PULSE CANADA

Pulses in Batter and Breading Applications

Consumer demand for higher levels of protein and fiber is increasing. The use of pulse ingredients in food formulations provides opportunities for food manufacturers to meet this demand.

This research evaluated the suitability of pea starch, flour, hull fiber and protein combinations as replacements for corn starch, wheat, soy and corn flours, wheat gluten, gums, whey and color in coatings for fried food applications, including French fries, mozzarella sticks, onion rings and more. Two native (unmodified) pea starches, three pea flours, three pea hull fibers and one pea protein isolate **(Table 1)** obtained from Canadian ingredient suppliers were evaluated as replacements for wheat flour, corn flour, gum, and coloring.

TABLE 1 Pulse ingredients evaluated in French fry, mozzarella stick and onion ring applications

INGREDIENT	FRACTIONATION METHOD
Starch 1 *(S-1)*	Wet
Starch 2 *(S-2)*	Dry
Whole pea flour *(WPF)*	Dry
Split pea flour *(SPF-1)*	Dry
Split pea flour *(SPF-2)*	Dry
Pea hull fiber *(PHF-1)*	Dry
Pea hull fiber *(PHF-2)*	Dry
Pea hull fiber *(PHF-3)*	Wet
Pea protein isolate *(PPI)*	Wet

Key Findings

- *Native pea starch can completely replace modified corn starch in coatings for French fries, mozzarella sticks and onion rings with minimal impact on processing and product quality*
- *Substituting dry pea ingredients (starch, flour and/or fiber) for traditional ingredients can create food products with a cleaner label, including enhanced nutrient content claims for fiber, with limited effects on functionality and sensory properties*
- *Dry pea ingredients in fry coatings enhance flavor, color and nutritional content and create opportunities for gluten-free coatings*
- *Ingredient cost-savings may be possible with the substitution of pea ingredients*

The research was undertaken in two phases: (1) cook-up and instant starch replacement and (2) optimized coatings with pea ingredients. Two native starches were evaluated independently as 100% replacements for modified corn starch in the coating mixtures. In the second phase, the selected pea starch was combined with the other pea ingredients (pea protein, pea flour and/or pea hull fiber) to optimize the coating formulations for French fries, mozzarella sticks and onion rings. Commercial formulations commonly used for these fry applications formed the base for the ingredient modifications.

All fry products were analyzed for physicochemical characteristics, sensory attributes, and nutritional profile.

Opportunities

Gluten-Free
Cleaner label
Enhanced color
Improved nutrient profile
Ingredient cost reduction

EVALUATION OF PEA STARCH AS CORN STARCH REPLACEMENT

In the three food applications, batters containing wet or dry fractionated native pea starch generally performed at an acceptable level compared to the control batter containing chemically modified, wet milled corn starch. All test batters were process capable; however there were some notable differences in the functional and sensory attributes for each application between the two pea starches.

The dry-fractionated pea starch (S-2) produced significantly thickened batter compared to French fries made with the control cook-up starch or the wet-fractionated pea starch (S-1). No other significant differences were noted for the other characteristics (batter pick-up, par fry yield, crumb production, cook yield or weight loss) between the two pea starches. However, sensory panelist ratings suggested that French fries made with S-1 pea starch were more moist and more similar to the control than fries made with the S-2 starch which produced crisper, more golden fries with a slightly rougher surface texture after 5 and 30 minutes holdings in a food warmer.

TABLE 2 Effect of pea starch on the physicochemical characteristics of coated onion rings

	CONTROL	PEA STARCH	PEA STARCH
	CORN STARCH	PEA (S-1)	PEA (S-2)
Batter Viscosity *(cp)*	675.75	661.25	626.00
Coating Pick-up *(%)*	54.34^{b}	55.6^{b}	50.94^{a}
Par Fry yield, %	55.87^{b}	57.68^{c}	52.98^{a}
Cook Yield, %	70.74	70.79	69.64
Weight Loss @30 min, %	3.94	4.13	3.3
Weight Loss @ 45 min, %	5.61	5.79	4.75
Weight Loss @ 60 min, %	7.23	7.32	6.14
Total Moisture	38.70^{b}	27.00^{a}	29.99^{a}

$^{a, b, c}$ *Means with differing superscripts are significantly different ($p<0.5$) across rows*

Unlike the French fry applications, there was no significant difference in batter viscosity observed between the wet and dry fractionated pea starches in the mozzarella sticks. However, the S-2 pea starch did have higher total moisture content than the control and the S-1 pea starch. The trained sensory panel rated the coated mozzarella sticks made with both pea starches as similar to the control mozzarella sticks for all attributes. Significant differences between the two starches were noted, however, after 45 minutes holding: S-2 pea starch mozzarella sticks were crisper and crunchier, had a softer cheese texture and a slight beany flavor compared to the S-1 pea starch or control mozzarella sticks.

In the onion rings, pea starch had minimal effect on batter viscosity with no significant differences noted **(Table 2)**. All batters were process capable as expected due to the small percentage of starch in the batter (3%). The control and the coating made with S-1 pea starch had significantly higher coating pick-up than onion rings using the S-2 pea starch (S-2). The par yields were all significantly different. No significant difference was noted in cook yield between the control and pea starch containing coatings. Pea starch onion rings did lose more moisture than the control during full frying but since the cook yield and weight loss over time was not affected, moisture loss could have been offset by fat uptake.

Preliminary testing of pea protein isolate as a replacement for 25% of the cook-up starch in the French fry, mozzarella stick and onion ring applications resulted in thicker batters, tougher coatings,

TABLE 3 Effect of pea starch and pea flour on the physicochemical characteristics of optimized battered French fries

	CONTROL	A	B	C	D
Cook up starch	Corn	Pea (S-1)	Pea (S-1)	Pea (S-1)	Pea (S-1)
Instant starch	Corn	Corn	Pea (S-1)	Corn	Pea (S-1)
Flour	Wheat/Corn	Split Pea (SPF-2)	Split Pea (SPF-2)	Whole Pea (WPF)	Whole Pea (WPF)
Batter Viscosity *(cp)*	423.5^{a}	567.5^{bc}	613.0^{c}	576.5^{bc}	509.0^{b}
Batter Pick-up *(%)*	14.89^{a}	14.44^{a}	14.49^{a}	18.44^{b}	19.14^{b}
Par Fry Yield, %	84.73^{b}	90.31^{c}	90.85^{c}	77.01^{a}	82.06^{b}
Crumb Production, %	1.92^{ab}	1.17^{a}	1.64^{ab}	3.27^{b}	3.24^{b}
Cook Yield, %	72.32	74.52	69.24	75.50	71.16
Weight Loss, %	2.52^{a}	2.56^{a}	4.35^{b}	2.15^{a}	2.29^{a}
Total Moisture	65.90	64.90	64.20	65.10	63.9

$^{a, b, c}$ *Means with differing superscripts are significantly different (pL0.05) across rows*

TABLE 4 Effect of pea starch and pea flour on the physicochemical characteristics of optimized mozzarella sticks

	CONTROL	PEA/WHEAT
Cook up starch	Corn	Pea (S-1)
Flour	Wheat & corn	Whole pea flour (SPF-2)
Other	Guar gum, gluten	Pea fiber (PFH-3)
Batter Viscosity *(cp)*	199.67	167.50
Batter Pick-up *(%)*	62.87	62.45
Par Fry Yield, %	102.35	102.87
Cook Yield, %	90.66	90.92
Weight Loss @30 min, %	0.61	0.47
Weight Loss @45 min, %	1.00	0.74
Weight Loss @60 min, %	1.40	1.07
Total Moisture	36.07^{a}	37.19^{b}

$^{a, b, c}$ *Means with differing superscripts are significantly different (p<0.5) across rows*

a mealy texture and a beany flavor and thus, further testing was discontinued.

For all three products, the S-1 (wet fractionated) pea starch was chosen to replace the modified corn starch ingredients in the optimized formulas as the functional properties of this pea starch were generally more similar to the control products and had less effect on texture and flavor.

OPTIMIZED PEA INGREDIENT FORMULATIONS

French Fries

The most promising French fry prototypes were those batters containing pea starch and pea flour. Four optimized French fry prototypes were developed where S-1 pea starch replaced both the cook-up corn starch and combinations of S-1 starch or instant corn starch and split pea flour (SPF-2) and whole pea flour (WPF) replaced the three traditional flours (all purpose and soft wheat and corn), xanthan gum and caramel color. Pea hull fiber and pea protein isolate addition were assessed but did not improve the sensory or nutritional quality of the battered French fries.

All test batters were thicker than the control and batter viscosity optimization needs to be further investigated to achieve optimum water hydration. Pea flour equal to or less than 425 microns in size with water holding capacity equal to or less than 100% would reduce excess viscosity. Batters containing whole pea flour had significantly higher batter pick-up than batters containing split pea flours but similar par fry yield, crumb production and cook yields **(Table 3)**.

Sensory evaluations indicated that French fries made with pea starch and pea flours had increased crispness and tenderness compared to control fries and were considered to have slightly high to moderately high overall quality.

Mozzarella Sticks

Mozzarella sticks utilized a combination of pea starch, pea flour and pea hull fiber in the six-step coating system to fully replace corn starch/flour and wheat flour. Guar gum and wheat gluten from the test batter and pre-dust were replaced with pea flour and pea hull fiber. No significant differences in batter viscosity, par fry yield cook yield or weight loss over time were observed **(Table 4)**.

The optimized pea/wheat prototype was significantly more golden with softer cheese and more beany flavor than the control, but no differences in coating texture or overall quality were noted by sensory panelists. Differences in color, cheese texture and flavor did not affect overall quality as the pea/wheat and control mozzarella sticks were similarly rated.



Nutritional differences were noted for par fried mozzarella sticks when pea starch replaced corn starch and other pea ingredients (flour and fiber) were added. The pea mozzarella sticks contained 0.7 g per 100g more protein and 3.6 g per 100 g more dietary fiber than the control sticks **(Figure 1)**. A "source of fiber" claim can be made for both pea starch mozzarella sticks and for the optimized pea/wheat product, whereas the control mozzarella sticks do not meet the requirements to make a fiber claim.

Onion rings

In the optimization phase, S-1 pea starch was used in combination with other pea ingredients as replacements for corn starch, wheat flour, corn flour, soy flour, wheat gluten, whey and guar gum. All pea flour batters required slightly higher levels of water to achieve similar cook yield and appearance as the control onion rings. After testing, split pea flour (SPF-2), whole pea flour (WPF) and pea hull fiber (PHF-3) were the pea ingredients with the most potential.

The optimized pea/wheat onion ring had lower batter viscosity, coating pick-up and par fry yield compared to the control but it had similar cook yield, weight loss over time and moisture content after full frying. Compared to the control onion ring, the pea/wheat prototype was more golden, darker in color and more beany in flavor. However, the beany flavor added a savory, roasted background note that complemented the flavor of the onion.

Nutritional analysis showed that the par fried optimized pea/wheat onion ring had more fiber, calcium, iron, fat and calories but less sodium than the control onion rings **(Table 5)**. An "excellent source of fiber" nutrient content claim can be made for the optimized pea/wheat onion ring whereas, in the control onion ring, only a "good source of fiber" claim can be made.

FIGURE 1 Nutritional comparison of par fried control and optimized pea mozzarella sticks (g/100g)

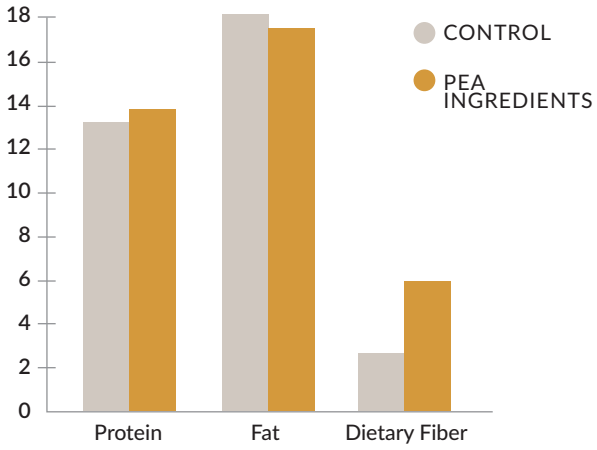

TABLE 5 Nutritional composition of par fried onion rings

	CONTROL	PEA STARCH (S-1)	PEA/WHEAT
Protein (g/100g)	3.7	3.8	4.6
Fat (g/100g)	13.6	14.1	16.5
Dietary Fiber (g/100g)	8.4	7.9	10.1
Calcium (mg/100g)	20.1	22.6	33
Iron (mg/100g)	1.8	1.7	2
Sodium (mg/100g)	406.9	396.7	341

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