Influence of Pre-Milling Thermal Treatments of Field Peas, Dry Edible Beans and Faba Beans on the Flavour and End Product Quality of Baked Products

Final Report

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Abstract

Pulse flours are an excellent source of nutrients and can improve the nutritional profile of processed foods when incorporated as ingredients. The demand for novel and nutritious ingredients for use by food processors is high, however undesirable off flavours found in pulses are an obstacle to the wide spread adoption of these ingredients. In this study, two thermal treatments prior to pulse flour milling were evaluated as a means to improve the flavour profile of pulses. Yellow peas, faba and navy beans were either roasted or exposed to infrared heating (micronization), milled into flours and processed into pan breads, pita breads and tortillas. Baked products were then assessed for end quality and flavour. Minimal differences in end quality were detected between products made with untreated and treated pulses. According to flavour analysis data, both thermal treatments were effective in reducing undesirable flavour attributes of pulses. However, differences were more pronounced in pan breads then pita breads or tortillas. This research has successfully quantified two processing methods that will enable food processors to effectively utilize pretreated pulse ingredients in baking applications, subsequently leading to increased demand and new markets for Manitoba pulses. Investments in thermal processes can present opportunities for both farmers and existing processors to add value and enhance marketability of Manitoba pulse crops.

Objectives

Cigi has been investigating pulses and their uses as healthy ingredients in various food products for over a decade. The demand for these novel and nutritious ingredients by food processors is high, however undesirable off flavours found in pulses are an obstacle to the wide spread adoption of these ingredients. A clear message from food processors is that beany type flavours in pulses are undesirable and therefore reduction and/or removal of these off flavours has the potential to enhance the utilization of pulses and ultimately their marketability. The focus of this study was to investigate the uses of thermal seed treatments prior to milling and determine their role in reducing, augmenting or removing beany flavours when pulses are used as ingredients in baked product applications.

This study addressed the following objectives;

- Determine the effects of pre-milling thermal treatments on pulse flour quality
- Determine and measure the effects of incorporating thermally treated pulse flours into baked products on end product quality and flavour

Materials and Methods

Yellow peas, navy and faba beans were sourced from Manitoba commercial suppliers. Pulses were either micronized using commercial parameters (InfraReady Foods, SK) or roasted (130°C, 30 min) in a Picard Electrical Revolving Tray Oven (Drummonville,QC).

Untreated and thermally treated pulses were milled into flour using a Ferkar multipurpose knife mill (Velenie, Slovenia) in two stages. During the first stage a coarse screen (3 mm) was used to pre-break the pulses. During the second stage a finer screen (1.0 mm) was used to produce a flour suitable for baking pan breads, tortillas and pita breads. Following milling flours were assessed for compositional and functional characteristics, including protein and starch contents, RVA pasting profile, starch damage, water absorption capacity foaming properties and emulsifying properties.

Pan Bread

Pan bread was processed using a blend of 15% pulse flour and 85% Canadian Western Red Spring wheat flour(CWRS) . A short time fermentation process was used to process the pan bread. Processing parameters remained the same for each treatment, with the exception of water addition and mixing times of the dough systems. Breads were baked in a Picard revolving tray oven (Drummonville, QC). The formulation used for pan breads can be found in Table 1.

Table 1. Formulation for pan bread containing pulse flours (15%)

Ingredients	**Percent Based On Flour Weight**	
	Baker's percent (%)	**Amount (g)**
Flour (wheat and pulse)	100	3000
Water	Variable	Variable
Sugar, refined	4	120
Vital gluten	3	90
Shortening	4	120
Salt	2	60
Yeast, fresh	4	120
Milk powder	2	60
No-time dough conditioner	2	60

Tortillas

Tortillas were produced using a blend of pulse flour (30%) and CWRS flour (70%). A Dough Xpress tortilla press (Pittsburgh, KS) in combination with a Vulcan griddle (Baltimore, MD) were used to bake the tortillas. The formulation used to produce tortillas can be found in Table 2.

Table 2. Formulation for tortillas containing pulse flours (30%)

Ingredient	**Percent Based On Flour Weight**	
	Baker's percent (%)	**Amount (g)**
Flour (wheat and pulse)	100	1000
Water	Variable	Variable
Salt	1.5	13
Sugar	0.5	5
Oil	10	100
Baking powder	1.5	15
Inactive dry yeast	1	10
Gum	0.35	3.5
Sodium stearoyl lactylate	0.375	3.75
Emulsifier	0.375	3.75
Calcium propionate	0.375	3.75
Fumaric Acid	0.375	3.75

Pita Bread

Pita breads were produced by blending pulse flour (30%) and CWRS flour (70%). Pita breads were processed using a Bloemhof dough sheeter (Kirkland, QC) and baked in a Pavailler Tunnel Oven (Rockville, MD). The formulation used for pita bread can be found in Table 3.

Table 3. Formulation for pita bread containing pulse flours (30%)

Ingredients	Percent Based On Flour Weight	
	Baker's percent (%)	Amount (g)
Flour (wheat and pulse)	100	1000
Water	Variable	Variable
Yeast (compressed)	1	10
Salt	1	10
Calcium propionate	0.375	3.75

Baked product analysis

Specific volume (SV) of pan breads was measured using a bread volume meter BVM L370, (Perten, Sweden). Crumb colour was evaluated using the Minolta Chroma Meter CR-310 (Konica Minolta, Japan) using a D65 illuminant. Colour measurements were measured on two slices of bread taken from the centre of the loaf and brightness (L*) values were recorded. Crumb firmness was measured using the TA_HD Plus Texture Analyzer (Stable Micro System, United Kingdom) equipped with a 30 kg load cell and TA 4 cylindrical probe attachment. Bread firmness was evaluated on three slices of bread taken from the centre of each loaf one day after baking.

Weight and dimensions of the pita breads were measured. These included pocket height and diameter. Brightness (L*) and firmness values were measured using similar equipment that was used for assessing the quality of pan breads.

Weight, diameter, thickness, brightness (L*) and firmness were used to measure the quality of tortillas. Brightness (L*) and firmness values for tortillas were measured using similar equipment as for pan breads.

For pan breads, tortillas and pita breads, a 100% wheat sample product was baked for reference purposes only. This product was not included in the statistical analysis.

Data was analyzed using ANOVA. Differences between mean values were determined using the Tukey-Kramer Method using JMP 11 (SAS, United States).

Sensory Evaluation

Pan breads, tortillas and pitas were evaluated for acceptability by a consumer panel of approximately 80 adults. Panelists were asked to evaluate overall acceptability, appearance, aroma, flavour, texture and aftertaste. Baked products were evaluated on a 9-point hedonic scale, (1=dislike extremely to 9=like extremely). Ballots also contained questions so panelists could choose individual words to describe the aroma and flavour of the baked product such as beany or nutty.

Results

Following milling, all pulse flours were assessed for composition and functional characteristics (Table 4). As expected, faba bean flours exhibited higher protein values than both the yellow peas and navy beans. Navy bean flours showed lower starch damage values overall when compared to the other pulse types. Neither of the treatments had an effect on starch damage specifically for yellow peas and navy beans. Roasting increased the viscosity of all flours, potentially due to the denaturation and aggregation of the denatured components present within the pulse flours. Analysis of flour functionality enables food processors to gain an understanding of how the flours will behave in various processing systems. For example, in baking applications water absorption capacity is of importance as it provides insight on the amount of water that needs to be added to the dough system to create an acceptable dough in terms of processing and handling. Water absorption capacity can be affected by the amount of starch damage present in a flour. Overall, thermal treatments had varied effects on the water absorption capacity for all samples. Moisture contents of all doughs were adjusted to accommodate these changes.

Table 4. Compositional and functional properties of untreated (Unt), micronized (Micro) and roasted whole yellow peas (WYP), navy beans and faba beans.

	Yellow Peas			Navy Beans			Faba Beans		
Analytical Test	Unt. WYP	Micro WYP	Roasted WYP	Unt. Navy	Micro Navy	Roasted Navy	Unt. Faba	Micro Faba	Roasted Faba
Protein Content, %	22.3	22.7	22.3	24.8	24.3	24.7	30.6	30.6	30.8
Total Starch Content, %	44.8	46.9	46.9	36.3	36.2	37.0	39.5	38.6	39.9
RVA Pasting profile									
Peak Viscosity, RVU	103	130	159	89	89	97	95	104	122
Hot Paste Viscosity, RVU	n/a	n/a	147	n/a	n/a	n/a	n/a	n/a	119
Breakdown, RVU	n/a	n/a	12	n/a	n/a	n/a	n/a	n/a	3
Final Viscosity, RVU	183	209	218	137	164	188	201	202	186
Setback, RVU			71						67
Pasting Time, min	6.94	5.80	5.64	6.73	7.00	7.00	7.00	7.00	6.07
Starch Damage, %	1.03	1.21	1.10	0.53	0.57	0.61	1.02	0.75	0.73
Water abs capacity (g water/g	1.70	1.43	1.34	1.35	1.30	1.54	1.31	1.24	1.29
Foam capacity	35.0	29.0	22.0	35.5	21.0	13.5	35.0	27.0	24.0
Foam stability									
10 min	90.1	91.4	86.5	86.4	88.1	93.5	90.2	84.0	81.5
30 min	77.5	81.4	69.2	86.4	76.1	80.6	70.7	84.0	59.3
60 min	67.5	62.9	53.8	66.7	68.1	71.0	65.8	64.6	46.3
120 min	41.2	48.6	48.1	66.7	68.1	61.3	59.8	45.2	40.7
Emulsifying capacity									
Emulsifying activity	36.1	35.5	34.7	36.7	38.7	20.2	35.8	36.1	24.2
Emulsion stability	31.9	4.5	6.9	72.7	22.9	16.0	90.7	77.3	43.3

Pan Bread

Measurement of specific volume for pan bread provides a quantitative measurement of baking performance and crumb quality. Statistical differences were not detected between any of the thermal treatments for all pulse types. Thermal treatments did however decrease L* or brightness values of all breads, with the exception of bread made with micronized faba beans. Thermal treatments decreased the firmness of all breads. Breads made using micronized pulses were firmer then breads made with roasted pulses with the exception of faba bean flour were roasting resulted with a firmer loaf. However these results were not statistically different (Table 5, Figure 1)

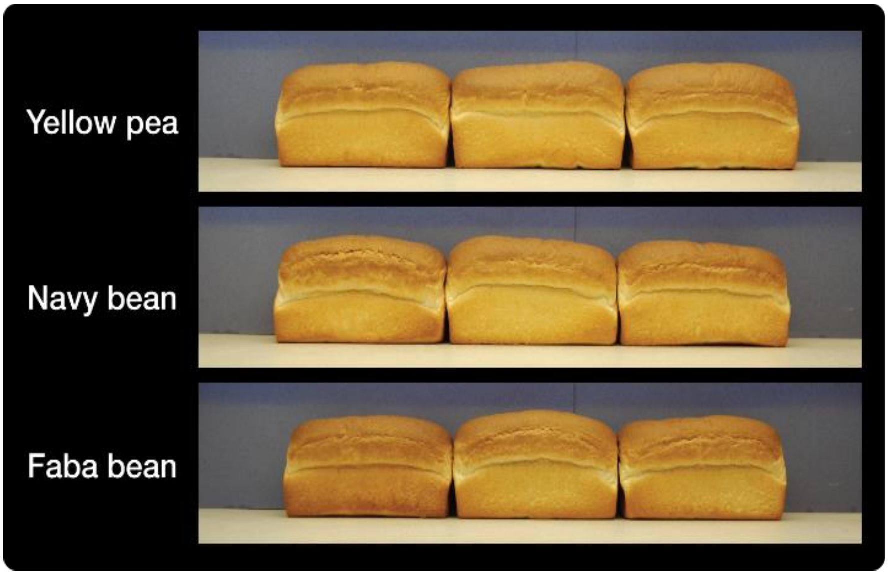
Table 5. Specific volume, brightness (L*) and firmness values for pan bread made using pulse flours

	Treatment	Specific Volume (cm^3/g)	L*[1]	Firmness (g)
Wheat	**Reference**	**6.5 ± 0.2**	**82.3 ± 0.3**	**116.2 ± 12.9**
Yellow Pea	Untreated	6.1 ± 0.2 a[2]	81.0 ± 0.4 a	136.7 ± 7.0 a
	Micronized	6.2 ± 0.1a	79.5 ± 0.5 b	130.5 ± 24.4 a
	Roasted	5.9 ± 0.1 a	79.5 ± 0.2 b	121.0 ± 7.6 a
Navy Bean	Untreated	6.0 ± 0.2 a	81.2 ± 0.4 a	134.0 ± 10.2 a
	Micronized	6.4 ± 0.2 a	80.1 ± 0.6 b	122.0 ± 8.9 a
	Roasted	6.1 ± 0.2 a	79.8 ± 0.2 b	118.6 ± 14.9 a
Faba Bean	Untreated	6.3 ± 0.0 a	78.6 ± 0.3 a	136.2 ± 14.4 a
	Micronized	6.6 ± 0.1 a	78.1 ± 0.4 a	122.9 ± 17.3 a
	Roasted	6.4 ± 0.1 a	76.7 ± 0.7 b	131.4 ± 5.7 a

[1] L* indicates the value of brightness (0 – black, 100 – white)

[2] Values with the same letter in a pulse type in the same column are not significantly different ($p < 0.05$)

Figure 1. Pan breads made with untreated, micronized and roasted pulses (from left to right within a pulse type)



Tortillas

Tortilla weights were not affected by thermal treatments with the exception of tortillas made with treated faba bean flours where higher weights were detected. Roasting of yellow peas resulted in tortillas that had lower diameters and were thicker when compared with the untreated tortilla samples. Roasting of all pulse types resulted in decreased L* values for tortillas.
Neither micronization nor roasting of pulses had an effect on tortilla firmness across all pulse types (Table 6, Figure 2)

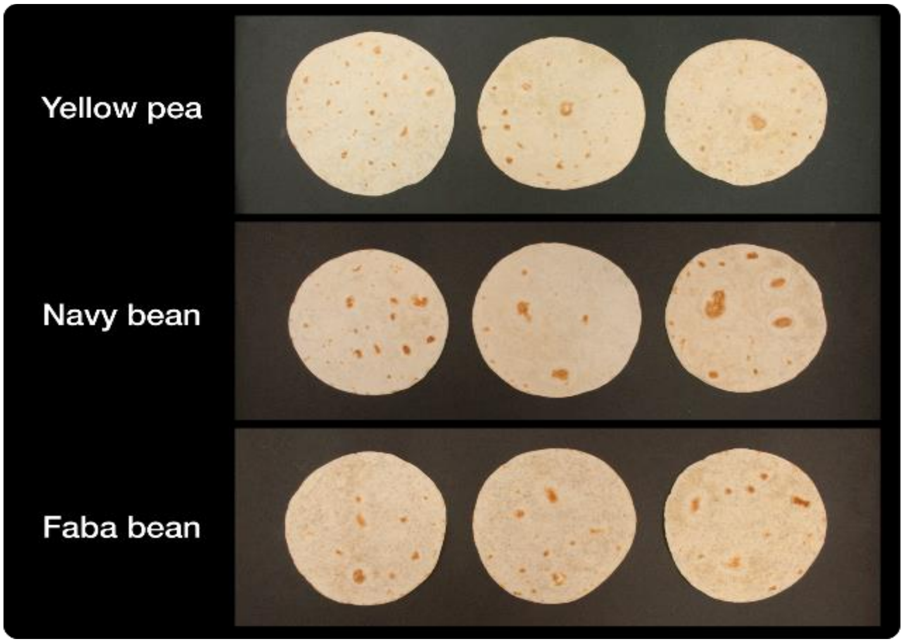
Table 6. Weight, diameter, thickness, brightness (L*) and firmness of tortillas made with pulse flours

Pulse Type	Treatment	Weigh (g)	Diameter (cm)	Thickness	L*[1]	Firmness
	Reference	**33.8 ± 1.8**	**16.4 ± 0.6**	**1.4 ± 0.7**	**80.5 ± 1.6**	**928.9 ± 93.9**
Yellow Pea	Untreated	34.0 ± 0.3a[2]	16.9 ± 0.3a	0.7 ± 0.2b	80.5 ± 0.4a	660.7 ± 46.4 a
	Micronized	33.4 ± 0.5a	16.4 ± 0.6ab	1.4 ± 0.5a	80.2 ± 0.6a	650.1 ± 89.8 a
	Roasted	34.0 ± 0.3a	16.0 ± 0.2b	1.3 ± 0.4ab	78.4 ± 0.8b	647.4 ± 130.5 a
Navy Bean	Untreated	33.8 ± 0.2a	16.3 ± 0.4a	1.6 ± 0.2a	80.4 ± 0.9a	638.0 ± 99.0 a
	Micronized	33.5 ± 0.9a	16.3 ± 0.2a	1.7 ± 0.2a	80.8 ± 1.0a	605.2 ± 31.7 a
	Roasted	33.7 ± 0.4a	15.9 ± 0.6a	1.8 ± 0.1a	78.5 ± 1.3b	611.4 ± 100.6 a
Faba Bean	Untreated	33.4 ± 0.3b	16.1 ± 0.3a	1.7 ± 0.2a	76.4 ± 1.2ab	848.4 ± 75.0 a
	Micronized	33.9 ± 0.3ab	15.9 ± 0.4a	1.8 ± 0.2a	78.2 ± 2.6a	834.8 ± 68.9 a
	Roasted	34.1 ± 0.5a	15.5 ± 0.5a	1.8 ± 0.1a	74.0 ± 0.5b	880.0 ± 68.9 a

[1] L* indicates the value of brightness (0 – black, 100 – white)

[2] Values with the same letter in a pulse type in the same column are not significantly different ($p < 0.05$)

Figure 2. Tortillas made with untreated, micronized and roasted pulses (from left to right within a pulse type)



Pita Breads

Pita breads made with roasted yellow peas displayed greater pocket heights, while for other pulse types pocket heights were unaffected by thermal treatment. Increased diameters of pitas were observed for products made with micronized navy beans compared to the untreated samples. Thermal treatments of pulses did not have a significant effect on the firmness values of pita breads (Table 7, Figure 3).

Table 7. Pocket height, diameter, brightness (L*) and firmness of pita breads made with pulse flours

	Treatment	Pocket Height (mm)	Diameter (cm)	L*[1]	Firmness[2](g)
Wheat	**Reference**	**71.9 ± 8.1**	**17.9 ± 0.3**	**77.8 ± 0.5**	**1182.9 ± 475.8**
Yellow Pea	Untreated	64.9 ± 5.6 b[3]	17.1 ± 0.3 a	72.0 ± 0.7 a	884.7 ± 120.6 a
	Micronized	62.3 ± 5.8 b	17.1 ± 0.4 a	70.4 ± 1.9 a	836.9 ± 301.9 a
	Roasted	72.7 ± 2.1 a	17.4 ± 0.2 a	70.5 ± 0.6 a	994.6 ± 133.5a
Navy Bean	Untreated	66.0 ± 1.0 a	17.3 ± 0.2 b	74.3 ± 0.4 a	880.04 ± 87.4 a
	Micronized	61.1 ± 4.2 a	17.8 ± 0.3 a	74.6 ± 0.9 a	955.2 ± 126.0 a
	Roasted	64.8 ± 3.6 a	17.4 ± 0.2 ab	74.3 ± 0.4 b	852.0 ± 188.6 a
Faba Bean	Untreated	66.5 ± 5.4 a	17.0 ± 0.4 a	66.9 ± 1.1 a	942.7 ± 90.2 a
	Micronized	68.6 ± 5.1 a	16.6 ± 0.7 a	66.6 ± 1.1 a	1052.9 ± 90.2a
	Roasted	66.9 ± 2.8 a	17.2 ± 0.1 a	65.6 ± 2.1 a	911.3 ± 61.5a

[1] L* indicates the value of brightness of the interior top layer (0 – black, 100 – white)

[2] Firmness of the top layer of the pita bread

[3] Values with the same letter in a pulse type in the same column are not significantly different ($p<0.05$)

Figure 3. Pita breads made with untreated, micronized and roasted pulses (from left to right within a market class)

Selected data from this study was included in a research poster entitled *Influence of Pre-milling Thermal Treatments of Pulses on End Product Quality of Processed Foods.* Appendix 1.

Sensor Evaluation and Purchase Intent

Sensory and purchase intent assessment of the products by consumers showed that for all three pulse types micronization and roasting resulted in a reduction in beany and bitter off flavours. Consumers were also more likely to purchase pan breads made with thermally treated pulse regardless of pulse type and pulse treatment when compared to those made with untreated pulse flour. Similarly, both micronization and roasting resulted in reduction of beany and bitter off flavours in pita breads. Purchase intent and acceptability was also improved for pita breads made with micronized or roasted yellow pea flours but not those made with navy or faba bean flours. For tortillas, neither the micronized nor roasted flours resulted in a reduction in beany or bitter flavours with the exception of tortillas made from micronization navy bean flour which had decreased bitterness. Consumer acceptance and purchase intent were not affected for tortillas to the same extent as for pan and pita breads.

Overall, sensory results from a consumer panel showed that micronization and roasting had the largest impact in pan breads followed by pita breads and to a lesser extent tortillas for acceptability and positive purchase intent. A comprehensive sensory analysis report of pan and pita breads and tortillas entitled *Consumer Sensory Evaluation of Baked Goods* can be found in Appendix 2.

Conclusions

This study has demonstrated that thermal pre-treatments such as roasting or micronizing prior to pulse milling can result in pulse flours and subsequently food products with improved flavour characteristics. In addition, it was found that the end product quality of baked products was minimally effected when flours derived from thermally treated pulses were incorporated into processed food formulations. This observation in particular is of benefit to food processors as minimal corrective actions will need to be addressed when using these types of flours in baked product formulations. However, it must be noted that all three baked products were effected to a different degree by the inclusion of treated pulse flours. Overall, the findings generated by this study will enable and assist food processors to confidently and effectively utilize thermally treated pulse ingredients in baked product formulations.

Based on the results generated it is recommended that thermal pre-treatment steps be considered prior to pulse flour production especially when the flours are destined for ingredients for baked products. Opportunities exist for producers to establish value added thermal treatment operations such as roasting or micronization on their farms in order to increase the value of pulse crops they grow. In addition, utilizing existing Canadian thermal treatment facilities prior to selling bulk seeds can be another option to increase the profitability for producers. Processing thermally treated pulse ingredient can create new markets for Manitoba pulses and increase the profitability for producers.

This study focused on gathering technical information on the effects of thermal treatment of pulses prior to milling. A comprehensive costing analysis is necessary in order to accurately measure the profitability of these types of value added operations. In addition, future work is needed to assess the efficacy of using thermally treated pulses in other processed foods. For example, the snack food industry is under immense pressures to provide consumers with healthier snack options. Past work at Cigi has shown that a variety of extruded snacks can be processed using pulse ingredients. However, information on the use of thermally treated pulses in snack food formulations is under investigated and warrants further examination.

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