Pulse Processing for End use Application

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Introduction

Pulses are well recognized for their nutritional and health benefits. They are easy to process for inclusion with wheat flour for a variety of applications enhancing the diversification of milled products. Milled

pulse products also offer a gluten free application opportunity. The focus of this presentation will be largely on providing information related to processing of pulses and their application in a range of end products.

Types of pulses grown in Canada

Peas

Yellow

Green

Split Yellow

Lentils

Large Green
Other names: Laird-type, Masoor Large Green

Red
Other name: Masoor

French Green
Other name: Dark Speckled

Chickpeas

Garbanzo
Other names: Kabuli, Bengal gram, Kabuli chana

Desi
Other names: Kala chana

Split Desi Chickpea
Other name: Chana dal

Beans

Navy
Other names: White Pea, Alubia Chica

Dark Red Kidney

Cranberry
Other names: Romano, Speckled Sugar, Borlotti

Light Red Kidney

Pinto

Black

Nutritional Advantage

- ✓ High Fiber
- ✓ High Protein
- ✓ Nutrient Dense
- ✓ Low Fat
- ✓ Gluten Free
- ✓ Low Allergenicity

Courtesy Pulse Canada

Ingredients with Nutrition

100 grams	Barley	Corn Meal	Oat	Rice (White)	Wheat	Pea	Lentil	Chick -Pea	Bean
Protein (g)	9.9	8.1	13.2	7.1	13.2	23.7	25.5	21.5	25.1
Fat (g)	1.2	3.6	6.5	0.7	2.5	1.2	1.2	5.6	1.4
Carbohydrate (g)	78	77	68	80	72	67	64	65	69
Fibre (g)	15.6	7.3	10.1	1.3	10.7	13.3	18.4	19.0	15.3
Iron (mg)	15.6	3.5	4.3	0.8	3.6	4.0	6.0	8.2	7.6
Magnesium (mg)	79	127	138	25	137	98	99	155	203
Potassium (mg)	280	287	362	115	363	1080	874	1105	1705

Source: USDA Nutrient Database; Silliker Data, 2013

Pulses are well known as a low glycemic index food.

	Glycemic Index
Rice	89
Potato	82
Pasta	60
Corn	60
Quinoa	53
Lentils	29

http://www.health.harvard.edu/healthy-eating/glycemic_index_and_glycemic_load_for_100_foods

Excellent Source of Fiber

		Carbs	Protein	Fibre
Lentils	½ cup cooked	20	9	8
Corn	½ cup cooked	12	2	1.6
Rice	½ cup cooked	22	2	0.3
Quinoa	½ cup cooked	20	4	2.6
Barley	½ cup cooked	22	1.8	3

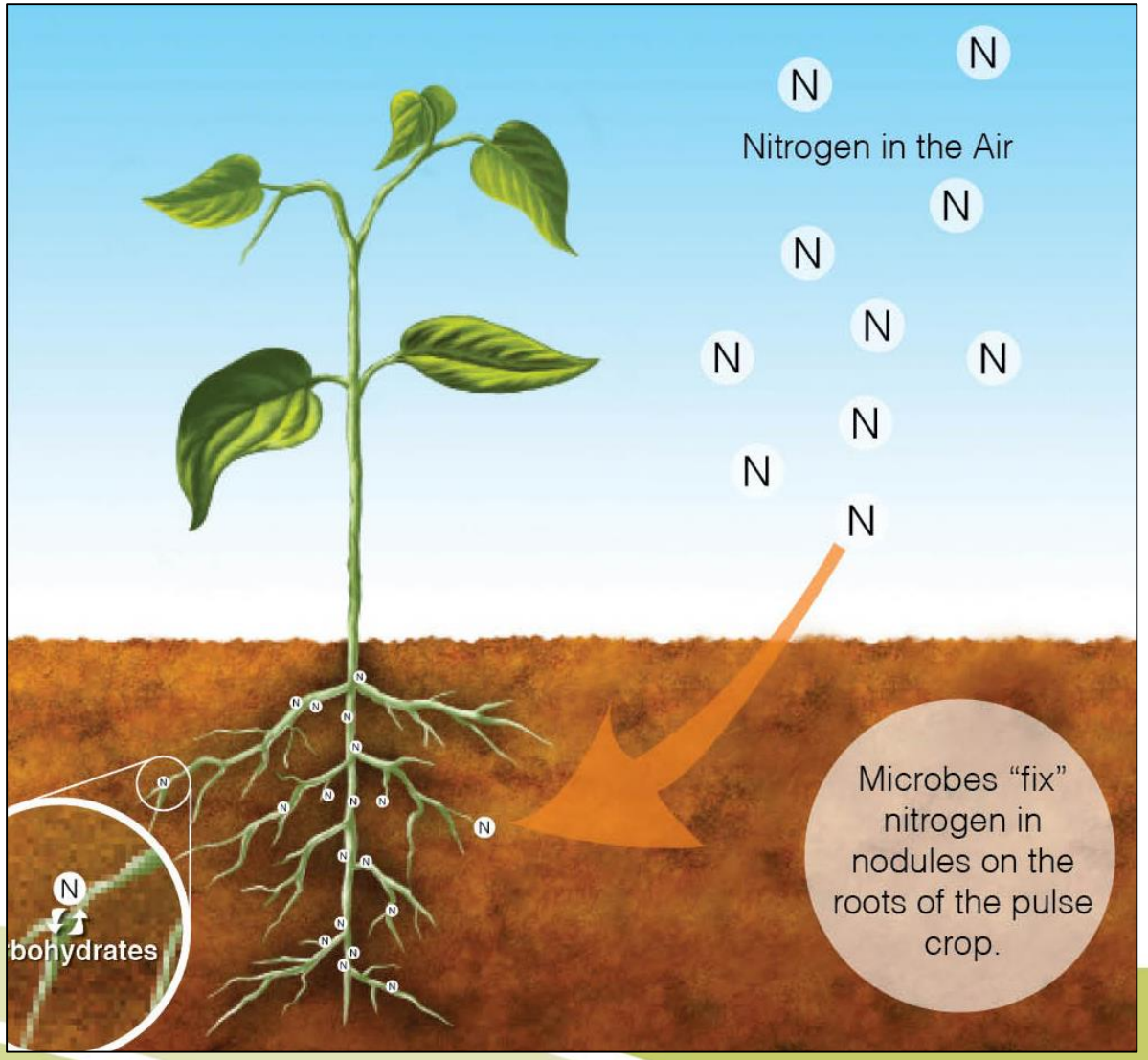
Source: USDA Nutrient Database

Source of Protein, Low in Fat

	Serving Size	Protein (g)	Fat (g)
Lentils	½ cup cooked	9	0.4
Eggs	2 whole, poached	12.5	9.5
Greek Yogurt (full fat)	100 g	8.25	3
Beef	1 steak (104 g)	27	18
Almonds	2 tbsp	7.6	18
Peanut butter	2 tbsp	9	12

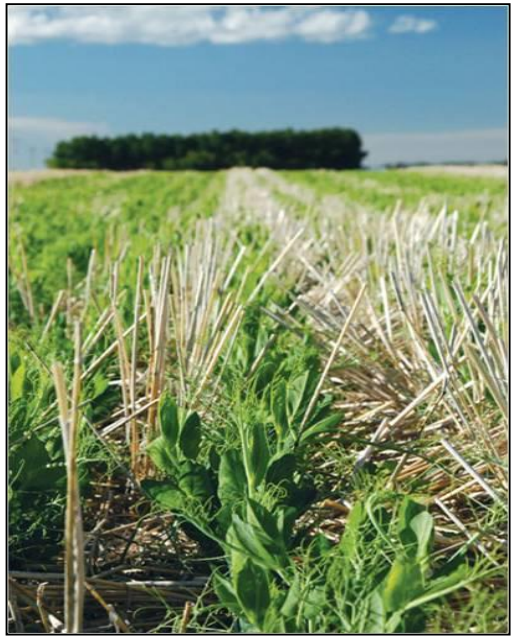
Source: USDA Nutrient Database

Pulses make their own fertilizer!



Pulses and Sustainability

- ✓ Low Carbon Footprint
- ✓ Low Water Footprint
- ✓ Drought Tolerant
- ✓ Improve Soil Health
- ✓ Improve Crop Rotations



Courtesy Pulse Canada

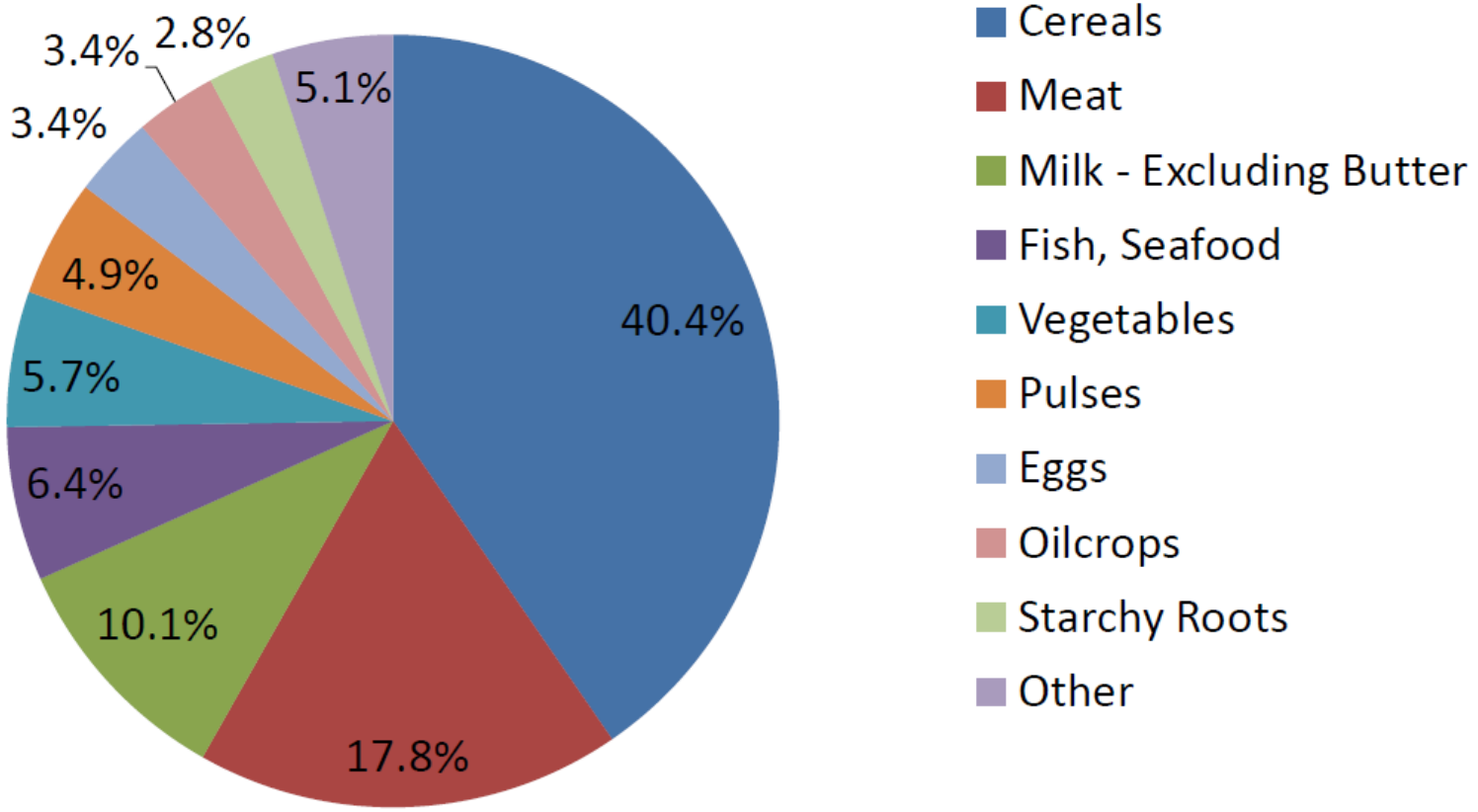
Key reasons for recent popularity of Pulses

- Nutritional & health benefits
- Availability & affordability
- Sustainability
- Versatility in processing and applications

PULSES

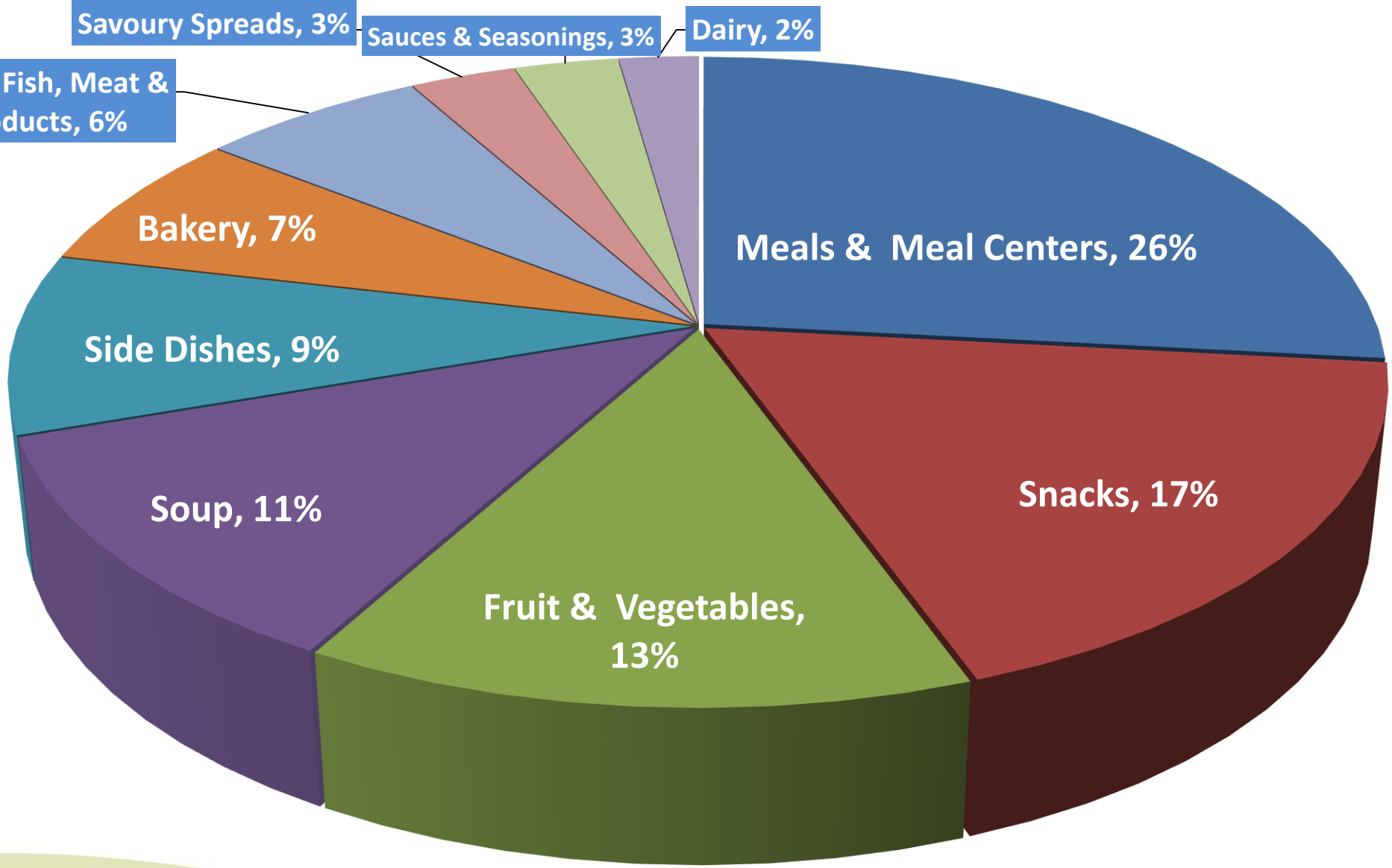
Key Messages

Global protein supply



New Product Releases Containing Pulse Ingredients in USA and Canada, January 2005 – December 2015

Source: *Mintel Global New Products Database, 2016*



Pulse Ingredients in New Products by Category (%), January 2005 – December 2015

Source: *Mintel Global New Products Database, 2016*

Processing of pulses for food applications

- Cleaned and bagged
- Cleaned, dehulled & split and bagged
- Clean seed milled into meal or flour for various applications
- Finely ground in pin mills & air classified for protein concentrates
- Wet processing for generating protein isolates
- Wet processing for starch separation for production of vermicelli noodles

Variety of Ingredients

WHOLE SEED	DEHULLED SPLIT	GROUND	FLAKED	FRACTIONATED	PURÉED
 Beans		 Bean Flour	 Bean Flakes	 Pea Starch	
 Lentils	 Split Red Lentil	 Lentil Flour	 Lentil Flakes	 Pea Fibre	
 Chickpeas	 Split Chickpea *(Chana)*	 Chickpea Flour *(Garbanzo, Besan)*		 Pea Protein	
 Peas	 Split Pea	 Pea Flour		 Texturized Pea Protein	






Whole pulse

Split pulse

Flours

Purées

Fraction s

Pre-Cooked





Processing of pulses for food applications

Most processing practices listed previously are well established and have been in use for a long time. The bulk of the research and development that is taking place is in the area of milling pulses into flour for a variety of end use applications. These pulse flours are blended with wheat flours in various proportions in order to balance nutritional value with acceptable product quality. This facilitates increased consumption of pulse flours by the segment of population that otherwise may miss the opportunity.

Application of pulse flour for instant noodles

Physical, Compositional, and Functional Properties of 20% YP Flour: 80% Wheat Flour Blends

	Wheat Control	UNT 150	UNT 85	EXT 150	EXT 85
Moisture, %	14.4 ± 0.1[a]	13.5 ± 0.1[b]	13.2 ± 0.0[bc]	12.8 ± 0.1[c]	12.8 ± 0.0[c]
Protein Content, % dmb	15.4 ± 0.0[c]	18.8 ± 0.0[b]	18.9 ± 0.0[ab]	19.0 ± 0.0[a]	19.0 ± 0.0[a]
Starch Content, % dmb	75.0 ± 0.3[a]	69.5 ± 0.3[b]	69.5 ± 0.0[b]	69.4 ± 0.0[b]	69.0 ± 0.3[b]
Dietary Fiber, %	3.7 ± 0.3[a]	4.1 ± 0.1[a]	5.0 ± 0.8[a]	4.8 ± 0.1[a]	5.1 ± 0.1[a]
[2]Glycemic Index	39.7 ± 0.2[a]	35.9 ± 0.1[c]	36.7 ± 0.2[bc]	38.6 ± 0.0[ab]	38.3 ± 1.2[ab]
Viscosity, dmb					
Peak Viscosity, RVU	321.1 ± 1.4[a]	273.2 ± 1.4[b]	270.8 ± 0.7[b]	242.0 ± 1.4[c]	236 .4 ± 0.7[d]
Final Viscosity, RVU	342.4 ± 2.1[a]	325.8 ± 1.4[b]	323.4 ± 0.7[b]	280.4 ± 2.1[c]	273.9 ± 1.4[c]
Starch Damage, % dmb	8.5 ± 0.0[b]	7.0 ± 0.1[c]	7.0 ± 0.0[c]	11.7 ± 0.2[a]	11.8 ± 0.3[a]
Water Absorption Capacity, g water/g flour dmb	0.8 ± 0.0[b]	0.7 ± 0.0[b]	0.7 ± 0.0[b]	1.0 ± 0.0[a]	1.0 ± 0.0[a]
Particle Size Distribution					
d(0.1) µm	24.5 ± 0.0[c]	25.6 ± 0.3[b]	21.3 ± 0.1[d]	26.4 ± 0.2[a]	24.2 ± 0.0[c]
d(0.5) µm	76.6 ± 0.3[c]	86.0 ± 0.7[a]	71.0 ± 0.1[e]	83.5 ± 0.6[b]	73.0 ± 0.1[d]
d(0.9) µm	145.7 ± 0.4[b]	185.1 ± 4.4[a]	139.9 ± 0.3[b]	179.1 ± 6.9[a]	141.0 ± 0.0[b]
d[4,3] µm	82.1 ± 0.2[b]	98.4 ± 1.8[a]	76.9 ± 0.1[b]	98.4 ± 6.6[a]	78.8 ± 0.1[b]

Physical, Compositional, and Functional Properties of 20% YP Flour: 80% Wheat Flour Blends

	Wheat Control	UNT 150	UNT 85	EXT 150	EXT 85
Moisture, %	14.4 ± 0.1[a]	13.5 ± 0.1[b]	13.2 ± 0.0[bc]	12.8 ± 0.1[c]	12.8 ± 0.0[c]
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Dietary Fiber, %	3.7 ± 0.3[a]	4.1 ± 0.1[a]	5.0 ± 0.8[a]	4.8 ± 0.1[a]	5.1 ± 0.1[a]
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Water Absorption Capacity, g water/g flour dmb	0.8 ± 0.0[b]	0.7 ± 0.0[b]	0.7 ± 0.0[b]	1.0 ± 0.0[a]	1.0 ± 0.0[a]
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Application of pulse semolina/flour for breakfast cereals

Whole Pea Semolina

Conditions – rep 1, rep2
Water flow rate (kg/h)- 2.1, 2.4
Blend feed rate (kg/h)- 36, 36
Screw speed (rpm)- 537, 650
Cutter speed (rpm)- 1178, 1207
Temperature (°C)- 107, 109
Pressure (kPa)- 700, 300

Refined Pea Semolina

Conditions – rep 1, rep2
Water flow rate (kg/h)- 2.1, 2.1
Blend feed rate (kg/h)- 36, 36
Screw speed (rpm)- 655, 655
Cutter speed (rpm)- 1079, 1122
Temperature (°C)- 106, 106
Pressure (kPa)- 400, 400

Whole Pea Flour

Conditions – rep 1, rep2
Water flow rate (kg/h)- 2.5, 2.2
Blend feed rate (kg/h)- 36, 36
Screw speed (rpm)- 602, 602
Cutter speed (rpm)- 1051, 1221
Temperature (°C)- 109, 110
Pressure (kPa)- 300, 300

Refined Pea Flour

Conditions – rep 1, rep2
Water flow rate (kg/h)- 2.5, 2.5
Blend feed rate (kg/h)- 36, 36
Screw speed (rpm)- 537, 673
Cutter speed (rpm)- 1093, 1122
Temperature (°C)- 109, 109
Pressure (kPa)- 300, 200

Yellow pea semolina & flour quality characteristics

	WPS	RPS	WPF	RPF
Protein, % dwb	25.7	26.7	21.7	22.5
Moisture, %	11.0	11.3	10.5	10.9
Total dietary fibre, % as is basis	20.2	9.5	14.8	7.8
Total starch, % dwb	37.4	36.1	52.0	58.2
Starch damage, % dwb	0.7	0.6	3.2	3.7
Particle Size Distribution				
d(0.1)	340.4	435.2	14.8	15.1
d(0.5)	606.0	650.9	51.4	42.1
d(0.9)	944.9	986.7	340.6	126.9
d[4,3]	613.3	686.3	116.5	58.2

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d[4,3]	613.3	686.3	116.5	58.2

Application of pulse flour for pan bread

Application of pulse flour for tortilla

Application of pulse flour for pita bread

Compositional & functional properties of treated & untreated pulse flours

Description	Unt. WYP	Micro WYP	Roasted WYP	Unt. Navy	Micro Navy	Roasted Navy	Unt. Faba	Micro Faba	Roasted Faba
PULSE FLOUR (db)									
Moisture, %	10.8	8.8	8.5	12.1	9.8	8.5	10.2	8.5	8.1
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
Final Viscosity, RVU	183	209	218	137	164	188	201	202	186
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 fl)	1.70	1.43	1.34	1.35	1.30	1.54	1.31	1.24	1.29
Mastersizer									
d(0.1) um	27.6	16.9	14.8	21.1	18.2	15.5	18.0	19.1	16.5
d(0.5) um	318.3	238.1	208.7	279.5	257.3	217.5	254.4	254.0	213.1
d(0.9) um	699.6	661.8	645.9	693.8	700.9	672.3	721.3	715.9	707.8
D[4,3] um	348.8	294.7	274.9	318.1	312.4	284.8	314.8	317.9	296.7

Compositional & functional properties of treated & untreated pulse flours

Description	Unt. WYP	Micro WYP	Roasted WYP	Unt. Navy	Micro Navy	Roasted Navy	Unt. Faba	Micro Faba	Roasted Faba
PULSE FLOUR (db)									
Moisture, %	10.8	8.8	8.5	12.1	9.8	8.5	10.2	8.5	8.1
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
Final Viscosity, RVU	183	209	218	137	164	188	201	202	186
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 fl)	1.70	1.43	1.34	1.35	1.30	1.54	1.31	1.24	1.29
Mastersizer									
d(0.1) um	27.6	16.9	14.8	21.1	18.2	15.5	18.0	19.1	16.5
d(0.5) um	318.3	238.1	208.7	279.5	257.3	217.5	254.4	254.0	213.1
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Pulse Milling Processes

- One Step or Simple Grinding System
- Gradual Reduction System

Pulse Milling Processes

- One Step or Simple Grinding System
  - Hammer Mill
  - Stone Mill
  - Pin Mill
  - Ferkar Mill
- Gradual Reduction System
  - Roller Milling System

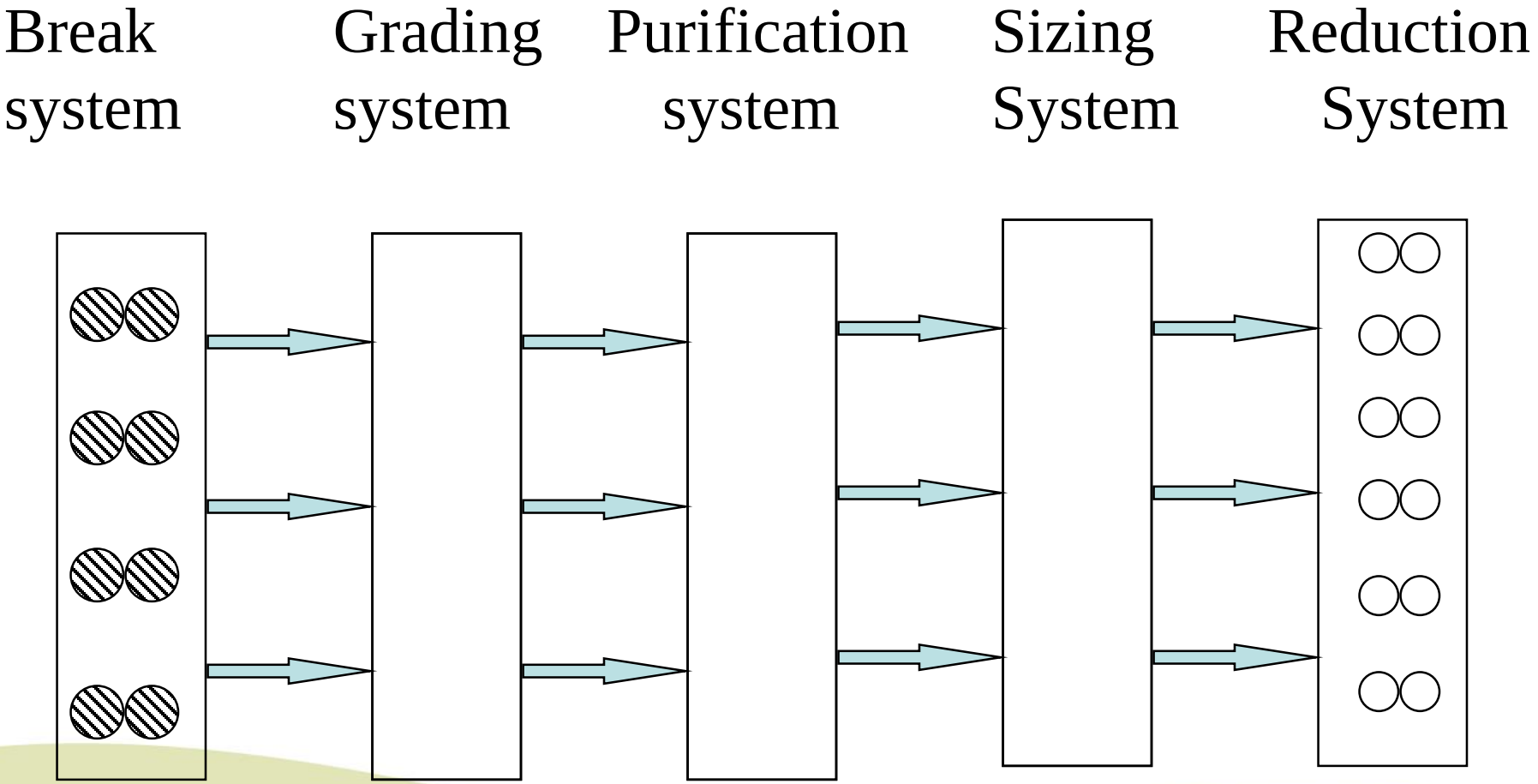
How does the approach to Pulse processing differ from processing of wheat ?

Peas & Wheat Processing Comparison:

Peas are simple in processing

Wheat processing is much more complex

Block Flow Diagram



Pulse Milling Processes

Peas

Pea Flour

Split Peas

Pea Flour

Pulse Milling Processes

Peas

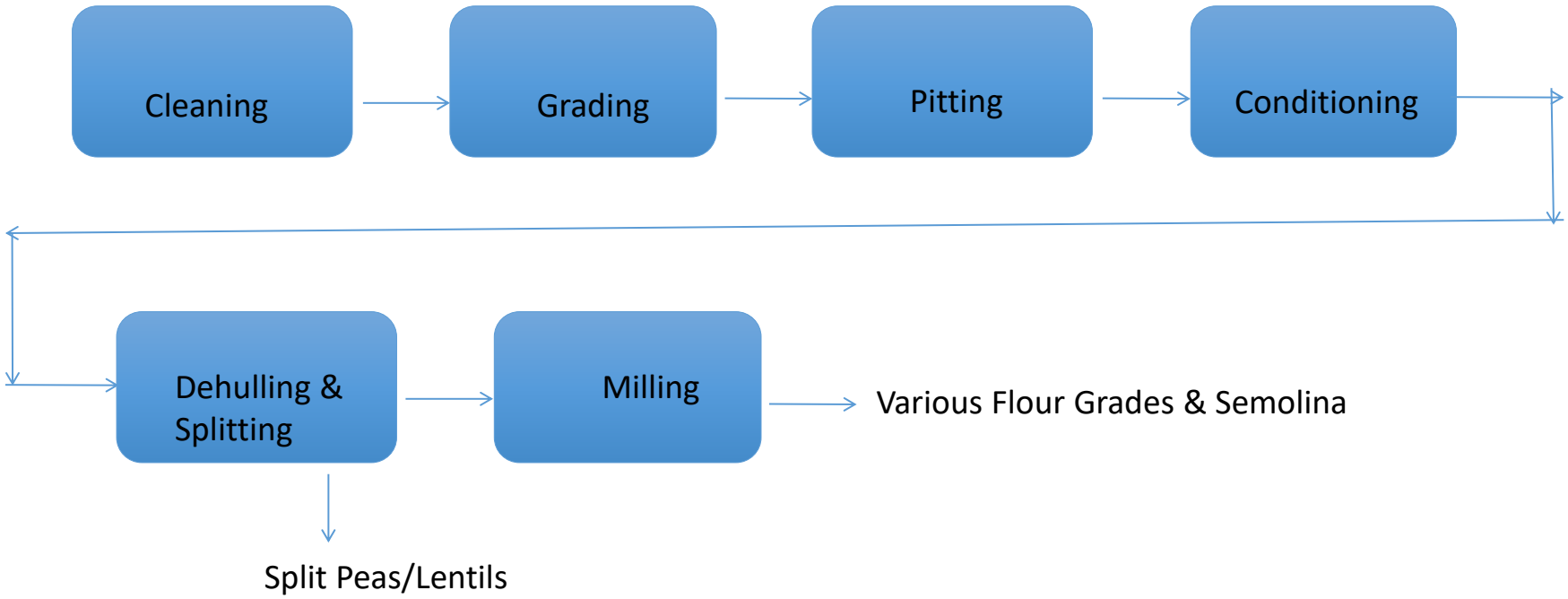
Split Peas

Pea Flour

Split Peas
Pea Flour

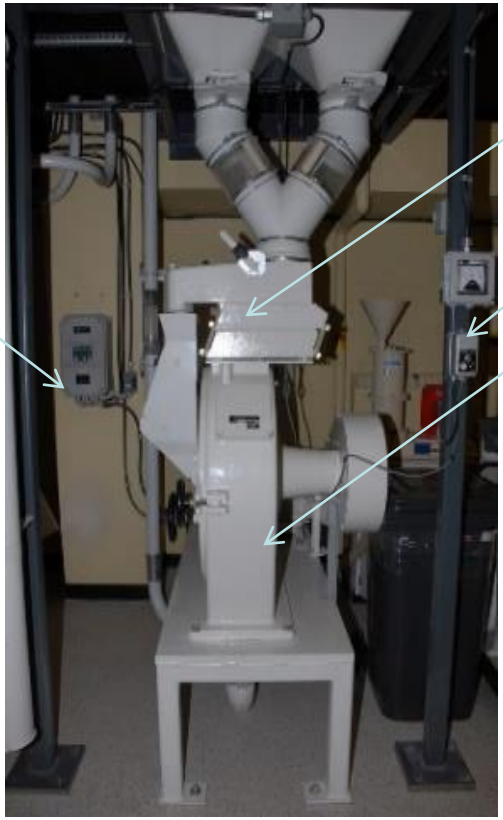
Pulse Milling Processes

Pulse Processing - General Flow Diagram

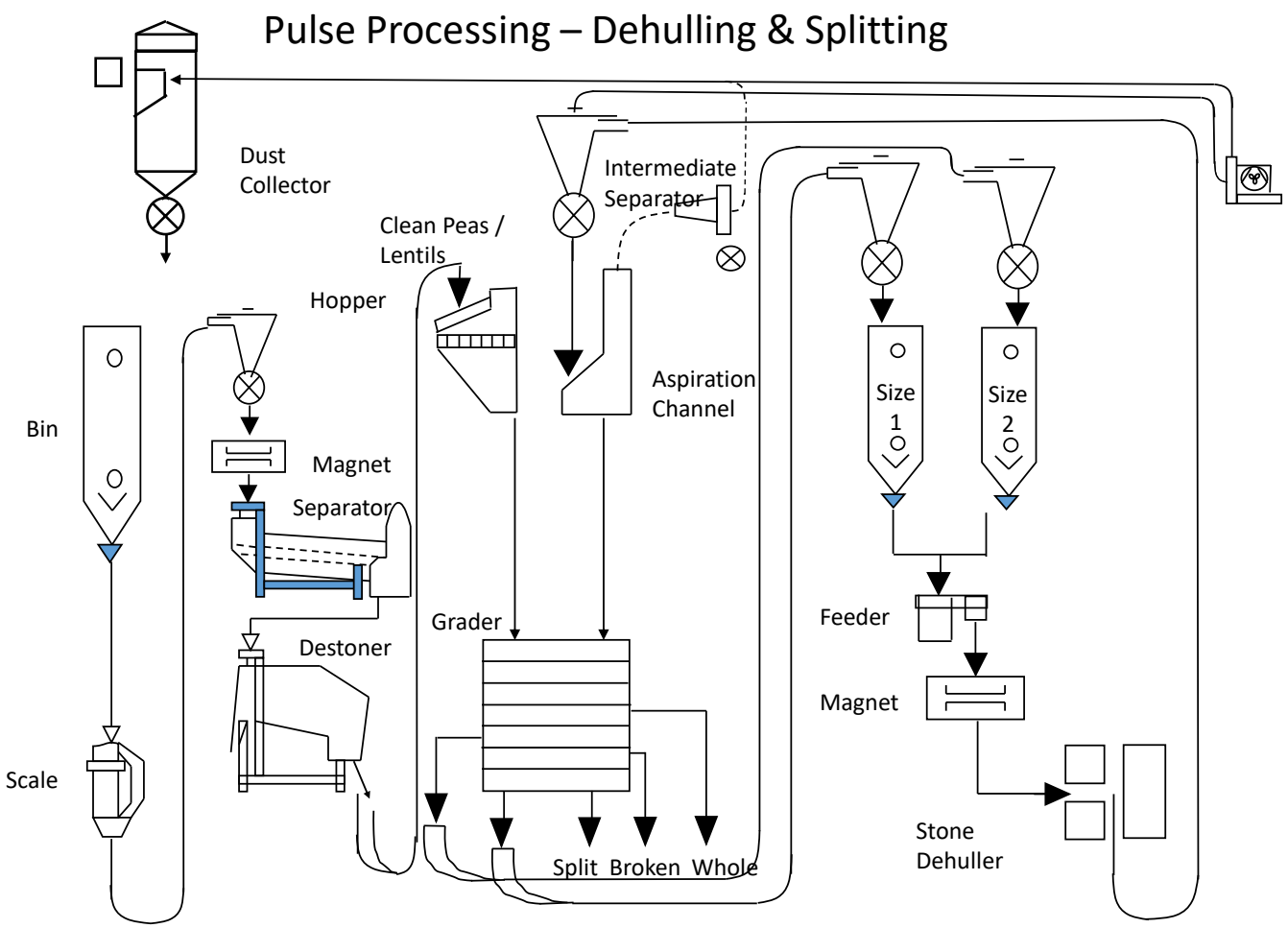


Dehuller

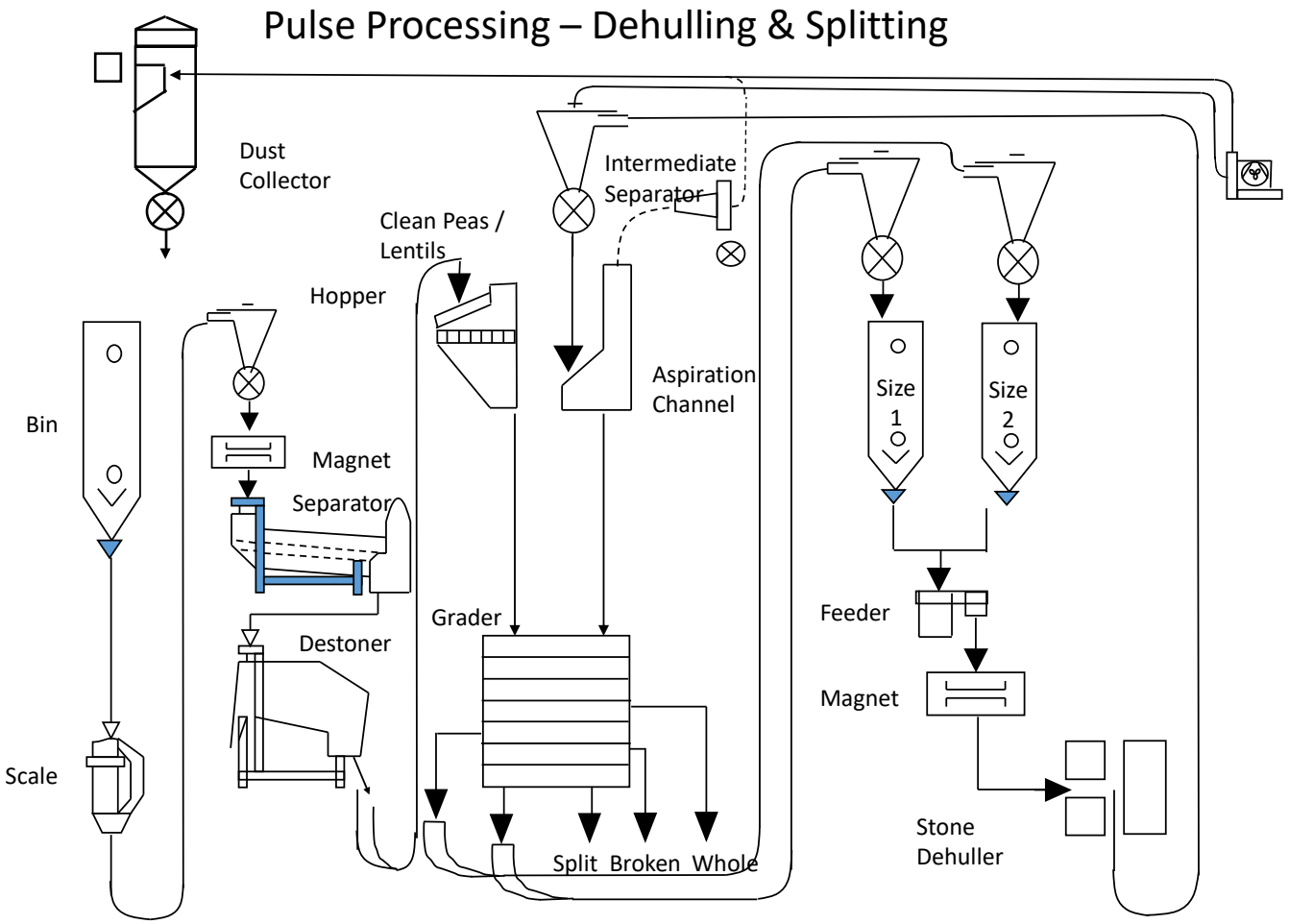
Pulse Milling Processes - Dehuller



Pulse Milling Processes – Dehulling & Splitting

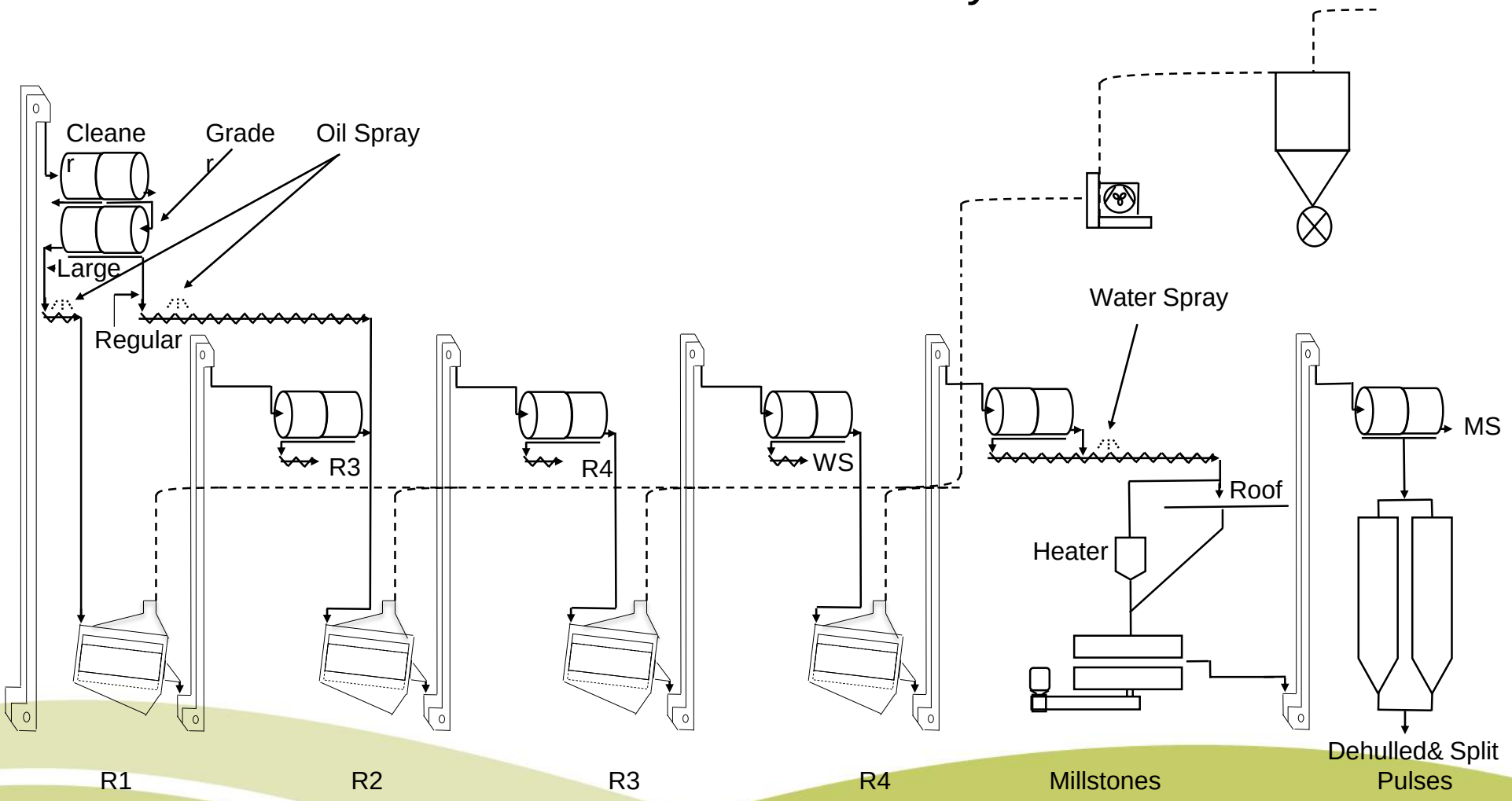


Pulse Milling Processes – Dehulling & Splitting



Pulse Processing Plant for Dehulling & Splitting in Northern India

With Dust Collection System



Raw material quality – Dehulling & Splitting Properties of Peas

Dehulling & Splitting	Various types of peas
Easy	Yellow peas
	Green Peas
	Chickpeas
Difficult	Pigeon peas

Size Grading

Pea

Large

Small

Key Quality Factors in Pulse Flour

- Protein content
- Particle size

Size reduction influences

:

- Colour
- Water absorption
- Rate of hydration
- Oil absorption
- Viscosity
- Cooking time
- Consistency
- Texture

Ferkar Mill

- The Ferkar mill is an advanced vertical milling equipment for the food, pharmaceutical, chemical and several other industries
- The ferkar mill is designed to mill materials in one pass.
- Multi purpose, knife type mill
- Model Ferkar 5, 10hp motor
- Ferkar mill can use both perforated and woven metal mesh screens
  Cigi (0.14 mm – 5.0mm)

Ferkar Mill

PSD using various screen sizes using whole & split yellow peas

Flour Description	WYP	SYP	WYP	SYP	WYP	SYP	WYP	SYP	WYP	SYP
Ferkar mill screen size (mm)	3.0		1.5		1.0		0.5		0.14	
Mastersizer	µm	µm	µm	µm	µm	µm	µm	µm	µm	µm
d(0.1)	124.8	138.1	24.7	23.0	18.5	19.3	10.4	11.2	6.2	8.2
d(0.5)	688.7	736.6	383.1	410.4	255.1	279.0	44.9	36.6	26.5	26.0
d(0.9)	1366.6	1404.6	907.0	973.9	648.8	658.3	310.7	260.0	260.7	128.6
D[4,3][1]	730.5	769.8	431.2	457.3	294.2	305.7	126.5	94.3	124.3	86.8

[1]Volume Weighted Mean

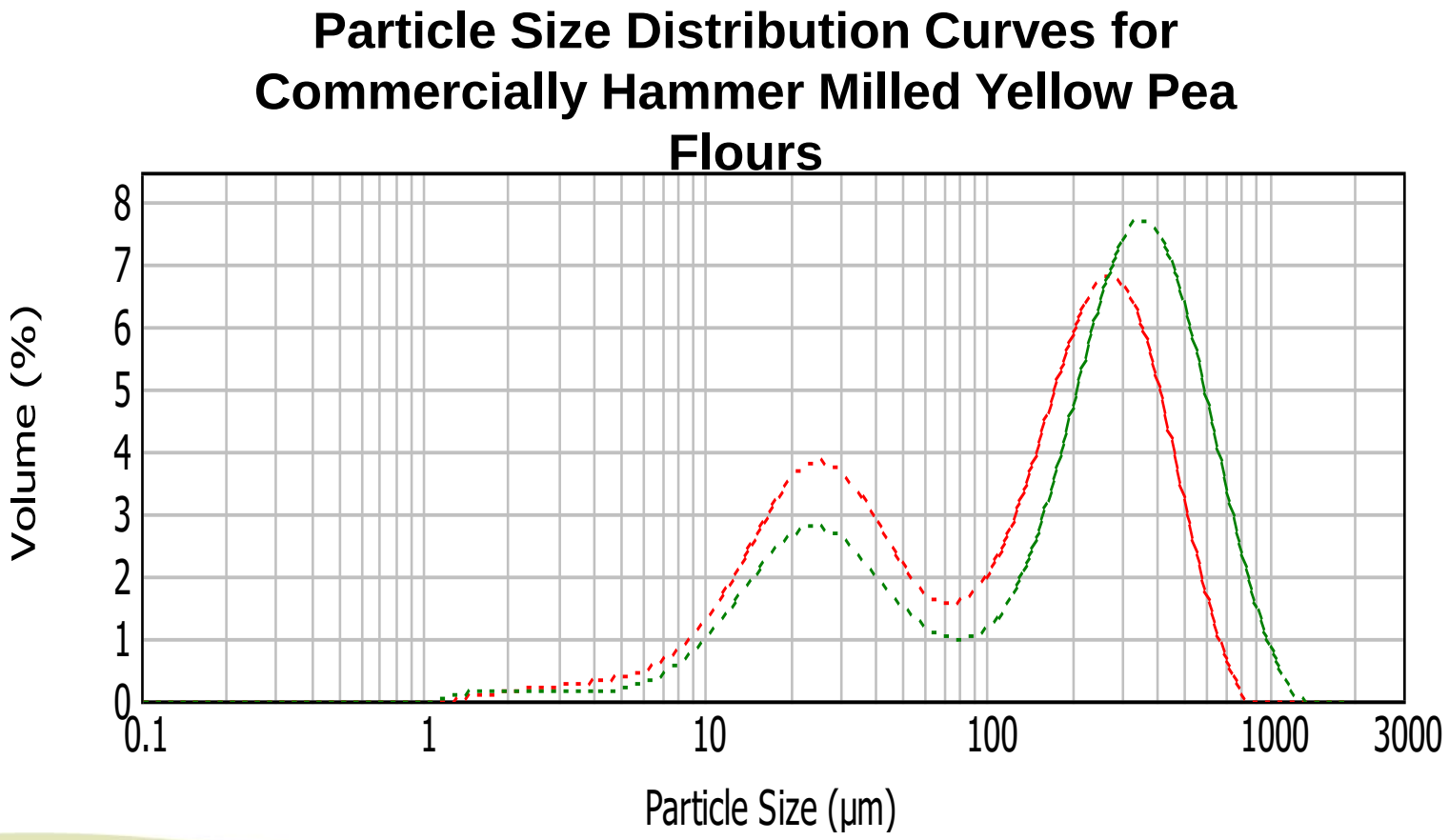
Flour quality comparison using various milling methods

Pulse milling & utilization project

Flour quality comparison using various milling methods

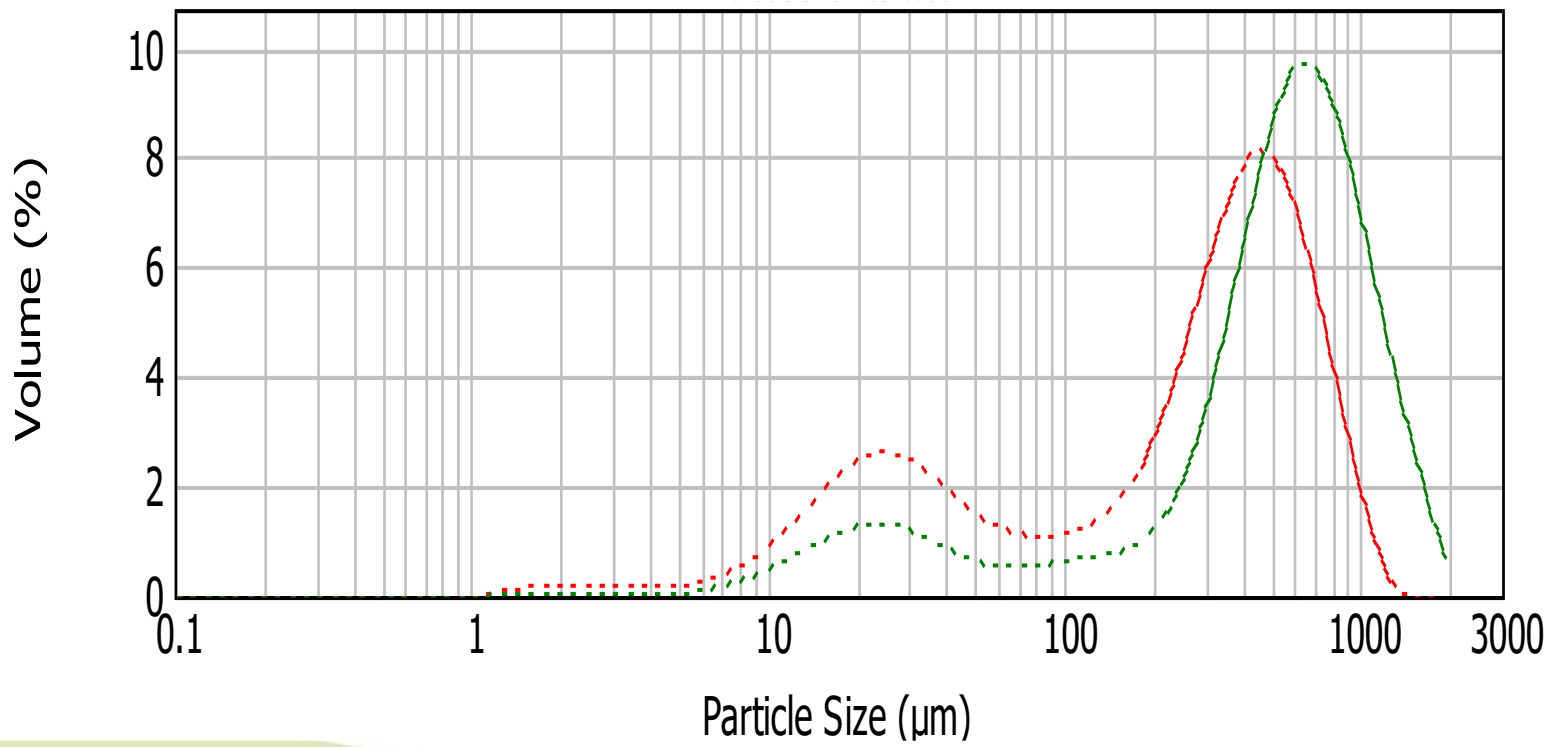
	Hammer Mill		Pin Mill (Fine)		Stone Mill		Roller Mill	
	Split	Whole	Split	Whole	Split	Whole	Split	Whole
Volume weighted Mean, µm	175.5	274.2	44.0	97.1	329.5	595.6	62.3	236.8
Protein, %	24.4	22.1	25.0	22.9	24.4	23.5	23.9	22.1
Fibre, %	12.0	21.8	7.3	15.3	14.6	17.8	7.0	16.0
Peak viscosity	150	107	202	155	101	65	218	159

Hammer Milled



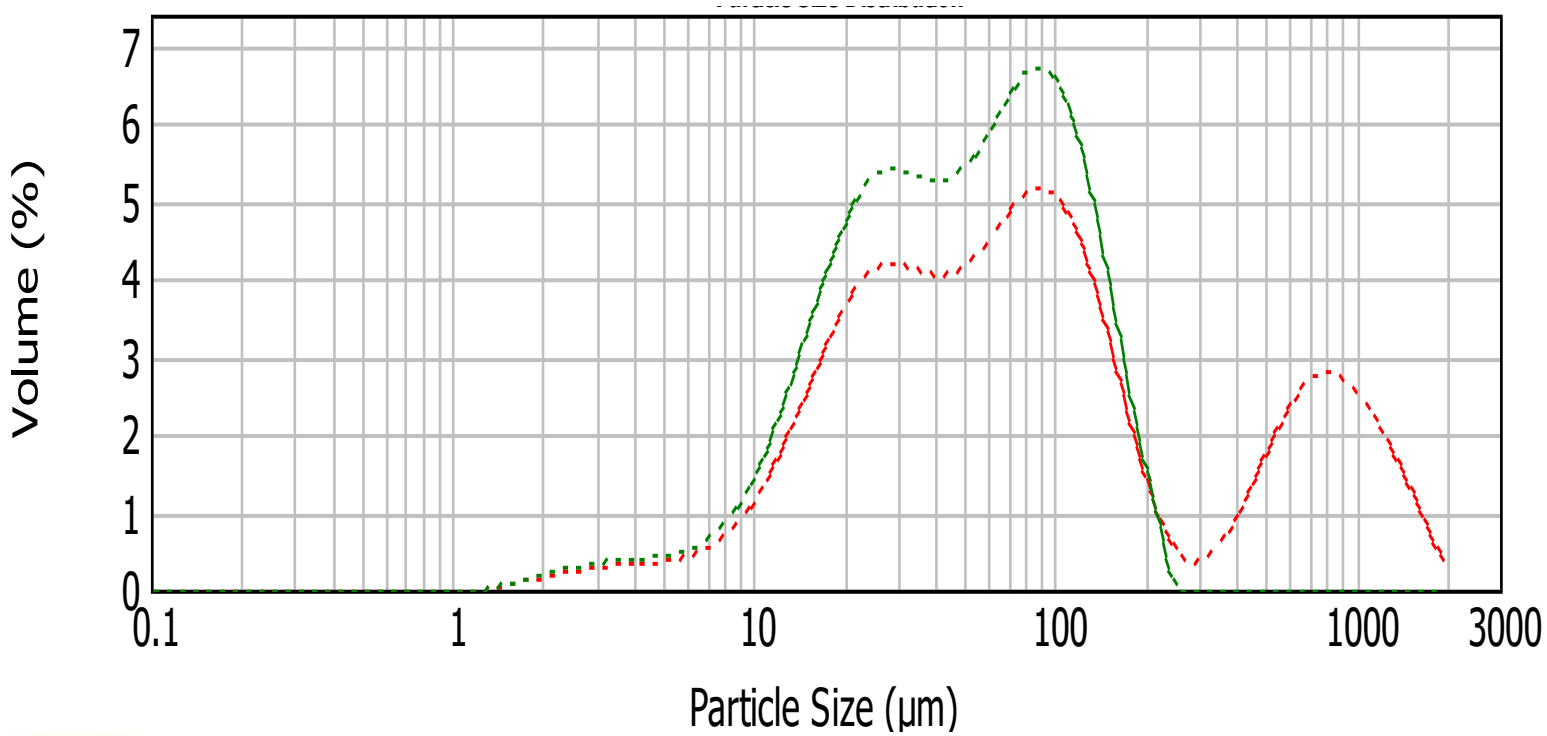
Stone Milled

Particle Size Distribution Curves for Commercially Stone Milled Yellow Pea Flours



Roller Milled

Particle Size Distribution Curves for Commercially Roller Milled Yellow Pea Flours



Quality products from processing of peas

Coarse Pea Semolina

Fine Pea Semolina

Pea Flour

CIGI Pilot Mill

Rollermill

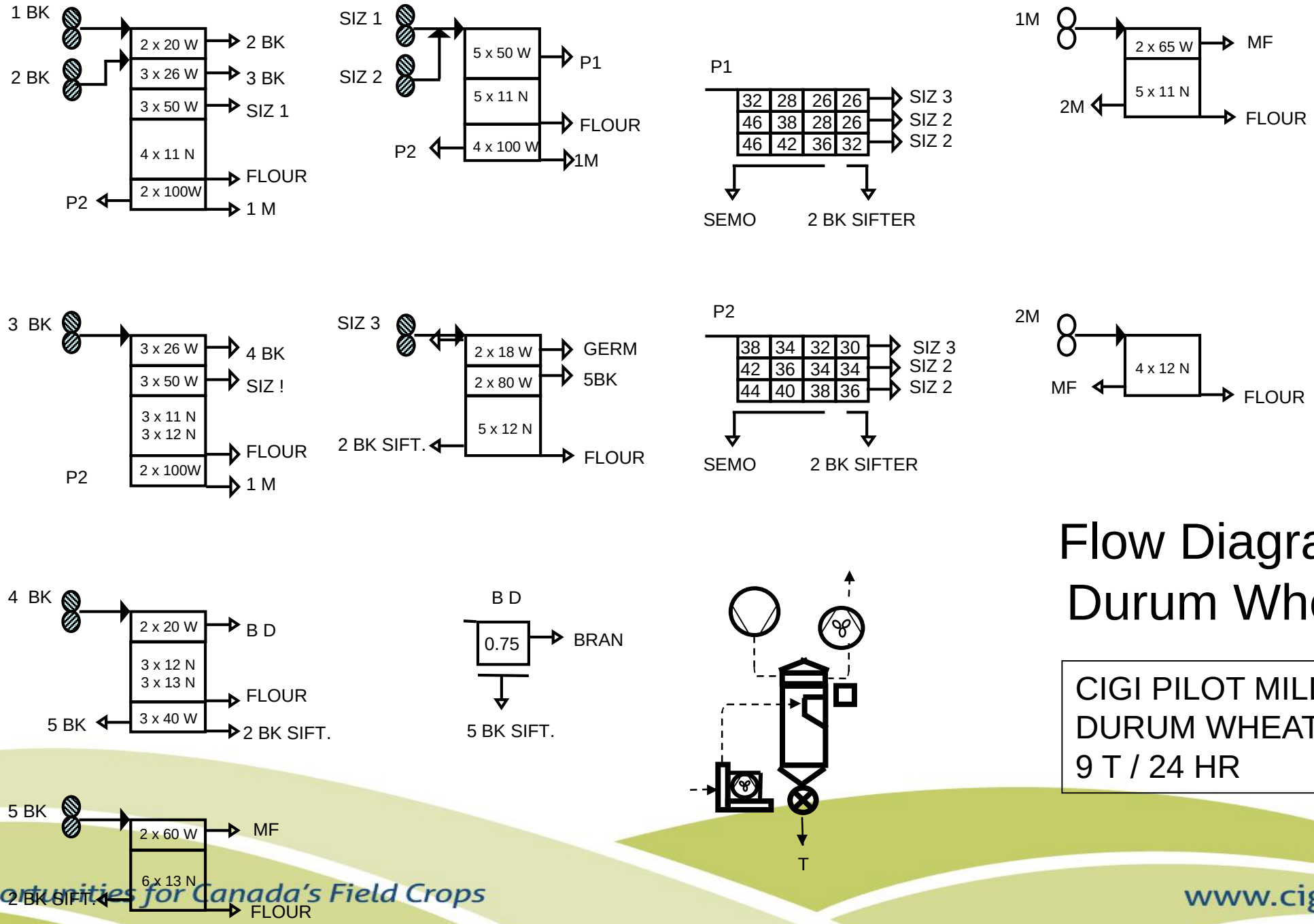
Feed gate on 3rd break

Filter Pressure Gauge

Transflowtron

Flow Balancers

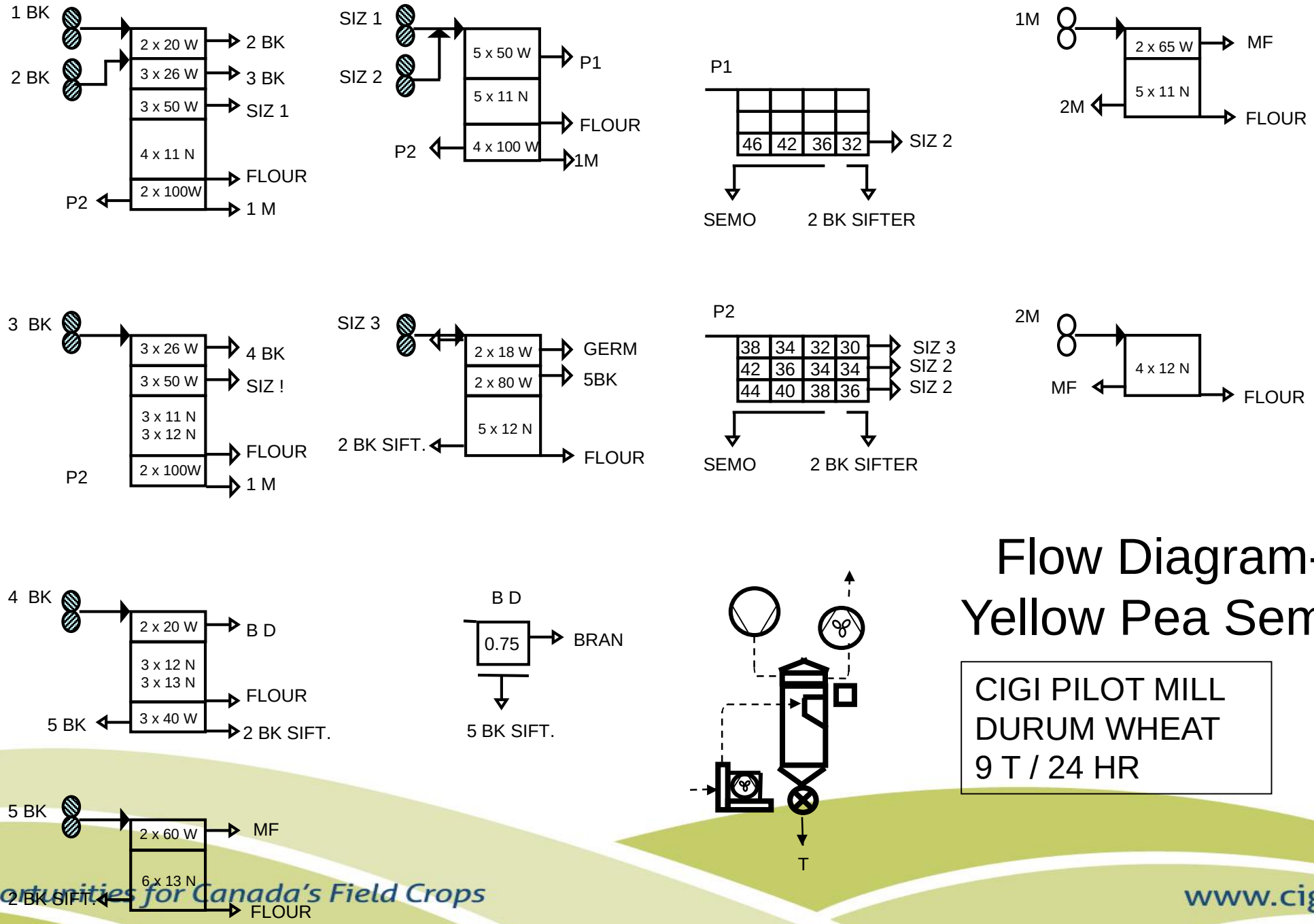
Flow Diagram- Durum Wheat



CIGI PILOT MILL
DURUM WHEAT
9 T / 24 HR

Flow Diagram- for Yellow Pea Semolina

CIGI PILOT MILL
DURUM WHEAT
9 T / 24 HR



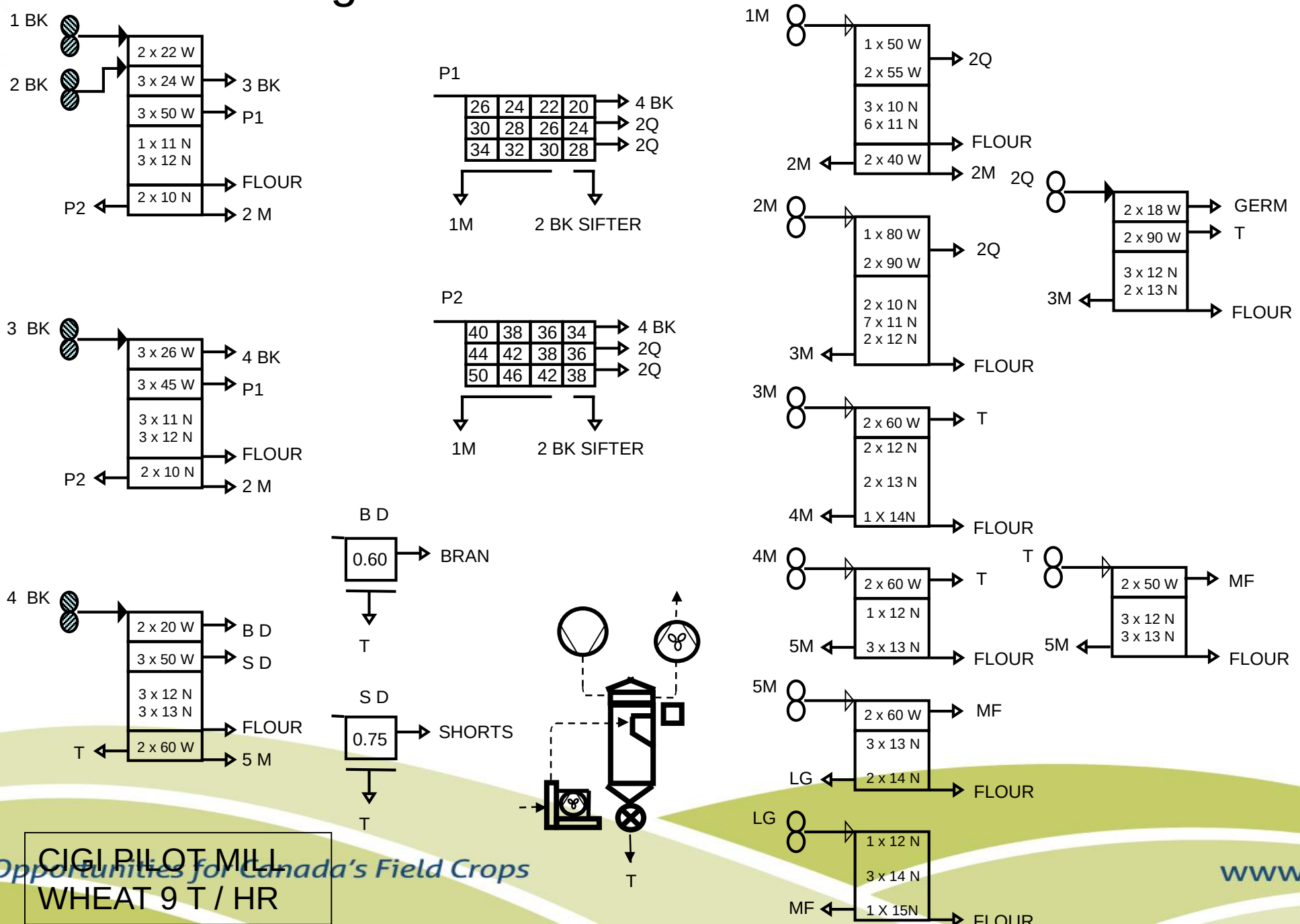
Pea Semolina & Flour Results

Product	Yield, %	Protein, %
Coarse Semolina	40.2	26.7
Fine Semolina	21.1	27.1
Flour	17.9	22.5

Pea Semolina & Flour Results

Product	Coarse Semolina	Fine Semolina	Flour
Yield, %	40.2	21.1	17.9
Protein, %	26.7	27.1	22.5
PSD			
d(0.1) um	435.1	227.0	15.1
d(0.5) um	650.9	367.5	42.1
d(0.9) um	986.7	585.3	126.9
D[4,3] um	686.2	389.3	58.2

Flow Diagram- Common Wheat



CIGI PILOT MILL
WHEAT 9 T / HR

Optimized Pea Semolina & Flour Results

Product	Semolina	Flour
Yield, %	25.4	63.9
Protein, %	23.5	22.4
PSD		
d(0.1) um	437.5	14.7
d(0.5) um	626.1	47.0
d(0.9) um	905.7	123.1
D[4,3] um	653.3	59.1

Flour Streams from the optimized milling

Passages	B1+B2	B3	1M	2M	3M	2Q	4M	5M	LG	T	B4
Flour, %	11.7	3.61	24.3	5.08	14.4	14.3	3.44	11.4	2.49	8.61	0.62
Protein, %	20	21.1	22.9	24.7	23.9	20.2	22.4	23.8	26.3	21.7	23.4
PSD											
d(0.1) um	15.4	15.4	17.4	15.4	14.3	14.6	15.7	13.5	10.5	11.8	18.4
d(0.5) um	39.3	45.3	72.6	59.1	46.3	38.3	57.1	41.1	31.4	31.5	84.9
d(0.9) um	126.6	145.6	152.1	140.0	109.8	125.4	127.8	100.6	93.3	103.1	229.1
D[4,3] um	56.7	65.3	79.0	69.2	55.0	55.8	65.1	49.9	60.7	45.5	107.4

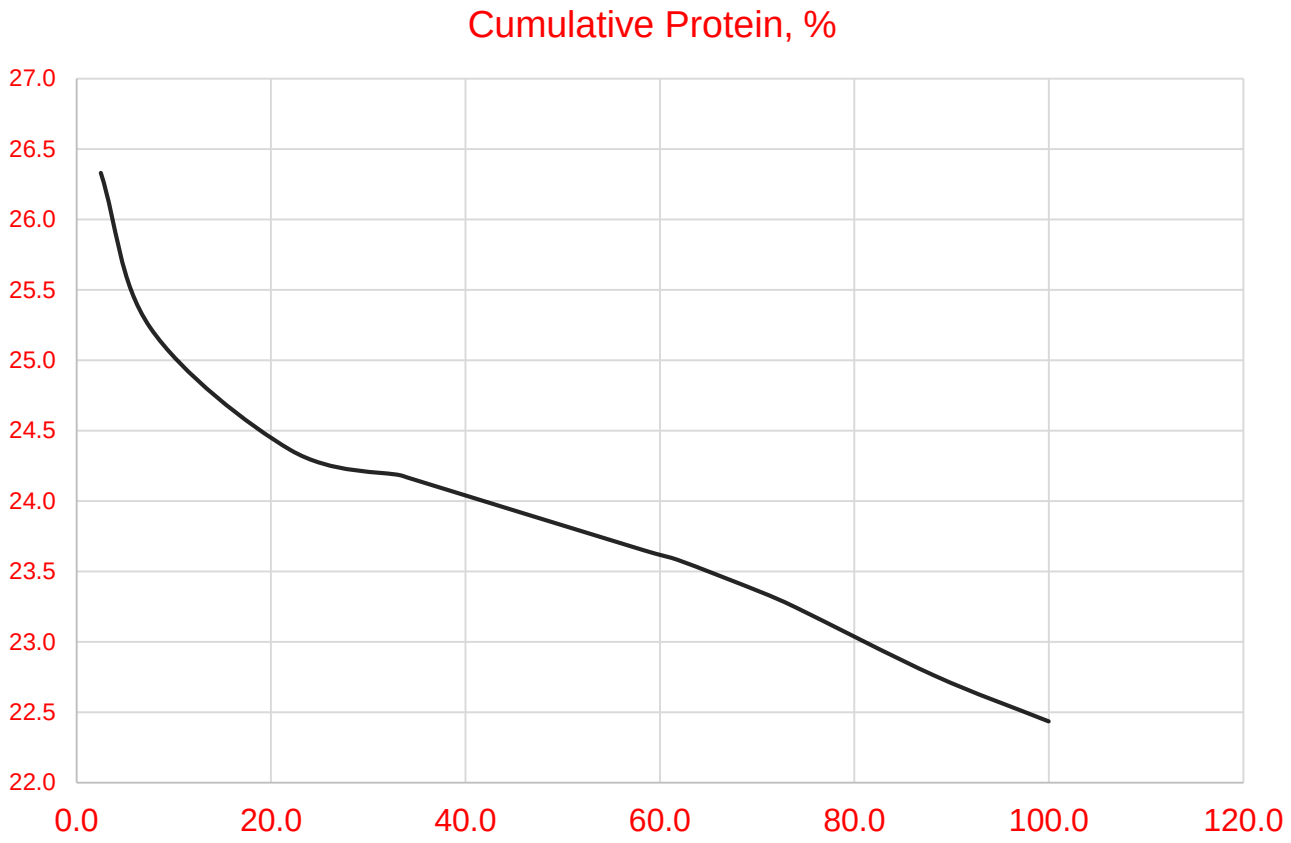
Flour Streams Yield and Protein content

Passages	Flour, %	Protein, %
B1+B2	11.71	20.0
B3	3.61	21.1
1M	24.33	22.9
2M	5.08	24.7
3M	14.40	23.9
2Q	14.28	20.2
4M	3.44	22.4
5M	11.43	23.8
LG	2.49	26.3
T	8.61	21.7
B4	0.62	23.4

Cumulative Protein

Flour, %	Protein, %
2.49	26.3
7.56	25.2
21.96	24.4
33.39	24.2
34.01	24.2
58.35	23.6
61.79	23.6
70.40	23.4
74.01	23.2
88.29	22.8
100.00	22.4

Cumulative Protein Curve



Flour Streams Yield and Protein content

Passages	Flour, %	Protein, %
B1+B2	7.7	20.6
B3	9.5	21.4
1M	17.9	23.4
2M	4.7	24.7
3M	22.6	24.7
2Q	15.8	22.3
4M	6.9	26.2
5M	5.2	26.9
LG	2.6	28.3
T	6.5	26.4
B4	0.5	23.2

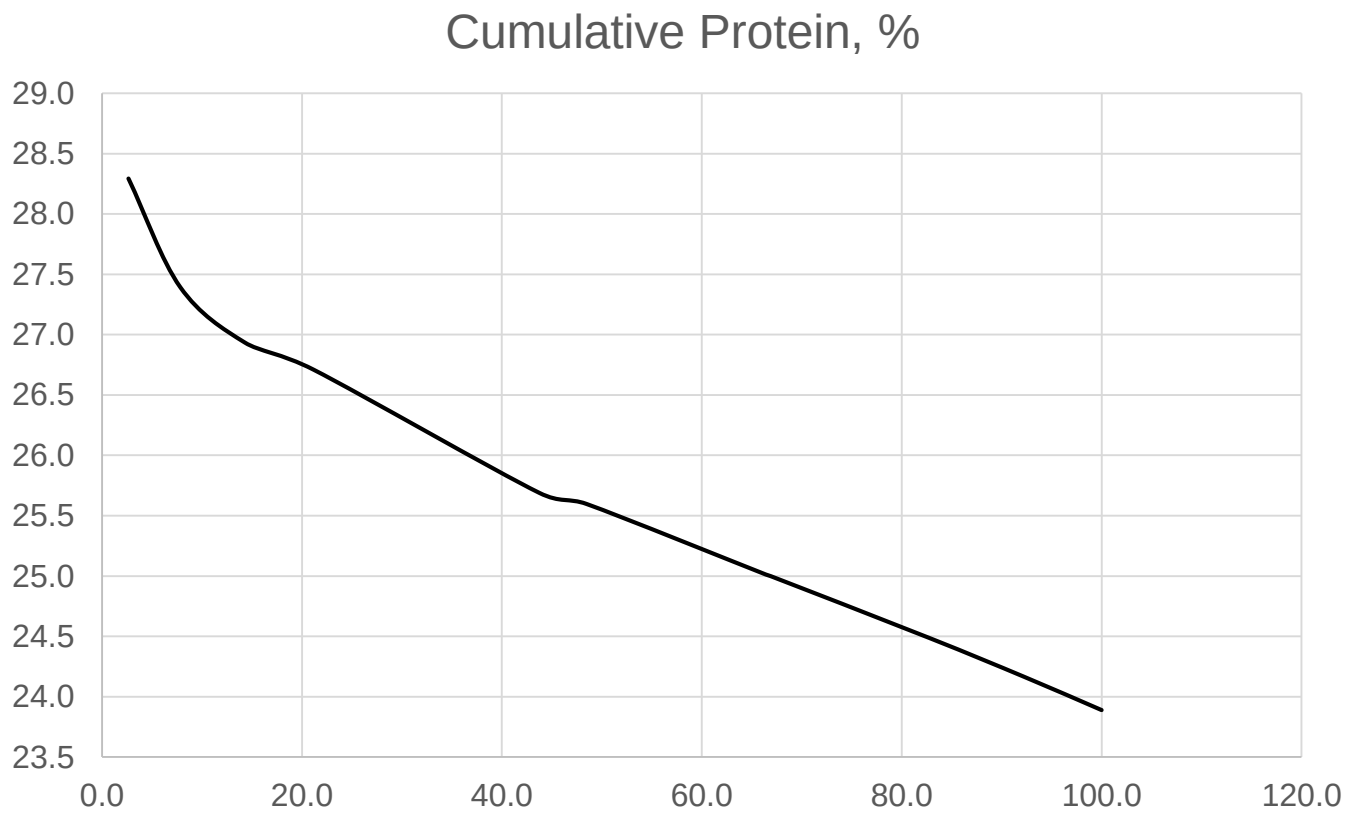
Flour Streams Yield and Protein content

Passages	Flour, %	Protein, %
LG	2.6	28.3
5M	5.2	26.9
T	6.5	26.4
4M	6.9	26.2
3M	22.6	24.7
2M	4.7	24.7
1M	17.9	23.4
B4	0.5	23.2
2Q	15.8	22.3
B3	9.5	21.4
B1+B2	7.7	20.6

Cumulative Protein

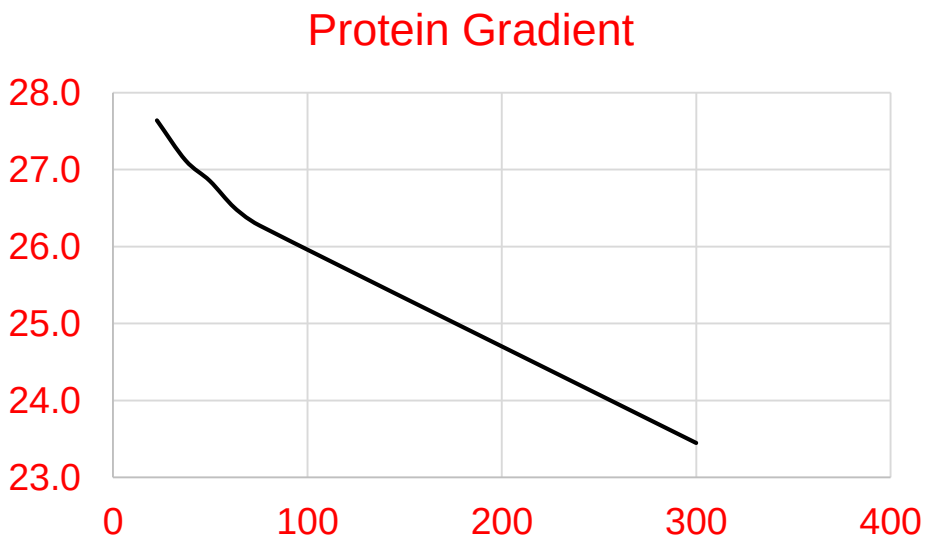
Passages	Cumulative Yield, %	Cumulative Protein, %
LG	2.6	28.3
5M	7.8	27.4
T	14.3	26.9
4M	21.2	26.7
3M	43.7	25.7
2M	48.5	25.6
1M	66.4	25.0
B4	66.9	25.0
2Q	82.7	24.5
B3	92.3	24.2
B1+B2	100.0	23.9

Cumulative Protein Curve



Pearlings of Pea & Protein content gradient

Pearlings	%	Protein
Pearl 1	22.5	27.6
Pearl 2	37.2	27.1
Pearl 3	49.7	26.9
Pearl 4	62.4	26.5
Pearl 5	75.4	26.3
	300	23.4



Roller milling of Peas & product diversification

Product	Yield, %	Protein, %
Semo		25.6
Flour 1	51.5	22.3
Flour 2	27.3	24.7
Flour 3	21.2	26.7
Flour 1	51.5	22.3
Flour 2	48.5	25.6

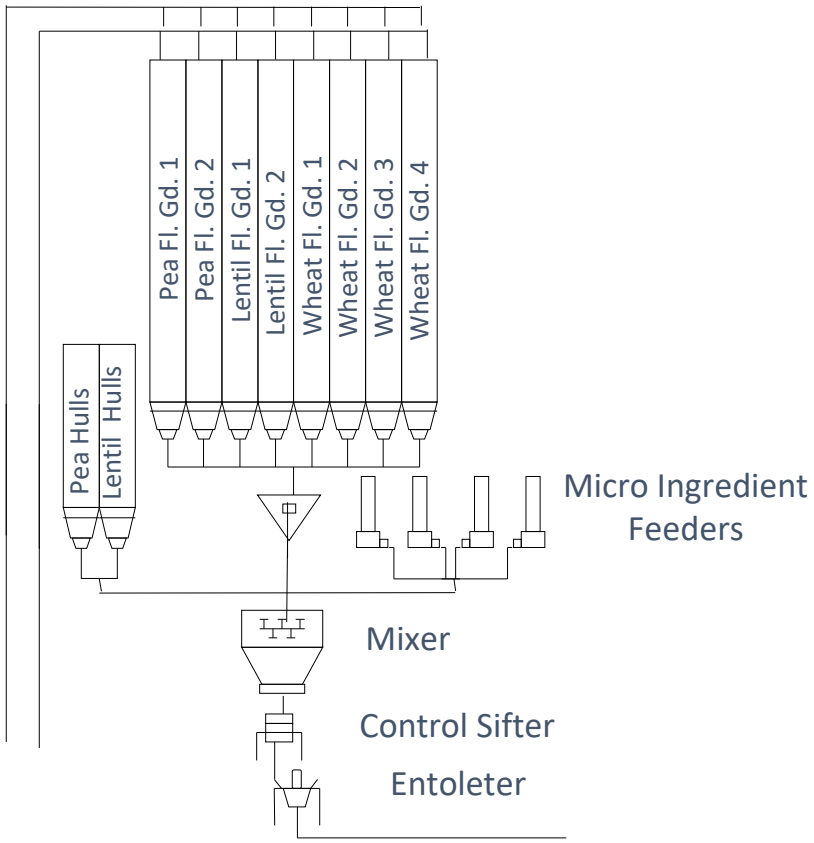
Roller milling of Peas & product diversification

Flour Grade	Yield, %	Protein, %	PSD (90% <), µm	Peak Visc., RVU
Str. Gd. Flour 1	100	23.7	147.7	213
Flour 1 A	51.5	22.3	150.5	227.2
Flour 2 A	48.5	25.6	144.7	205.4
Flour 1 B	51.5	22.3	150.5	227.2
Flour 2 B	27.3	24.7	148.9	212.1
Flour 3 B	21.2	26.7	139.3	196.7

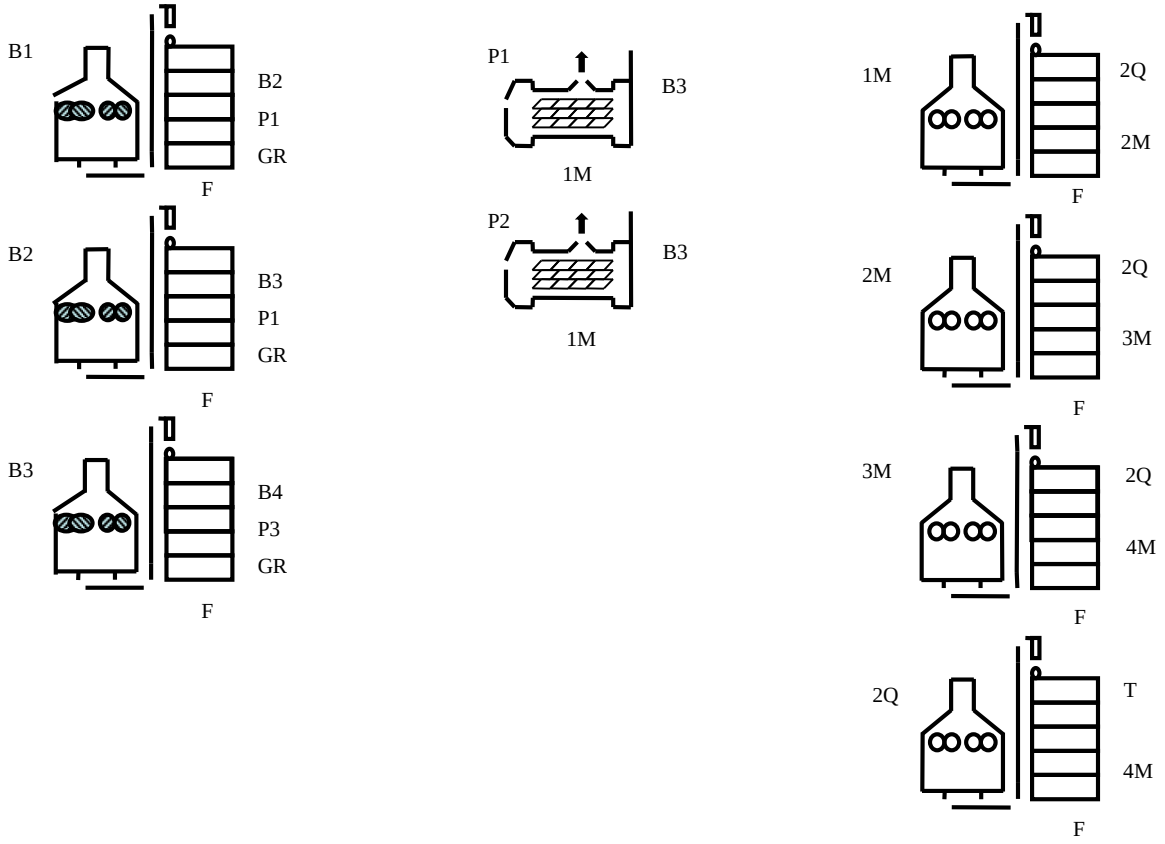
Flour Grade	Yield, %	Protein, %	PSD (90% <), µm	Peak Visc., RVU
Coarse Semolina	28.o	25.6	---	62
Fine Semolina	25.0	25.8	---	162

Roller milling of Peas & product diversification

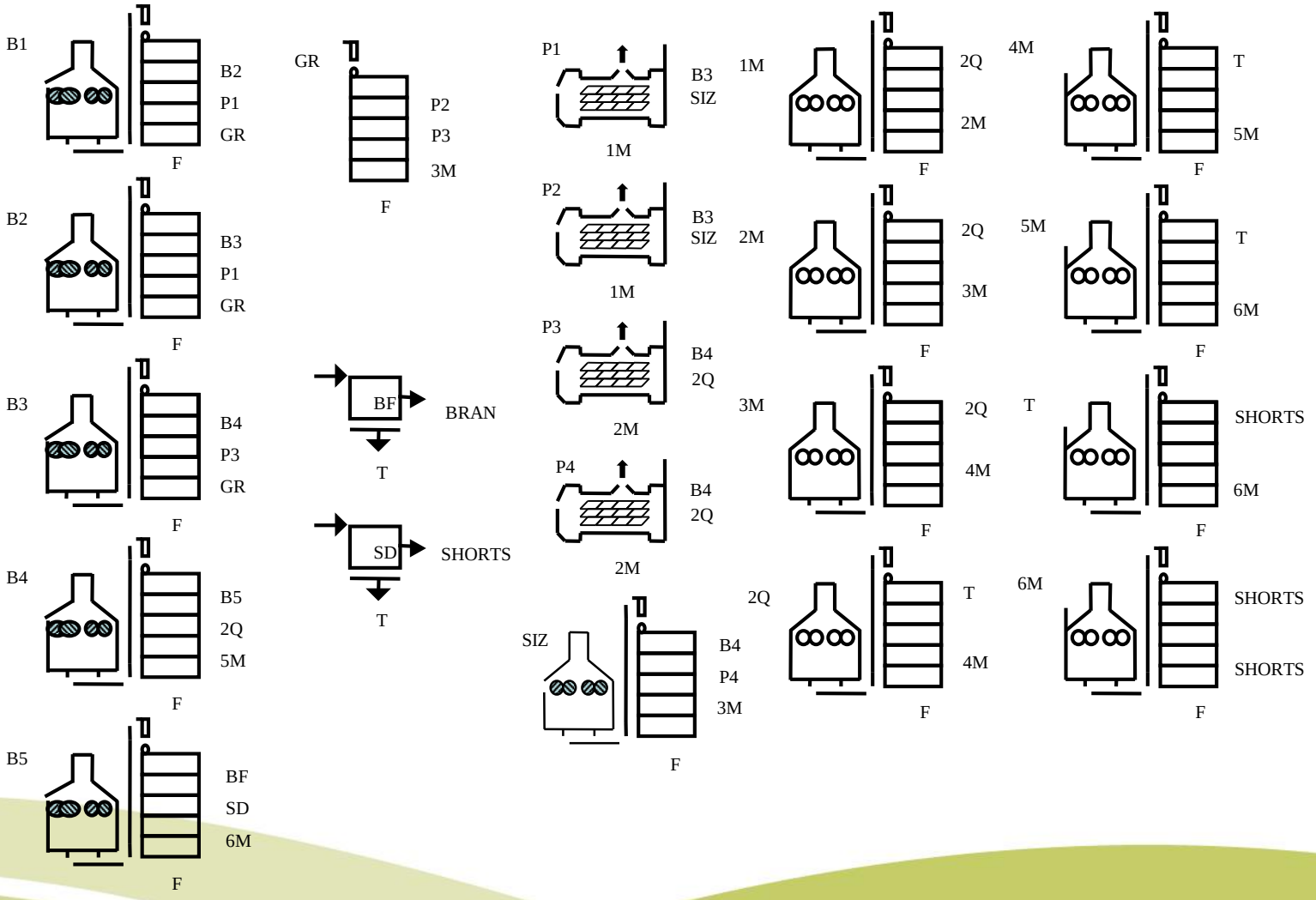
Product Diversification with Pulse Flours



Yellow Pea Milling

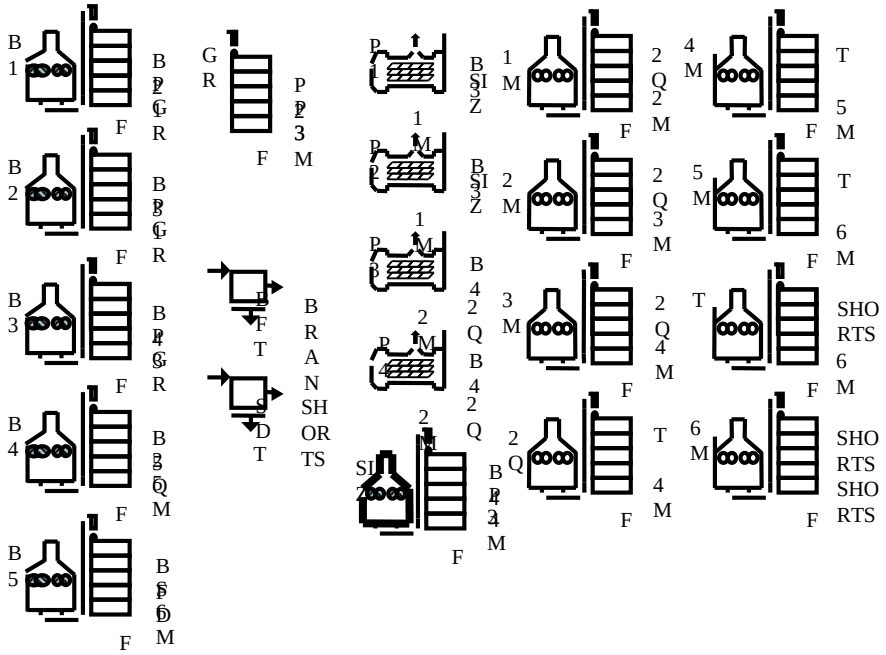


Common Wheat Milling

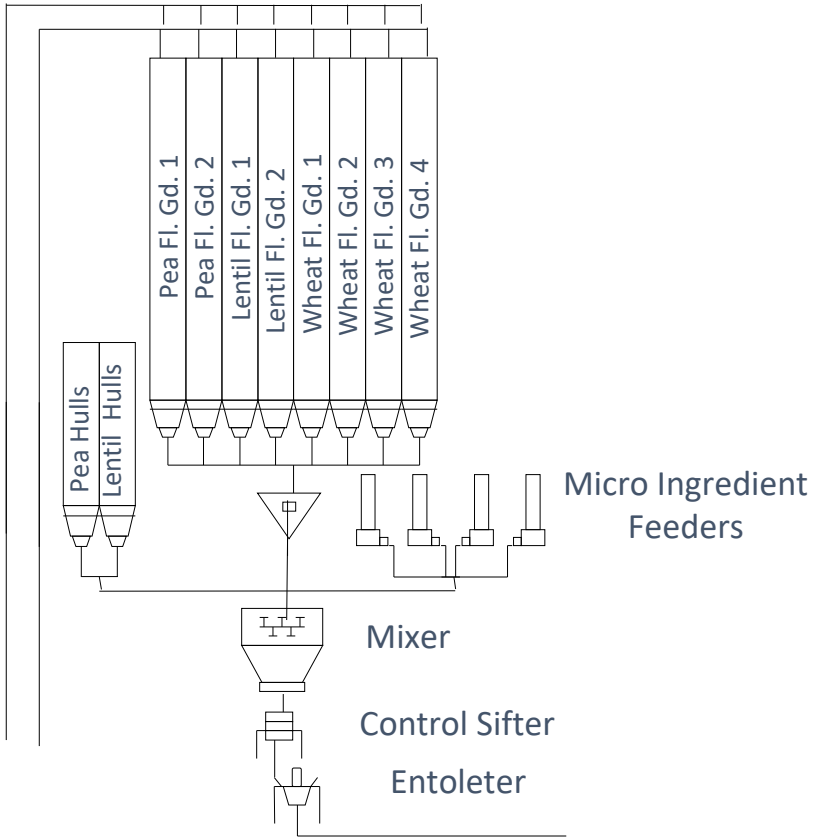


Roller milling of Peas & product diversification gluten free option

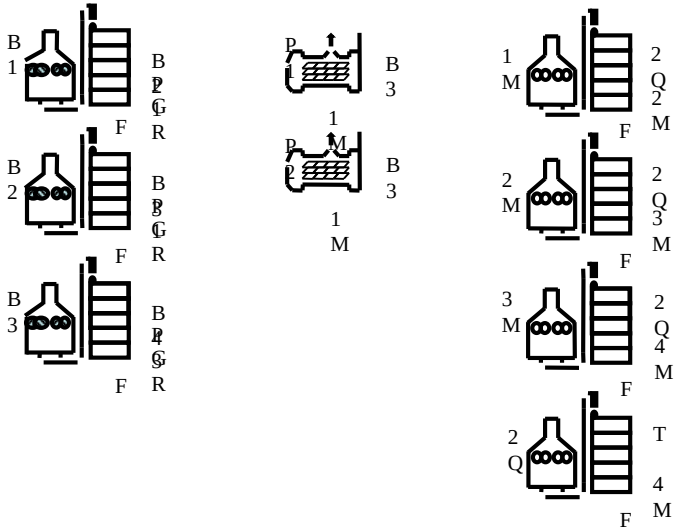
Common Wheat Milling



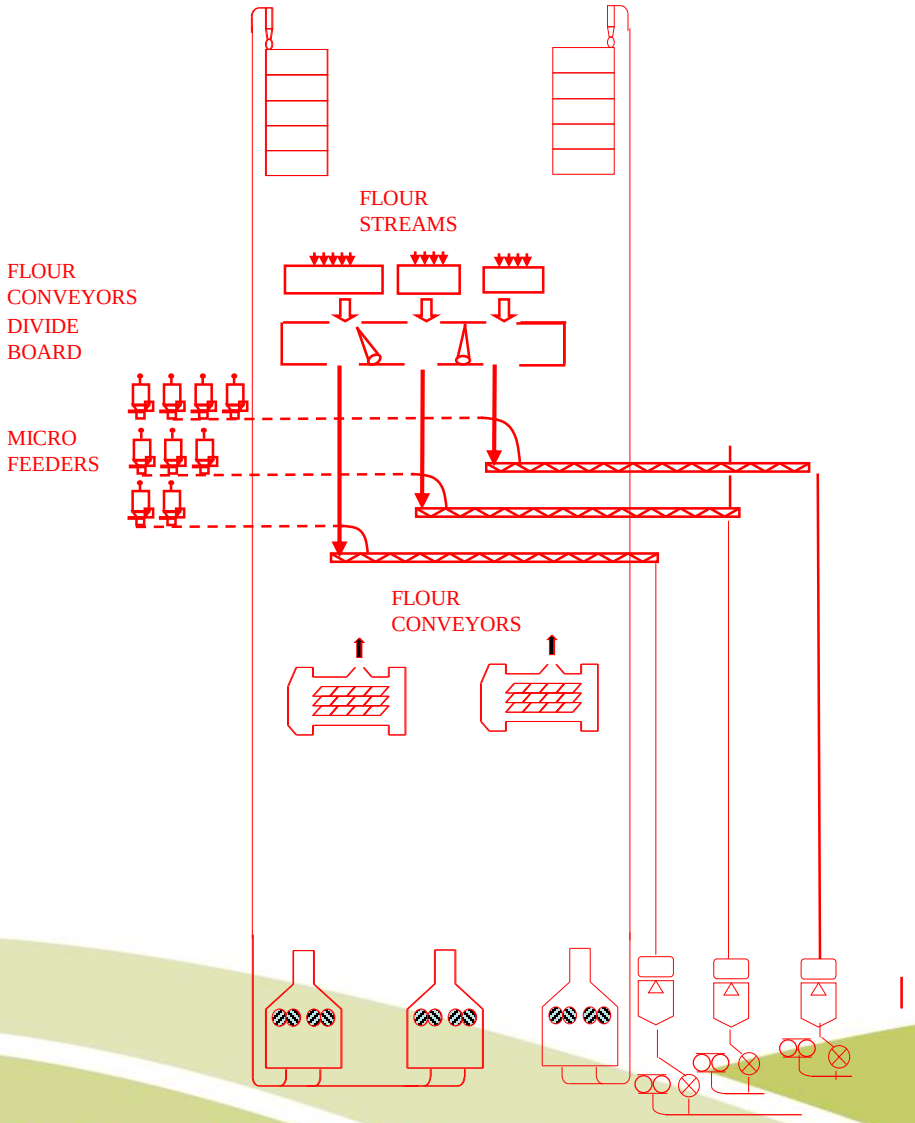
Product Diversification with Pulse Flours



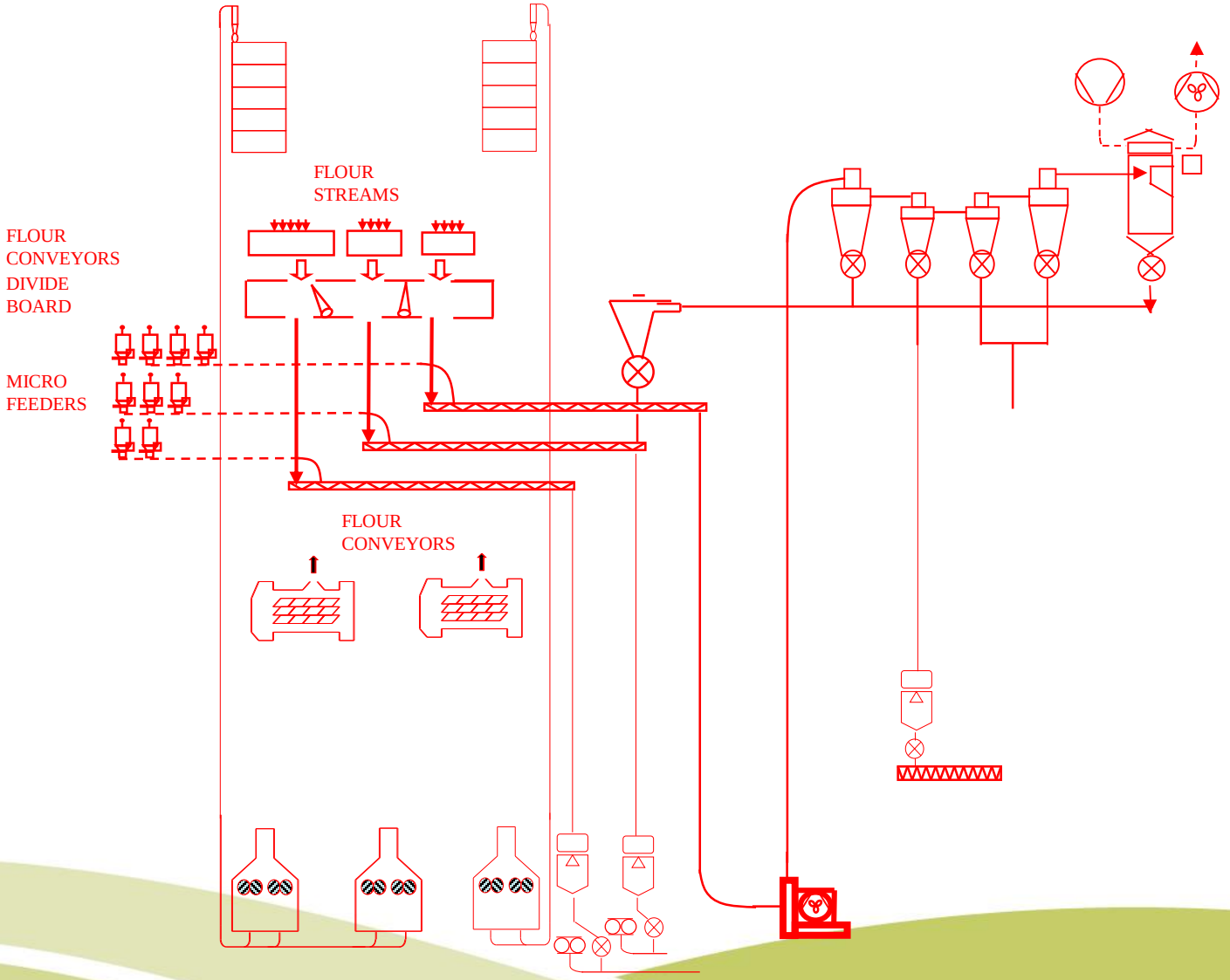
Yellow Pea Milling



Roller milling of Peas & product diversification



Roller milling of Peas & product diversification – Enhancing protein



Products with Pulse Ingredients

Acknowledgement

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Partnering on Pulse Industry Initiatives

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University of Manitoba

SunOpta

University of Saskatchewan Crop Development Centre

BÜHLER

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Nestlé

OBG Ontario Bean Growers

Newly Weds Foods

Port Royal Mills

Ingredion

Parrheim Foods

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Inland Empire Foods

Legumex Walker We are stronger together.

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