

Table 15. Dimensions of control and gluten-free tortillas containing 30% inclusion of pulse flour

Flour Blend	Weight (g)	Diameter (cm)	Thickness (mm)
Control	28.26 ± 0.64[a1]	15.82 ± 0.12[a]	3.13 ± 0.30[b]
30% Yellow pea flour	23.28 ± 1.56[a]	15.69 ± 0.30[ab]	4.07 ± 0.10[ab]
30% Chickpea flour	24.04 ± 3.74[a]	15.40 ± 0.10[ab]	4.62 ± 0.12[a]
30% Pinto bean flour	26.13 ± 0.13[a]	15.44 ± 0.09[ab]	4.38 ± 0.25[ab]
30% Navy bean flour	21.94 ± 1.52[a]	15.12 ± 0.02[b]	3.41 ± 0.54[ab]
30% Green lentil flour	22.08 ± 2.63[a]	15.47 ± 0.00[ab]	3.69 ± 0.35[ab]

[1]Values with the same letter within a column are not significantly different ($p < 0.05$)

Colour
Tortilla colour represents quality from a visual standpoint, which is important when manufacturers' consider how the tortilla will appeal to their consumers. Refined wheat-based tortillas are typically very bright (high L*), with a medium yellowness (mid-range b*), and reduced redness (lower a*). Whole wheat-based tortillas will have increased redness due to the presence of the bran, and therefore reduced brightness and yellowness. When looking at the gluten-free tortillas prepared in this experiment, the navy bean flour and control tortillas would look most similar to a refined wheat-based tortilla (Table 16). In contrast, the pinto bean and green lentil tortillas would look more similar to a whole wheat-based tortilla. While all tortillas

had a different set of L*, a*, and b* values, the ideal tortilla colour will be dependent on the preferences of the manufacturer and their target market.

Table 16. L*, a*, b* Colour values of gluten-free tortillas containing 30% inclusion of pulse flour

Flour Blend	L*	a*	b*
Control	79.03 ± 0.08ab[1]	-0.19 ± 0.12c	19.61 ± 0.27d
30% Yellow pea flour	76.60 ± 0.82ab	-0.23 ± 0.45c	31.47 ± 0.53b
30% Chickpea flour	75.38 ± 1.33b	-0.13 ± 0.74c	35.83 ± 0.47a
30% Pinto bean flour	62.96 ± 0.38c	6.21 ± 0.09a	17.22 ± 0.18e
30% Navy bean flour	79.99 ± 0.29a	-0.10 ± 0.08c	19.18 ± 0.28d
30% Green lentil flour	63.93 ± 1.85c	4.03 ± 0.21b	21.77 ± 0.54c

[1]Values with the same letter within a column are not significantly different ($p < 0.05$)

Sensory Characteristics

No significant differences for toasted spots, puffing, opacity/translucency, or overall eye appeal were apparent according to Cigi's tortilla scoring standard. However, differences were observed for total sensory score where the pinto bean flour tortilla received the highest total score and the navy bean flour tortillas received the lowest total score. (Table 17).

Table 17. Sensory assessment scores of control and gluten-free tortillas containing 30% inclusion of pulse flour

Flour Blend	Toasted Spots (/5)[1]	Puffing (/4)[1]	Opacity/ Translucency (/5)[1]	Overall Eye Appeal (/4)[1]	Total Sensory Score (/18)[1]
Control	4.5 ± 0.7a	3.5 ± 0.7a	2.0 ± 0.0a	4.0 ± 0.0a	14.0 ± 1.4ab
30% Yellow pea flour	5.0 ± 0.0a	4.0 ± 0.0a	2.0 ± 0.0a	4.0 ± 0.0a	15.0 ± 0.0ab
30% Chickpea flour	5.0 ± 0.0a	4.0 ± 0.0a	2.0 ± 0.0a	4.0 ± 0.0a	15.0 ± 0.0ab
30% Pinto bean flour	5.0 ± 0.0a	4.0 ± 0.0a	3.0 ± 0.0a	4.0 ± 0.0a	16.0 ± 0.0a
30% Navy bean flour	4.0 ± 0.0a	3.0 ± 0.0a	2.0 ± 0.0a	4.0 ± 0.0a	13.0 ± 0.0b
30%Greenlentil flour	5.0 ± 0.0a	3.0 ± 0.0a	3.0 ± 0.0a	4.0 ± 0.0a	15.0 ± 0.0ab

[1]Values with the same letter within a column are not significantly different ($p < 0.05$)

Texture

While cohesiveness was not significantly different among the tortillas, differences were seen for tortilla firmness. The control tortillas were significantly more firm than all tortillas made with pulse flours with the exception of the green lentil flour tortillas (Table 18). Texture of the tortillas could be improved through the addition of dough conditioners in the formulation.

Table 18. Texture of gluten-free tortillas containing 30% inclusion of pulse flour

Flour Blend	Firmness (g)	Cohesiveness (g*s)
Control	1044.04 ± 186.10a[1]	2943.84 ± 726.05a
30% Yellow pea flour	606.29 ± 92.88b	1729.26 ± 330.09a
30% Chickpea flour	484.23 ± 18.61b	1512.55 ± 299.29a
30% Pinto bean flour	540.25 ± 52.76b	1789.66 ± 291.96a
30% Navy bean flour	630.31 ± 112.85b	1896.44 ± 303.11a
30% Green lentil flour	761.42 ± 22.03ab	2354.71 ± 54.62a

[1]Values with the same letter within a column are not significantly different ($p < 0.05$)

Rollability

The rollability of a tortilla reflects its practical quality when used in meal preparations by the consumer (i.e. when making wrap or burritos). After 1 day from being processed, no differences in rollability were seen among the tortillas. After 5 days from being processed, the tortillas made with chickpea and navy bean flours exhibited the highest rollability scores and were significantly more rollable than tortillas made from pinto bean flour and from the control (Table 19). Similar to texture, rollability of the tortillas can also be improved through the addition of dough conditioners in the formulation.

Table 19. Rollability after 1 and 5 day(s) of processing gluten-free tortillas containing 30% inclusion of pulse flour

Flour Blend	Day 1	Day 5
Control	3.5 ± 0.7[a1]	2.0 ± 0.0[b]
30% Yellow pea flour	5.0 ± 0.0[a]	3.0 ± 0.0[ab]
30% Chickpea flour	4.5 ± 0.7[a]	4.0 ± 0.0[a]
30% Pinto bean flour	4.5 ± 0.7[a]	2.0 ± 0.0[b]
30% Navy bean flour	5.0 ± 0.0[a]	3.5 ± 0.7[a]
30% Green lentil flour	5.0 ± 0.0[a]	3.0 ± 0.0[ab]

[1]Values with the same letter within a column are not significantly different ($p < 0.05$)

Nutritional Properties

The addition of pulse flour to gluten-free tortillas in this experiment helped to improve the product's nutritional contents. Per 55g serving of tortilla, fibre content was either doubled or tripled when pulse flour was added to the formulation and protein was increased from 2g in the control to 3g in the pulse flour tortillas. In addition, contents of potassium, iron, riboflavin, folate, magnesium, and zinc were also increased after the inclusion of pulse flours in formulation. Navy bean flour appeared to have the most positive effect on increasing the nutritional value of the gluten-free tortillas (Table 20).

Table 20. Nutrition facts generated by genesis software for gluten-free tortillas containing 30% inclusion of pulse flour

Nutrient	Gluten-Free Tortilla Formulation					
	Control	30% Yellow Pea Flour	30% Chickpea Flour	30% Pinto Bean Flour	30% Navy Bean Flour	30% Green Lentil Flour
Calories (kcal)	160	160	160	160	160	160
Total Fat (g)	4.5	4.5	5.0	4.5	4.5	4.5
Saturated Fat (g)	0.4	0.4	0.4	0.5	0.4	0.4
Trans Fat (g)	0	0	0	0	0	0
Cholesterol (mg)	0	0	0	0	0	0
Sodium (mg)	105	105	105	105	105	105
Potassium (mg)	45	120	110	160	210	125
Total Carbohydrates (g)	28	26	26	26	26	26
Total Fibre (g)	1	3	2	3	3	3
Sugar (g)	0	0	0	0	0	0
Protein (g)	2	3	3	3	3	3
Vitamin A (% DV)	0	0	0	0	0	0

Vitamin C (% DV)	0	0	0	0	0	2
Calcium (% DV)	4	4	4	4	6	4
Iron (% DV)	2	6	6	6	10	8
Thiamine (% DV)	6	8	8	6	8	6
Riboflavin (% DV)	0	2	2	2	2	2
Folate (% DV)	2	15	15	8	20	20
Magnesium (% DV)	8	10	10	10	15	8
Zinc (% DV)	4	6	6	6	8	8

Kcal = kilocalorie; % DV = percent of daily value

Results and Discussion (gluten – free pan bread)

Colour

Crumb colour of the gluten-free breads was dependent on the type of pulse flour used in the formulation and generally intensified with the higher inclusion level. French lentil flour produced the darkest (low L*) bread with the highest degree of redness (high a*) and lowest degree of yellowness (low b*). Navy bean flour produced the brightest bread (high L* values) which translated to the whitest crumb colour. Both whole and split yellow pea flours and chickpea flour produced bread with high b* values indicating a yellow crumb. All gluten-free breads with pulse flours in their formulation had a darker exterior or crust colour compared to the control (Table 21)

Table 21: Crumb colour of a gluten – free control bread and breads containing pulse flours

Control	-	79.89	-1.16	20.22
Chickpea	30	75.39 ± 0.16^{bcd1}	0.38 ± 0.06^{ef}	31.08 ± 0.01^{c}
Chickpea	50	74.04 ± 0.41^{efg}	0.98 ± 0.15^{d}	34.10 ± 0.08^{a}
Faba bean	30	74.67 ± 0.19^{def}	-0.43 ± 0.0^{g}	22.88 ± 0.55^{h}
Faba bean	50	73.30 ± 0.10^{g}	-0.24 ± 0.01^{g}	24.69 ± 0.00^{g}
French lentil	30	49.92 ± 0.08^{h}	4.40 ± 0.04^{a}	12.56 ± 0.15^{k}
French lentil	50	43.24 ± 0.65^{i}	4.61 ± 0.08^{a}	11.18 ± 0.25^{l}
Navy bean	30	77.76 ± 0.30^{a}	0.13 ± 0.08^{f}	19.90 ± 0.04^{j}
Navy bean	50	77.81 ± 0.11^{a}	0.58 ± 0.03^{e}	20.79 ± 0.02^{i}
Split red lentil	30	76.20 ± 0.27^{b}	0.50 ± 0.02^{e}	26.92 ± 0.04^{f}
Split red lentil	50	73.71 ± 0.04^{fg}	1.42 ± 0.03^{c}	30.07 ± 0.05^{d}
Split yellow pea	30	75.90 ± 0.02^{bc}	0.50 ± 0.04^{e}	29.11 ± 0.11^{e}
Split yellow pea	50	74.31 ± 0.01^{efg}	1.22 ± 0.05^{cd}	32.66 ± 0.30^{b}
Whole yellow pea	30	75.08 ± 0.24^{cde}	0.98 ± 0.05^{d}	27.40 ± 0.20^{f}
Whole yellow pea	50	73.72 ± 0.24^{fg}	1.83 ± 0.08^{b}	29.79 ± 0.30^{de}

[1] Values with the same letter within the same column are not significantly different ($p < 0.05$)
[2] L* indicates the value of brightness (0 – black, 100 – white)
[3] a* indicates the degree of red – green (-a – greenness, +a – redness)
[4] b* indicates the degree of yellow – blue (-b – blueness, +b – yellowness)

Figures 23 – 29 show a sliced control gluten free bread and gluten-free breads made with different inclusion levels of pulse flours.

Figure 23. Sliced control, 30% and 50% Chickpea flour bread

Figure 24. Sliced control, 30% and 50% faba bean flour bread

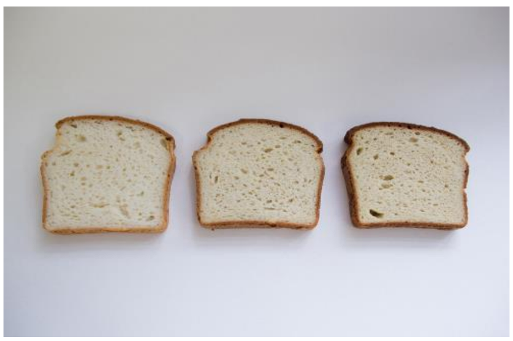


Figure 25. Sliced control, 30% and 50% French lentil flour bread

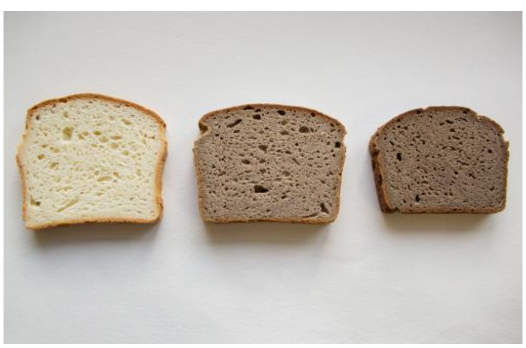


Figure 26. Sliced control, 30% and 50% navy bean flour bread

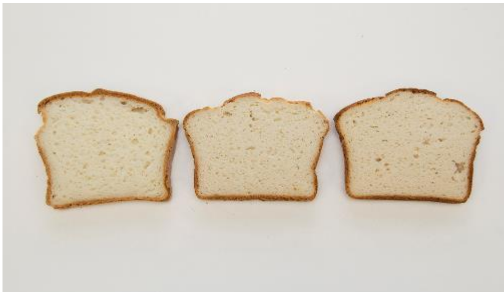


Figure 27. Sliced control, 30% and 50% split red lentil flour bread

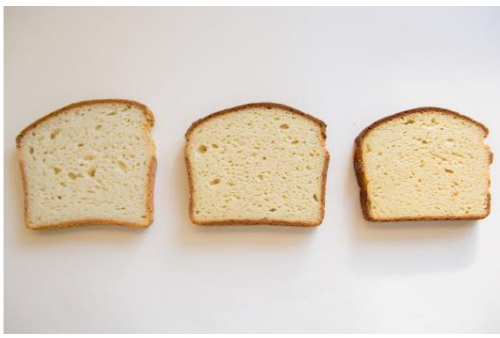


Figure 28. Sliced control, 30% and 50% split yellow pea flour bread

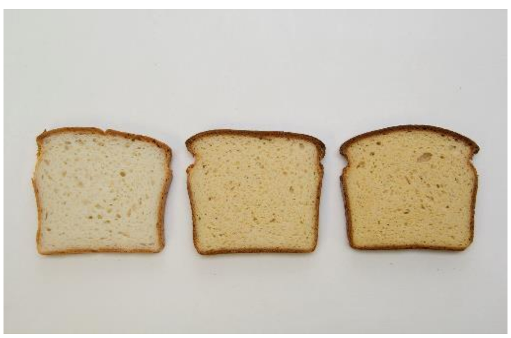
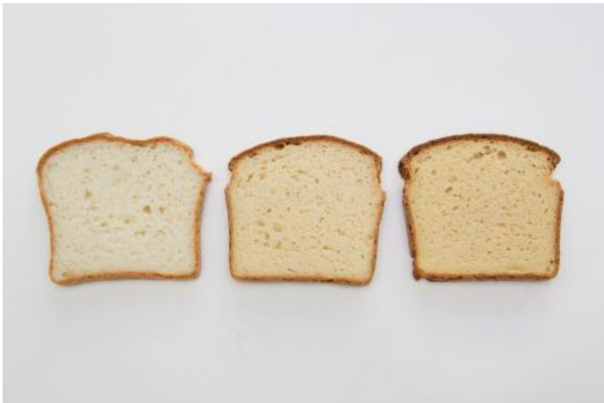


Figure 29. Sliced control, 30% and 50% whole yellow pea flour bread



C-Cell Analysis

The bread with the greatest height was the control, although some of the pulse flours produced breads that were similar to the control for height. French green lentil flour produced bread with the lowest height, whereas chickpea, and split yellow pea flours produced bread with the greatest heights. Among inclusion levels, significant differences were observed between the red lentil and French lentil breads where the 50% inclusion produced bread that was lower in height compared to the 30% inclusion level.

French lentil flour added at 50% produced bread with the greatest number of cells. Furthermore, the cell wall thickness and average cell diameter were the lowest in the 50% French lentil bread. Bread made with 30% split yellow pea flour exhibited the lowest number of cells, with the greatest average cell diameter and cell wall thickness.

Table 22. C-Cell analysis of a gluten – free control bread and breads containing pulse flours

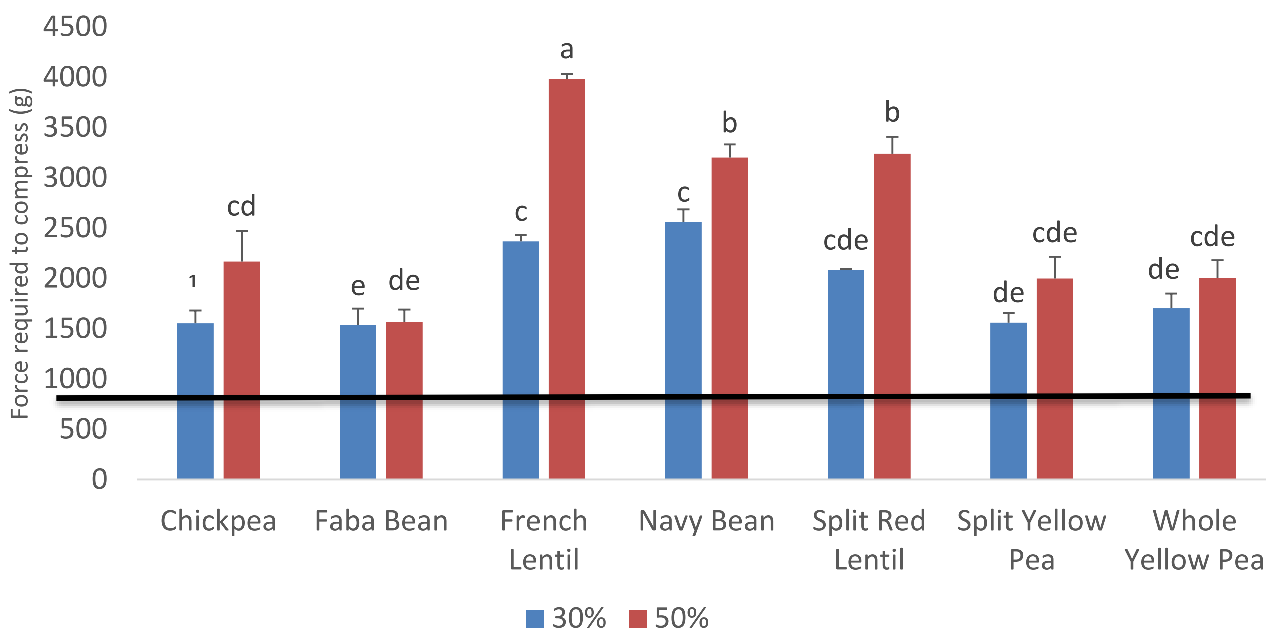
Control	-	10.2	5249.6	0.52	2.23
Chickpea	30	10.1 ± 0.15^{a1}	5974.3 ± 263.7^{bcd}	0.48 ± 0.01^{abc}	1.83 ± 0.14^{abc}
Chickpea	50	9.8 ± 0.17^{abc}	6193.0 ± 58.1^{abcd}	0.47 ± 0.00^{abc}	1.67 ± 0.07^{bcde}
Faba bean	30	10.0 ± 0.12^{a}	5769.7 ± 108.6^{cd}	0.48 ± 0.01^{abc}	1.86 ± 0.07^{ab}
Faba bean	50	10.0 ± 0.06^{a}	5894.3 ± 24.2^{cd}	0.48 ± 0.00^{abc}	1.95 ± 0.03^{a}
French lentil	30	9.4 ± 0.06^{de}	6185.0 ± 134.1^{abcd}	0.46 ± 0.01^{bcd}	1.54 ± 0.03^{e}
French lentil	50	9.0 ± 0.06^{f}	6882.0 ± 280.3^{a}	0.43 ±0.01^{d}	1.29 ± 0.03^{f}
Navy bean	30	9.4 ± 0.20^{e}	6092.2 ± 73.5^{bcd}	0.47 ±0.01^{abc}	1.66 ± 0.06^{cde}
Navy bean	50	9.7 ± 0.06^{bcde}	6676.7 ± 120.5^{ab}	0.45 ± 0.04^{abc}	1.57 ± 0.03^{e}
Split red lentil	30	9.9 ± 0.00^{ab}	5936.3 ± 728.6^{cd}	0.48 ± 0.03^{ab}	1.77 ± 0.11^{abcd}
Split red lentil	50	9.5 ± 0.20^{cde}	6372.0 ± 113.0^{abc}	0.46 ± 0.00^{bcd}	1.61 ± 0.03^{de}
Split yellow pea	30	10.1 ± 0.06^{a}	5624.7 ± 66.4^{d}	0.49 ± 0.00^{a}	1.96 ± 0.06^{a}
Split yellow pea	50	10.1 ± 0.10^{a}	5872.0 ± 41.6^{cd}	0.48 ± 0.01^{abc}	1.89 ± 0.02^{a}
Whole yellow pea	30	9.9 ± 0.12^{ab}	5797.3 ± 163.1^{cd}	0.49 ± 0.01^{a}	1.87 ± 0.04^{a}
Whole yellow pea	50	9.8 ± 0.06^{abcd}	5902.0 ± 230.2^{cd}	0.47 ± 0.00^{abc}	1.82 ± 0.07^{abc}

[1] Values with the same letter within the same column are not significantly different ($p < 0.05$)

[2] Control not included in statistical analysis

Texture Analysis
On the day of baking (Day 0), all of the GF breads containing pulse flours were firmer than the control. The French lentil flour, when included at 50%, produced the firmest bread while the faba bean flour, at 30% produced the least firm or the softest bread. Regardless of pulse type, the bread became firmer as the amount of pulse flour in the formulation increased. Both lentil flours and the navy bean flours produced the firmest breads among the pulse types. (Additional texture results for day 1 and 4 of testing are available in the full report for this activity available upon request).

Figure 30: Firmness of a gluten – free control bread and breads containing pulse flours measured on day 0.



[1] Bars with the same letter are not significantly different ($p < 0.05$).

Results and Discussion (gluten-free cookies)

Figure 31 represents cookies baked with a gluten-free flour mix, mesquite flour and various pulse flours.

Figure 31. Gluten-free cookies made with mesquite bean flour, a retail gluten-free flour mix, and pulse flour.

Average sensory scores for each cookie are shown in Table 23.

Table 23. Average Scores for Sensory Acceptability of Cookies

	Cookie Sample				
Sensory Attribute	**Control**	**15% Navy Bean**	**15% Chickpea**	**15% Pinto Bean**	**15% Yellow Pea**
Taste/ flavour (/5)	3.3	2.7	3.6	3.4	2.3
Odor/ aroma (/5)	3.0	3.0	3.3	2.9	2.9
Texture/ mouthfeel (/5)	2.9	3.0	3.3	3.3	2.6
Aftertaste (/5)	3.1	2.4	3.4	3.1	2.4
Overall acceptability (/5)	3.4	2.9	3.5	3.6	2.3

Conclusions

Tortillas

The objective of this work was to determine how the inclusion of five different pulse flours in a gluten-free tortilla would affect end-product quality. This work demonstrated that the quality of gluten-free tortillas containing a base formulation of brown rice, white rice, and tapioca flours can be improved by the inclusion of pulse flours in the formulation. It was shown that tortilla thickness, total sensory score, texture, rollability, and nutritional content were enhanced by the addition of pulse flours. Chickpea flour allowed for more puffing of the tortilla during cooking and therefore these tortillas had greater thickness. Pinto bean flour tortillas received the highest total sensory score. Firmness was decreased in all pulse flour tortillas compared to the control. Chickpea and navy bean flour addition allowed for improved rollability after 5 days from processing compared to the control. Finally, all pulse flour tortillas had greater fibre, protein, potassium, iron, riboflavin, folate, magnesium, and zinc contents than the control. Each pulse flour offered a unique colour to the tortillas, which would play a large role in the marketability of the product. It is therefore the gluten-free tortilla manufacturer who will ultimately decide what quality characteristics are most important for their product and which pulse flour would be best suited for their consumer.

Pan bread

Adding pulse flours increased the nutritional profile of the gluten-free bread and, depending on the inclusion level, made them eligible for a dietary fibre nutrient content claim in Canada. Although all three pulse flours were successfully incorporated into a gluten-free pan bread formulation, the faba bean flour produced a bread that was comparable to the control in regards to crumb colour, texture and height. The addition of faba bean flour also produced a pan bread with a less intense beany flavor compared to the chickpea and the split yellow pea flour as indicated by preliminary taste trials. Cigi pulse department technology staff are continuing to optimize gluten-free pulse bread formulations to meet the needs of gluten-free companies, retailers and consumers. A summary product profile sheet has been developed to assist in the promotion of pulse based gluten-free pan bread to the industry (Appendix I)

Cookies
Cookies made with 15% addition of chickpea flour received higher scores for 4 out of the 5 sensory attributes compared to all other cookies. Cookies formulated with pinto bean flour received high scores for texture/mouthfeel and overall acceptability. Yellow pea flour was the least acceptable in the cookie formulation. It would therefore be recommended that chickpea or navy bean flour be added to gluten-free cookies containing mesquite bean flour to enhance the sensory acceptability of the product.

Activities focused on positioning pulses as ingredients in the gluten-free processed food industry are currently in year two of a four year project. Work completed to date has shown great potential for pulses as ingredients in these types of foods. Pulses improve the nutritional profile of gluten free foods while delivering high quality end products. Future activities will include developing additional food products using pulse ingredients, optimizing and partnering with gluten-free food manufacturers to transfer knowledge and scale-up products to commercial status. This activity will conclude with a program/short course delivered by Cigi on how to effectively utilize pulse ingredients in gluten-free products. The purpose of the program is to transfer information generated by this activity to the industry and to promote Canadian pulses as ingredients in this market.

4.6 Standardization of pulse flours for food product applications

(Additional funding for this project was obtained from AAFC – Agricultural Innovation Program)

Background and Objectives
Several milling technologies can be successfully applied to produce pulse flours. There is a gap in knowledge regarding what quality of flour each of these systems is capable of producing and if there are flours which are best suited to specific applications. This sub-project is designed to assess commercially available pulse flours as provide recommendations and to which flours should be used for what product applications.

Purpose
The purpose of this activity is to understand the variation in pulse flour quality and provide recommendations and support to commercial partners and food processors focused on understanding flour specifications required for specific end uses.

Materials and Methods
Pulse Flours
Cigi partnered with a food processor who was interested in producing extruded snacks using red lentil flours. Cigi sourced red lentils from a Canadian commercial supplier and milled the lentils to three granulations (very coarse, coarse and fine) using a Buhler pilot mill.

Extrusion Processing
Three lentil flour granulations were produced using a Buhler pilot roller mill. Flours were blended with a spice mixture to evaluate the effects of red lentil flour particle size on snack food extrusion properties. Round puffs were extruded using a Clextrall EV 25 pilot scale extruder. Quality of the snacks was assessed by measuring the diameter (expansion ratio), bulk density and weight of the samples. In addition, protein content, moisture content and resistant starch levels of puffs were analyzed.

Results and Discussion

Flour Analysis

Flour characteristics analyzed included starch damage, moisture content, protein content, total starch, amylose, amylopectin. Flours with increasing particle size had lower starch damage values and total starch contents. All other characteristics were not significantly different.

End Product Quality

Three granulations of red lentil flours showed different levels of starch damage. These flours were extruded to form round puffs. Following extrusion no differences in resistant starch were found in the samples. No significant differences were found in finished products for expansion ratio, bulk density and weight. Overall, red lentil granulation did not affect the properties of extrusion.

Discussion

Results from this work indicate that red lentils are a promising ingredient to use in direct expanded extrusion applications. Differences in flour quality will not affect product quality and therefore will create highly consistent end products. Following this study, this confidential work was transferred to the Saskatchewan Food Industry Development Centre to complete commercialization trials of this work for a commercial snack food application.

4.7 Pargem Project

(Additional funding for this project was obtained from Alberta Agriculture and Rural Development and the Alberta Pulse Growers)

Background and Objectives

Pargem is a process developed by Buhler AG in Switzerland which involves the controlled partial germination of grains. Cigi has partnered with Dr. Eliana Zamprogna (Buhler, Switzerland), Dr. Jay Han (Food Product Development Centre, Leduc Dr. Joyce Boye (AAFC, St Hyacinthe) and Dr. Jim House (University of Manitoba, Winnipeg) to undertake the project. The objectives of this study were to evaluate the nutritional quality, processing attributes and consumer acceptance of partially germinated yellow pea flour derived from the Pargem process.

Purpose

The purpose of this activity was to evaluate the Pargem process and to measure the efficacy of the methodology developed by Buhler AG. Results from this activity provide information to food processors on the direct effects that germinated flours will have on the quality of processed food products. This information enables food processors to make more informed decisions on the type of pea ingredients used in their products.

Project Update

Final report for this project has been completed and submitted to the principal investigator Dr. Jay Han at the Food Research and Processing Centre in Leduc, AB.

A report on Cigi activities during this project is included in Appendix II.

A research poster summarizing a section of Cigi activities part of this project was presented at the 2015 AACCI Meeting in Providence, RI and is included in Appendix III.

5. **AgriMarketing Program (AMP) Activities**

During the current reporting period a portion of Cigi's AMP funding has been allocated for the promotion of Canadian pulses in international markets. Cigi pulse staff was able to travel to markets in the United Kingdom and the Netherlands to participate in a mission for the purpose of investigating new markets and seeking new opportunities for Canadian pulses and pulse ingredients. This mission was organized and attended in partnership with Pulse Canada. Full report of findings from this activity can be found in Appendix IV.

In addition, Cigi pulse staff were able to support the Saskatchewan Trade and Export Partnership (STEP) during a mission to Mexico. A complete report for this activity can be found in Appendix V.

6. Statement of Expenditures for Year 5.

(Refer to Statement of Project Expenditures for Year 5 prepared by the Cigi finance department in Appendix VI)

7. Research Accomplishments Year 5

- Assessed the effects of micronization of pulses on the end product quality of spaghetti. Results will be communicated the industry in a research poster at AACCI 2015.
- Measured the functional and compositional characteristics of protein fractions derived from pulse flours
- Determined methodology and parameters for the fractionation of peas and faba beans using an air classifier
- Measured the effects of functional ingredients including starch, fibre, sugar and salt on the quality of a pea flour based directly expanded extruded snacks
- Demonstrated that variety and environment play a significant role on the hydration and cooking qualities of peas and lentils
- Tested the quality of competitors peas and lentils and communicated results to pulse breeders
- Assessed the feasibility of using pulse flours in gluten-free tortillas, pan breads and cookies and communicated selected results to the industry
- Determined that French lentil flour produced gluten-free bread with similar appearance to whole grain bread formulations and shared information with the industry
- Determined that faba bean flour produced the highest quality gluten-free pan bread with good shelf life characteristics and shared information with the industry
- Determined that red lentil flour regardless of particle size distribution retained desirable extrusion quality characteristics with respect to bulk density, size and shape of the extruded snack and communicated results with the industry
- Determined the effects of partial germination on the end product quality of spaghetti and directly expanded extruded snacks and communicated results with the industry

8. Success Stories

Continually increasing the knowledge on Canadian pulse quality, pulse processes and on the utilization of pulses allows Cigi to deliver a high level of support to the pulse value chain to enhance the marketability of Canadian pulse crops. During the current reporting period the following success stories were documented;

Through the standardization of pulse flours activity Cigi has been able to assist several companies to better understand pulse ingredients. Under this activity, selected pulse ingredients were tested for their viscosity characteristics to indicate their functionality in a gelled food product application. This information was transferred to a global food company interested in understanding novel protein ingredients for their applications. This work assisted the company in identifying potential Canadian ingredients to meet their ingredient specifications for nutrition content, functionality and flavor.

In another example of potential for pre-commercialization, a company interested in using lentil flour in an extruded snack food product contacted Cigi to better understand the effects of lentil flour and flour characteristics on product quality. This project enabled Cigi to work with the company to demonstrate that lentil flours, regardless of their particle size, could be successfully processed into a high quality snack food within their quality specifications. This work helped to connect the company with a Canadian supplier of pulses for their product needs as well as to increase the amount of Canadian lentil flour in their formulation. The work also fostered a connection between the food company and the Saskatchewan Food Industry Development Centre which is continuing the product development past the pre-commercial stage.

During the current reporting period, various producer groups have contacted Cigi to learn about results of pulse research projects and to apply the information to value added initiatives on their farms. In one such instance a farmer contacted Cigi to try to add value to his crop using equipment available at Cigi. In this case product developed at Cigi on behalf of the farmer was delivered to a potential customer for product validation.

An on-farm family partnership received information from Cigi in the 2014-2015 year to better understand how to add value to their crops. They received information from Cigi on pulse flour milling, quality and product development and have since applied their knowledge to produce their own pulse flours and breads. They are now looking to expand their operation and have made inquiries to the Cigi team on what milling process would best to suit their needs.

A Canadian milling company in partnership with a multinational North American food company has explored the potential of pulse flours in value added food applications. The milling of pulse flours for food product trials was conducted at Cigi. The result of this work remains in a pre-commercial state but technology transfer to the companies on the opportunity and quality of pulse flours has been successful.

Cigi had the opportunity to participate in a number of international investigative missions during the current reporting period. The objectives of these activities were to assess the opportunities for Canadian pulses as ingredients in international markets. In Mexico for example, numerous contacts have been made with food processors who are interested in the benefits of Canadian pulses in their products. One such processor was interested in using pulse fractions in his extruded snack products. As a result of discussions with Cigi he was successfully connected with a Saskatchewan pulse ingredient supplier.

Pulse Canada has been working closely with the Chinese Cereals and Oils Association to develop highly acceptable products made from pulse ingredients for the Chinese market. These products include steamed bread, biscuits and Asian noodles. The flours used in these product trials were developed via the standardization of pulse flours activity. The researchers will assess the quality of the flours in these food applications with the anticipation that this information will lead to further commercialization of pulse flours for the Chinese market.

9. Technology Transfer Activities

- P. Frohlich attended the **AACCI Annual Meeting and Exposition in Providence, Rhode Island October 5 - 8, 2014** where he delivered a poster presentation entitled *Effect of Processing Conditions During the Partial Germination of Whole Yellow Peas on the Quality of Spaghetti and Extruded Snacks (*Appendix III)
- P. Frohlich attended the **PGDC Annual Meeting in Banff, Alberta, February 24-26, 2015.**
- G. Boux and L. Bourre attended the **2015 Bakery Congress Conference and Trade Show, May 31 – June 1** in Montreal, Quebec.
- An article on pulse quality was published in a peer reviewed journal in collaboration with the CDC; L. Malcolmson, **P. Frohlich**, G. Boux, A-S Bellido, J. Boye, T. D. Warkentin *Aroma and flavour properties of Saskatchewan grown field peas (Pisum sativum L.)* Can.J.Plant Sci. 94: 1419-1426, 2014.
- Technical support was provided to the industry and to researchers as requested.
- Demonstrations on Canadian pulse quality, processing and utilization were given to Cigi course participants and visitors. (Cigi delivers on average 50 programs to domestic and international participants annually, approximately 30 of these contain pulse content).

10. Acknowledgments (actions taken to acknowledge support of funders)

Since 2006 Cigi has received funding from SPG and MPSG that enabled the development and maintenance of a world class pulse research program at Cigi. In the past decade Cigi had the opportunity to contribute to the value chain through numerous applied research activities. The knowledge generated from these activities has been transferred to the industry and at the same time funding support has been reguralarly acknowledged in oral presentations, research posters, pulse information/technical booths, demonstrations to Cigi program participants, published material developed by Cigi communications department and material that is published in peer reviewed journals. Cigi greatly appreciates the financial assistance of the growers and is looking forward to a future partnership between the SPG and MPSG.