POTATO APPLICATION

# FRESH, DRIED AND FILLED PASTA




Potatoes USA

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# INTRODUCTION

The purpose of the study was to provide formulation and application information on the use of potato ingredients in pasta applications for food manufacturers. Due to the known multifunctionalities of dehydrated potato ingredients, it was hypothesized that dehydrated potato ingredients would provide different functional benefits that could be tailored by food formulators depending on desired product attributes.

# KEY TAKEAWAYS

The addition of dehydrated potato ingredients in pasta resulted in:

### ENHANCED COLOR

Pasta made with potato flour and standard potato flakes enhanced the natural yellow hue of semolina pasta, whereas pasta made with potato granules was slightly muted in color.

### REDUCED BREAKAGE

Dried pasta can be brittle and prone to breakage during packaging and transport, especially long, thin shapes like spaghetti. The use of potato flour, granules and standard potato flakes all helped to enhance structural integrity and reduce breakage of the dried pasta and would be particularly beneficial in alternative pastas such as gluten-free or high fiber formulations.

### IMPROVED TEXTURE

Standard potato flakes showed improved texture integrity of both fresh and dried pasta. Potato flour and granules enhanced the texture of dried pasta but did not perform as well in fresh pasta. Conversely, low-peel/low-leach (LP/LL) potato flakes improved the texture of fresh pasta, but made the texture of dried pasta slightly softer.

### COST REDUCTION

Three of the potato ingredients tested successfully allowed for reduction of ricotta cheese and panko breadcrumbs in the fresh pasta spinach cheese filling: potato flour, standard potato flakes and LP/LL potato flakes. These potato ingredients could be considered where cost savings are desired or where gluten-containing breadcrumbs need to be replaced, as they absorbed moisture without noticeably changing the eating qualities.

# APPLICATION OVERVIEW

## BACKGROUND

Pasta is a widely consumed cereal-based food product, which are pieces of unfermented dough that are boiled, not baked. It has been made since the 13th century, becoming a staple of the Italian diet by the 17th century with the popularity of commercially produced noodles.[1] The average American consumes 20 pounds annually, with 77% eating pasta at least once per week, and 33% eating pasta three or more times per week.[2] Pasta can be made in an infinite number of shapes and sizes, with many varieties now commonly available in retail markets, including: dried, fresh and precooked. Fresh pasta is sold refrigerated with a shorter shelf life than dried pasta, which has been processed to remove moisture and prevent spoilage, typically sold in cardboard boxes or plastic film without refrigeration.[3] Fresh-filled pastas, like ravioli and tortellini, are pre-gelatinized by undergoing a steaming process to pasteurize the pasta and help maintain texture, preventing moisture migration from filling to pasta. Precooked pastas are also available in a variety of prepared foods, such as cold pasta salads, hot entrées in deli cases, freezer meals and shelf-stable soups and meals. These prepared foods may utilize either fresh or dried pasta products in manufacturing.

## TYPES OF FORMULAS

In the most basic form, pasta is simply water and flour, often semolina wheat flour. Other ingredients are commonly used such as eggs and salt.[4] Beyond these basic ingredients, there are other varieties of pastas now available such as whole wheat, gluten free, flavored and fiber or protein fortified. The method of manufacture determines the shape of the pasta. The two common methods of manufacture are extrusion and sheeting.[3] Formulation of pasta is chosen per the final application; dried pastas typically contain flour and water while prepared pasta may require the addition of protein ingredients such as egg whites to remain intact after further processing. Many pasta (noodle and/or macaroni) products have a standard of identity as defined by the Food and Drug Administration. Regulation 21 CFR139.150 should be referenced for labeling requirements relating to both ingredients and formulation.[5]

## SELECTION APPLICATIONS

Both dried extruded pasta (spaghetti) and fresh-filled sheeted pasta (spinach ricotta ravioli) were chosen for this study. These two products exhibit both formulation variation (with the sheeted pasta containing liquid whole eggs) and process variation (one extruded, the other sheeted).

# INGREDIENTS AND FUNCTION

## PASTA DOUGH INGREDIENTS

### SEMOLINA FLOUR

Most pastas are made with durum semolina wheat flour, the coarsely milled endosperm of hard spring wheat. Durum wheat contains very little free starch and requires less water to hydrate than other flours.[4] It contains higher levels of carotenoid pigments than other wheat flours, which gives it a yellow color. The high protein content of durum semolina flour makes it a good choice for pasta as it provides structure during extrusion, as well as resistance to breakage and overcooking.[6]

### WATER

Water plays a critical role in the efficiency of production, with only enough water added to allow for proper extrusion. If too much water is used, dough may be difficult to process through equipment. If too little water is used, the dough may be too crumbly, which may cause problems in all steps of processing. After production, noodles are dried to a specific moisture content, typically 10 to 12%, which may be difficult to achieve if the formula has too much water.[7]

### EGGS

In fresh pasta, whole eggs are often used to provide color, flavor and enhance texture. Eggs contain proteins that form a cross-linked network that, in the presence of heat, changes from a fluid to a solid gel.[8] These properties contribute to a desirable, firm texture and structural integrity in refrigerated pasta.

## PASTA FILLING INGREDIENTS

Fresh pasta can be stuffed with various seasoned mixtures of cheese, vegetables and/or ground meat. Spinach ricotta filling is a classic Italian stuffing for pasta and commonly sold in the U.S. Ingredients include:

### SPINACH

Spinach that has been blanched, chopped and individually quick frozen (IQF) is commonly used in both commercial formulations and home recipes. It contains a considerable amount of moisture, which is typically absorbed by breadcrumbs or another starchy ingredient. Without a binder, the filling would be too moist or lack cohesion.

### CHEESE

Depending on the desired flavor of the filling, a variety of cheeses may be used in fresh pasta. Ricotta is a fresh cow's milk cheese that does not melt and has a granular texture and mild flavor; in addition to spinach, it often forms the bulk of spinach ricotta filling formulas. Mozzarella cheese is a smooth, melting cheese made from buffalo or cow's milk; it helps hold the filling together and provides rich flavor. Parmesan cheese is a full-flavored, aged hard cheese that has some melting qualities and is used at low levels in fillings for its savory flavor. Cheeses are typically the expensive ingredient in pasta fillings, an important consideration for food manufacturers.

### BREADCRUMBS

In pasta fillings, breadcrumbs are added to absorb excess moisture from other ingredients and to "extend" more costly ingredients, such as cheese and meat. In the filling used in this study, neutral-flavored panko breadcrumbs help to absorb moisture from spinach and cheese.

### SALT

Salt is an important flavoring ingredient in cheese fillings, as it enhances the flavors of the other ingredients. It should be adjusted based on the salt content of any cheeses used.

### SEASONINGS

Beyond salt, other herbs and spices may be added as desired to cheese fillings. In the filling used in this study, granulated garlic, onion and black pepper were used.

## POTATO COMPOSITION

Potato ingredients have a wide range of functionality, and different dehydrated potato ingredients may be considered for use in application. Water absorption is a key attribute to consider; potato ingredients with native starch intact absorb less water, while potato flakes, flour and granules absorb more water. The amount of gelatinization, starch availability and presence of intact or damaged potato cells influence the functionality of the potato ingredient. Ultimately, knowledge about these ingredients allows product developers to choose attributes for different applications. The high water-holding capacity of the starch in potato ingredients contributes to the functionality in many foods, especially baked goods.

### STARCHES

In general, potato starch granules are very large in size compared to the starch in other grains such as wheat or corn and include a mixture of 25% straight chain (amylose) and 75% branched chain (amylopectin) molecules.[9] Potato ingredients manufactured using heat have a high water-holding capacity; this is due to the gelatinization of starches during the process. In addition, high amylopectin starches are helpful in producing moist eating qualities and extending shelf life of gluten-free baked goods.

### SUGARS

The sugar content of potatoes can vary depending on the variety, maturity and physiological state of the potatoes. The main sugars present are sucrose, glucose and fructose.[10] The latter two are reducing sugars, which react with amino acids in the Maillard reaction to produce brown color and flavor compounds, which may or may not be desirable in the finished product.

### FIBERS

Non-starch polysaccharides such as cellulose, hemicellulose, pentosans and pectic substances make up the crude fiber of the potato.[10] Fibers absorb many more times their weight in water and help to produce moist baked goods with good eating qualities over time. One medium potato with the skin provides two grams of dietary fiber, while dehydrated potato ingredients typically contain between two to three grams of dietary fiber per hundred grams.[11]

### PROTEIN

Protein is found throughout the potato as part of the cellular membranes, cytoplasmic structures and enzymes. The protein fractions include albumin, globulin, glutelin, prolamine, as well as other proteins.[10]

Protein quality is often expressed in terms of its biological value (BV), which takes into account the amino acid profile of the protein along with its bioavailability. Egg protein has a biological value of 100 and is considered the reference protein. Potatoes have a relatively high BV of 90 compared with other key plant sources of protein (e.g., soybean with a BV of 84 and beans with a BV of 73).[12] It is a common misconception that plant proteins are missing or lacking in essential amino acids. Potatoes contain all nine essential amino acids and their amino acid profile is comparable to other key vegetable proteins. In addition, potatoes have lower levels of the sulfur-containing amino acids, which have been shown to increase calcium excretion and may negatively impact bone mineral density.[13]

Dehydrated potato ingredients typically contain between seven to nine grams of protein per hundred grams.[14]

### LIPIDS

Lipids are found at very low levels in potatoes (<0.2%). Lipids in potatoes include free fatty acids, triglycerides and phospholipids and are found in the cytoplasmic membrane of the potato cell. They are thought to regulate membrane permeability. Most of the fatty acids are unsaturated and, therefore, can undergo oxidation, which can be important in manufacture and storage of dehydrated potato products.[10]

## DEHYDRATED POTATO INGREDIENTS

There are many starch and flour ingredients to consider when formulating gluten-free bakery products and dehydrated potato ingredients offer many functional benefits. However, dehydrated potato ingredients vary considerably from one another in their functional attributes and should be selected based on desired product attributes, such as color, browning, texture and flavor (see Table 1).

### POTATO GRANULES

Potato granules are a spray-dried slurry of cooked potato. The granules are made of precooked individual potato cells with cellular material still around most of the cells. The cells are relatively strong and don't readily break apart during reconstitution, resulting in less starch damage. They are high absorbing with low water-holding ability with relatively low viscosity. Compared to other potato ingredients, they hold water without much cohesion, with a texture similar to wet sand rather than mashed potatoes. They do not have the gelling properties of other potato ingredients and leave moisture for other ingredients to absorb, which can be preferable depending on the application.

## POTATO FLAKES

Standard potato flakes are precooked flaked layers of individual potato cells with some broken cellular material, allowing some starch to escape the cell. Because they are cooked, cooled and cooked again, the starch retrogrades and is less sticky. The cells are more intact unless or until the resulting product is overmixed. Retail potato flakes have moderate water-holding ability with moderate viscosity. The water-holding capacity increases if the flakes are ground. They are bright white in color and, when reconstituted, have the dry, mealy texture and flavor of freshly cooked mashed potatoes. Standard potato flakes can be ground to various sizes—often called "ground standard flake." In fact, they can be ground so finely that they resemble flour, but they differ considerably in functionality from potato flour.

## LP/LL POTATO FLAKES

Low-peel/low-leach potato flakes (LP/LL) are fully cooked, flaked layers of individual cells with a relatively high level of broken cells and high levels of released starch. As their name suggests, LP/LL flakes are also very lightly peeled to retain more potato flavor. Light peeling affects the color of the final product, making these flakes more off-white than white. These flakes have high water-holding ability with high viscosity and are stickier and more cohesive than retail potato flakes. LP/LL flakes are typically used to manufacture fabricated potato snacks, including sheeted and extruded snacks, but have some functional attributes that could be desirable in other products, such as baked goods.

## POTATO FLOUR

Potato flour consists of precooked flaked layers of individual cells with very high level of broken cells and released starch. Potato flour has very high water-holding capacity and high viscosity. While potato flour may look like finely ground potato flakes, the two products are very different. True potato flour produces a sticky product when liquid is added and is best used in small amounts to extend other flours. The particle size of potato flour is larger than that of other flours; granular potato flour will pass through a 40-mesh, or 420-micron screen, while fine flour passes through an 80-mesh, or 177-micron screen.

### DEHYDRATED POTATO INGREDIENT CHARACTERISTICS

| Potato Ingredient | Cell Damage | Free Starch | Water Absorption | Viscosity | Rehydrated Texture |
|---|---|---|---|---|---|
| **Granules** | Low | Low | Low | Low | Similar to mashed potatoes |
| **Standard Flakes** | Low-moderate | Moderate | Moderate | Moderate | Similar to mashed potatoes |
| **Standard Flakes – Ground** | Moderate-high | Moderate-high | Moderate-high | Moderate-high | Sticky |
| **LP/LL Flakes** | High | High | High | High | Sticky |
| **Flour** | Very high | Very high | High | High | Very sticky |

*Table 1 (modified from Potatoes USA)*

# DRIED PASTA FORMULATION

A control dried pasta formula (Table 2) was created to compare with formulas containing potatoes. Test formulas with potato ingredients replaced 15% of the semolina flour with one of four dehydrated potato ingredients: flour, granules, flakes or LP/LL flakes as seen in Table 3.

### CONTROL DRIED PASTA

| Ingredient | Percentage | Batch (g) |
|---|---|---|
| Water, hot (60–70°C) | 27.25 | 190.75 |
| Semolina flour | 72.75 | 509.25 |
| **Potato Ingredient** | – | – |
| **Total** | **100%** | **700.00** |

*Table 2*

### TEST DRIED PASTA – 10.91% POTATO INGREDIENT

| Ingredient | Percentage | Batch (g) |
|---|---|---|
| Water, hot (60–70°C) | 27.25 | 190.75 |
| Semolina flour | 61.84 | 432.86 |
| **Potato Ingredient** | 10.91 | 76.39 |
| **Total** | **100%** | **700.00** |

*Table 3*

# DRIED PASTA PROCESSING

## PRODUCTION

Consistent batching, portioning and dehydration procedures were used to limit variables. Each test was batched in the same mixer using standardized mixing procedures. Water was added if necessary to the test doughs to replicate the texture of control. Dehydration times were not adjusted or optimized for each test formula, instead a standardized time and temperature was used to ensure each test experienced the same conditions.

## METHOD

In dried pasta, the dough is forced from a hopper through an extruder, fit with various shaped-dies, which determine the shape of the noodle. The pasta dough is extruded through the die and cut into the appropriate length. For dried pasta, it is placed on wire racks and dehydrated to a specified moisture content for shelf stability. The rate of drying is extremely important; too slow and the moisture will encourage microbial growth, while drying too fast can precipitate cracking and compromise noodle integrity.[4]

For these tests, a modified benchtop processing method was used: the dough was made in a Robot Coupe food processor with a stainless-steel blade and then extruded through a six-quart standing KitchenAid mixer fit with a pasta attachment and spaghetti-shaped round die. Pasta was dehydrated in an Excalibur Food Dehydrator.

1. Put flour into Robot Coupe fitted with the stainless blade.
2. With the machine running, pour water into machine through a funnel aimed at the flour (away from the center of the blade and not onto the wall of mixer). Let mix until dough starts to form (around 2 minutes). Scrape the sides of the bowl if necessary.
3. Wrap ball of dough tightly in plastic wrap and rest on countertop for a minimum of 30 minutes and maximum of 2 hours 30 minutes.
4. Run small (walnut-sized) chunks of dough through pasta attachment. Extrude until pasta is 12 inches in length, then cut and set aside on a floured baking sheet.
5. Dehydrate 150 grams per rack of pasta at 135°F for 2 hours.

Note: Potato ingredients were added with the flour in step 1.

# FRESH PASTA FORMULATION

A control fresh pasta formula (Table 4) was created to compare with formulas containing potatoes. Test formulas with potato ingredients replaced 13% of the semolina flour (10% of the total formula) with one of four dehydrated potato ingredients: flour, granules, flakes or LP/LL flakes, as seen in Table 5.

### CONTROL FRESH PASTA

| Ingredient | Percent | Batch (g) |
|---|---|---|
| Flour, oat, whole | 75.50 | 528.50 |
| Egg, whole, liquid | 13.50 | 94.50 |
| Water | 11.00 | 77.00 |
| Potato Ingredient | – | – |
| **Total** | **100%** | **700.00** |

*Table 4*

### TEST FRESH PASTA 10% POTATO INGREDIENT

| Ingredient | Percent | Batch (g) |
|---|---|---|
| Flour, oat, whole | 65.50 | 458.50 |
| Egg, whole, liquid | 13.50 | 94.50 |
| Water | 11.00 | 77.00 |
| Potato Ingredient | 10.00 | 70.00 |
| **Total** | **100%** | **700.00** |

*Table 5*

A control spinach ricotta filling formula (Table 6) was created to compare with formulas containing potatoes. Test formulas replaced 23% of the ricotta cheese (6% of the total formula) and replaced the 4% panko breadcrumbs in the control formula entirely with one of four dehydrated potato ingredients: flour, granules, flakes or LP/LL flakes, as seen in Table 7.

### CONTROL SPINACH RICOTTA FILLING

| Ingredient | Percent | Batch (g) |
|---|---|---|
| Spinach, chopped, IQF | 40.00 | 200.00 |
| Ricotta cheese, whole milk | 26.00 | 130.00 |
| Mozzarella cheese, shredded | 16.00 | 80.00 |
| Parmesan cheese, shredded | 12.00 | 60.00 |
| Potato Ingredient | – | – |
| Breadcrumbs, panko | 4.00 | 20.00 |
| Salt, fine | 0.80 | 4.00 |
| Onion, granulated | 0.60 | 3.00 |
| Garlic, granulated | 0.35 | 1.75 |
| Black pepper, ground | 0.25 | 1.25 |
| **Total** | **100%** | **500.00** |

*Table 6*

### TEST SPINACH RICOTTA FILLING 10% POTATO INGREDIENT

| Ingredient | Percent | Batch (g) |
|---|---|---|
| Spinach, chopped, IQF | 40.00 | 200.00 |
| Ricotta cheese, whole milk | 20.00 | 130.00 |
| Mozzarella cheese, shredded | 16.00 | 80.00 |
| Parmesan cheese, shredded | 12.00 | 60.00 |
| Potato Ingredient | 10.00 | 50.00 |
| Breadcrumbs, panko | – | – |
| Salt, fine | 0.80 | 4.00 |
| Onion, granulated | 0.60 | 3.00 |
| Garlic, granulated | 0.35 | 1.75 |
| Black pepper, ground | 0.25 | 1.25 |
| **Total** | **100%** | **500.00** |

*Table 7*

# FRESH PASTA PROCESSING

## PRODUCTION

Consistent batching, portioning and sheeting procedures were used to limit variables. Each test was batched in the same mixer using standardized mixing procedures. Water was added if necessary to the test doughs to replicate the texture of control.

## METHOD

In fresh pasta, the dough is forced from a hopper through an extruder, sheeted to specified thickness. For refrigerated pasta, it is cut and/or filled, then steamed to partially gelatinize the starches and kill any bacteria, after which it must be refrigerated.

For these tests, a modified benchtop processing method was used: the dough was made in a Robot Coupe food processor with a stainless-steel blade and then extruded through an Imperia electric pasta machine. Filling was made in a six-quart Kitchen Aid mixer fitted with a paddle attachment. Finished ravioli were steamed in a Hamilton Beach electric steamer.

### PASTA SHEETS

1. Put flour into Robot Coupe. While the machine is running, pour eggs and water through a funnel aimed at the flour (away from the center of the blade). Let mix until dough starts to form, 2 minutes; scrape the sides of the bowl if necessary.
2. Wrap dough tightly in plastic wrap and rest at room temperature for 30 minutes.
3. Divide dough into 350 gram portions, press flat into a 5-inch by 5-inch square. Work with one unwrapped portion at a time.
4. Set pasta maker to setting #10 and pass dough through four times, folding the dough as needed to be as rectangular as possible.
5. Change to setting #8 and pass dough through once. Fold dough in half and pass through with seam side first. Repeat twice for a total of four folded passes.
6. Change to setting #6 and pass dough through without folding, four times.
7. Change to setting #4 and pass dough through once. Fold dough in half and pass through with seam side first. Repeat, for four folded passes.
8. Change to setting #3 and pass dough through without folding for four passes.
9. Change to setting #2 and pass dough through once. Fold dough in half and pass through with seam side first. Repeat twice for a total of four folded passes. Pass the dough through one final time without folding on setting #2.
10. Cut pasta sheets into pieces 15 inches long and 5 inches wide. Lightly dust with flour and cover until ready to fill.

Note: Potato ingredients were added with the flour in step 1.

### FILLING

1. Mix all ingredients together in stand mixer fitted with the paddle attachment on medium speed until combined.

### ASSEMBLY

1. Lay out pasta sheets on a lightly floured surface. Place 10 grams (teaspoon-sized scoops) of filling onto the dough, approximately 1 1/2 inches apart.
2. Moisten the dough between fillings with water with a pastry brush.
3. Fold dough over to cover filling and press seam down firmly between each ravioli.
4. Use a fluted cutter to cut each each ravioli.
5. Steam ravioli until filling reaches 160°F.
6. Allow to cool on a greased wire rack, then cover and refrigerate for up to 7 days.

## ANALYTICAL MEASURES AND NOTES

Both the dry and cooked pasta were analyzed using industry standard pasta-specific evaluation methods.

### DRIED PASTA DOUGH NOTES

Extruded pasta dough is crumbly in nature before processing, but the addition of the potato ingredients resulted in a drier dough compared to control. Instead of adding additional water, the doughs were vacuum sealed to assist in the hydration process. This made the dough easier to feed into the extruder without creating a vastly different dough to control. These changes in processing allowed an even extruded noodle.

# SENSORY EVALUATION

Pasta samples were evaluated in both uncooked and cooked form by panelists and commentary was recorded. The following attributes were assessed:

### APPEARANCE

The visual appearance of the pasta was assessed for smoothness, color, brittleness and breakage.

### COLOR

Dried pasta should be a pale cream color, and fresh pasta should be pale yellow.

### COOKED APPEARANCE

The cooked pasta was evaluated based on color after cooking, stickiness and breakage.

### AROMA

The aroma of cooked pasta should be faint and floury, with no other characterizing scents.

### FLAVOR

Pasta should have a relatively mild flavor, no bitterness or sweetness, and no other characterizing flavors.

### TEXTURE

The texture of the noodles should be slightly firm and toothsome, enough so to be able to bite through without the noodle becoming gummy or disintegrating in the mouth. The noodles should not be so sticky that they form clumps and should maintain their integrity when handled with a fork or tongs. The filling in ravioli should be light and fluffy.

### OVERALL LIKABILITY

Considering all sensory aspects, pasta samples were rated on overall acceptability and ranked by panelists.

# DRIED PASTA RESULTS

The results of this study, including processing notes, analytical measures, sensory commentary and photographs are summarized below in Tables 8–12.

## CONTROL: DRIED PASTA

| Attribute | Results/Comments |
|---|---|
| Water Added to Dough | N/A |
| Dough Quality | Slightly crumbly dough; cohesive and smooth once extruded |
| Brittleness | Very easily broken by hand, clean break |
| **Sensory Attribute** | **Comments** |
| Dried Appearance | As expected |
| Dried Color | Pale, creamy, even |
| Cooked Appearance | Some broken noodles; fragile when handled with tongs |
| Cooked Color | As expected, creamy and light |
| Aroma | As expected, smells of pasta |
| Flavor | As expected, mild pasta |
| Texture | As expected, al dente, some chew and a little give |
| Overall Likability | Best flavor and texture in the mouth, but broke too much when handled |

*Table 8*

Dried

Cooked

## POTATO FLOUR TEST: DRIED PASTA

| Attribute | Results/Comments |
|---|---|
| Water Added to Dough | 20g water added to 700g batch (2.8%) |
| Dough Quality | Similar to control, slightly crumbly; cohesive and smooth once extruded |
| Brittleness | More substantial than control, but still relatively easy to break cleanly |
| **Sensory Attribute** | **Comments** |
| Dried Appearance | Flatter than control, did not keep round shape during drying. Some visible bumpiness, not as smooth |
| Dried Color | More yellow than control, but acceptable |
| Cooked Appearance | Stayed more intact in comparison to control, stuck together slightly more. Looks a little starchy on the edges |
| Cooked Color | Slightly more yellow than control |
| Aroma | Mild potato, not strong or off-putting; would not be noticeable in application |
| Flavor | Slightly stronger than control, appealing to panelists |
| Texture | Slightly softer than control, can feel that the noodles are not quite as smooth as control, but would not likely be noticeable in application |
| Overall Likability | Panelists liked the richer flavor, but did not find the texture to be as appealing as control |

*Table 9*

Dried

Cooked

## POTATO GRANULES TEST: DRIED PASTA

| Attribute | Results/Comments |
|---|---|
| Water Added to Dough | 20g water added to 700g batch (2.8%) |
| Dough Quality | The crumbliest of all the tests; firm and difficult to mold. Required more time to fully hydrate than other tests, sat for 30 minutes longer before it could extruded |
| Brittleness | Similar to control |
| **Sensory Attribute** | **Comments** |
| Dried Appearance | Very round and smooth noodles |
| Dried Color | Pale, whiter than control with a gray hue |
| Cooked Appearance | More intact noodles than control; even, round shape |
| Cooked Color | Pale, whiter than control |
| Aroma | Similar to control |
| Flavor | Slightly muted flavor |
| Texture | Smoother texture than potato flour; similar to control, with more intact noodles. Slightly starchy mouthfeel |
| Overall Likability | The panelists found the pale color to be off-putting, commenting that it looked like gluten-free pasta. The texture was deemed an improvement over Control |
| Recommendations | Further water adjustment to the dough may be necessary. Pasta made with potato granules may be better suited for extrusion through a larger die and, therefore, larger shaped noodles. |

*Table 10*

Dried

Cooked

## POTATO FLAKES TEST: DRIED PASTA

| Attribute | Results/Comments |
|---|---|
| Water Added to Dough | 20g water added to 700g batch (2.8%) |
| Dough Quality | Crumbly dough, performed similarly to control in extrusion |
| Brittleness | Similar to potato flour and LP/LL flakes; more substantial than control, but still relatively easy to break cleanly |
| **Sensory Attribute** | **Comments** |
| Dried Appearance | Did not keep round shape after drying, but rounder than potato flour. Similar to control in smoothness |
| Dried Color | Similar to control |
| Cooked Appearance | More intact noodles than control |
| Cooked Color | More yellow than potato flour, looks appealing |
| Aroma | Slightly stronger starchy aroma in comparison to control |
| Flavor | Less flavorful than control and potato flour, but more flavorful than potato granules |
| Texture | Similar to control, more intact noodles |
| Overall Likability | Looks the best, with a rich yellow color and texture similar to control |
| Recommendations | Adjust water to aid in extrusion. Helps to enhance noodle integrity |

*Table 11*

Dried

Cooked

## LP/LL FLAKES TEST: DRIED PASTA

| Attribute | Results/Comments |
|---|---|
| Water Added to Dough | 25g water added to 700g batch (3.5%) |
| Dough Quality | Visible specs of peel in dough; performed similarly to potato flour and standard flakes |
| Brittleness | Performed similarly to potato flour and standard flakes; more substantial than control, but still relatively easy to break cleanly |
| **Sensory Attribute** | **Comments** |
| Dried Appearance | Slightly flatterer in comparison to control, but not nearly as much as potato flour. Slightly visible rough texture, not as smooth as control |
| Dried Color | More yellow than control, similar to potato flour. Appealing to panelists |
| Cooked Appearance | Slightly stuck together, but this may have been due to positioning during dehydration |
| Cooked Color | Darker in color in comparison to control |
| Aroma | Slightly muted aroma in comparison to control |
| Flavor | Slightly muted flavor in comparison to control |
| Texture | Slightly softer than control and the softest of all the pasta tests, with a slightly gummy mouthfeel |
| Overall Likability | This ingredient did not perform as well as the other potato tests |
| Recommendations | Add water to the dough to aid in extrusion |

*Table 12*

Dried

Cooked

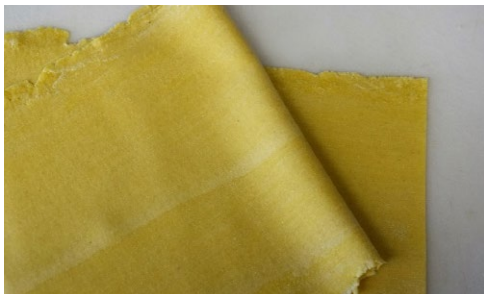
# FRESH PASTA RESULTS

The results of this study, including processing notes, analytical measures, sensory commentary and photographs are summarized below in Tables 13–17.

## CONTROL: FRESH PASTA

| Attribute | Results/Comments |
|---|---|
| Water Added to Dough | N/A |
| Dough Quality | Slightly crumbly dough; cohesive and smooth once extruded |
| Filling Quality | Soft, slightly granular texture with even distribution of spinach and cheeses |
| **Sensory Attribute** | **Comments** |
| Pasta Appearance | As expected; smooth and slight sheen |
| Filling Appearance | As expected; mixed green spinach and ricotta with parmesan cheese particulates |
| Pasta Color | As expected; pale yellow |
| Filling Color | As expected; green and white ricotta filling |
| Aroma | As expected; spinach, garlic, parmesan cheese |
| Pasta Texture | As expected; al dente and slightly chewy with a substantial bite |
| Filling Texture | As expected; light and fluffy, with a grainy, crumbly mouthfeel; just holds together |
| Pasta Flavor | As expected; starchy, floury and slightly sweet |
| Filling Flavor | As expected; spinach, garlic, parmesan, black pepper |
| Overall Likability | As expected |

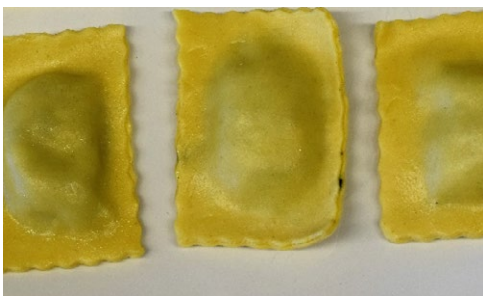
*Table 13*



Dough

Filling

Raw



Cooked

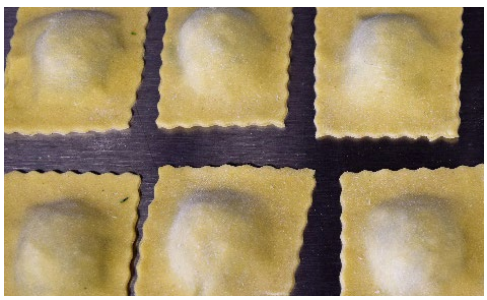
## POTATO FLOUR TEST: FRESH PASTA

| Attribute | Results/Comments |
|---|---|
| Water Added to Dough | 20g water added to 700g batch (2.8%) |
| Dough Quality | Similar to control; crumbly in texture, but smooth once extruded |
| Filling Quality | More cohesive than control, denser in texture |
| **Sensory Attribute** | **Comments** |
| Pasta Appearance | Similar to control; spinach filling is more visible through cooked pasta |
| Filling Appearance | More cohesive than control; denser in texture |
| Pasta Color | Similar to control; no noticeable difference in color |
| Filling Color | Similar to control; no noticeable difference in color |
| Aroma | Mild potato aroma; reminiscent of a pierogi |
| Pasta Texture | More tender than control; slight gummy texture, but is not off-putting. Reminiscent of pasta made with flour rather than semolina |
| Filling Texture | More gummy and homogenous than control; not as appealing, but not significantly different |
| Pasta Flavor | Muted flavor in comparison to control, but not off-putting |
| Filling Flavor | Similar to control; no noticeable difference |
| Overall Likability | Pasta and filling are both acceptable |

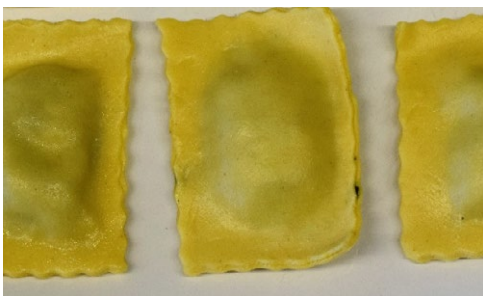
*Table 14*

Dough

Filling



Raw



Cooked

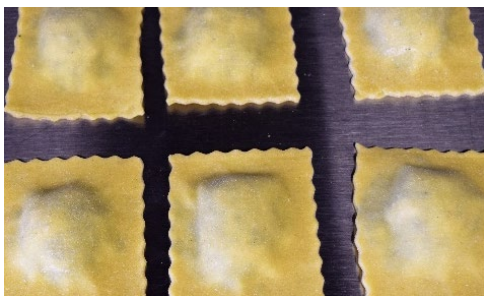
## POTATO GRANULES TEST: FRESH PASTA

| Attribute | Results/Comments |
|---|---|
| Water Added to Dough | 20g water added to 700g batch (2.8%) |
| Dough Quality | Similar to control; crumbly in texture, but smooth once extruded |
| Filling Quality | More cohesive than control |
| **Sensory Attribute** | **Comments** |
| Pasta Appearance | Similar to control; spinach filling is more visible through cooked pasta |
| Filling Appearance | Denser than control; not as light and fluffy in texture |
| Pasta Color | Comparable to control |
| Filling Color | Comparable to control |
| Aroma | Slightly muted aroma in comparison to control |
| Pasta Texture | More tender than control; slight gummy texture, but is not off-putting. Reminiscent of pasta made with flour rather than semolina |
| Filling Texture | Fine, granular and pasty texture; unappealing to panelists |
| Pasta Flavor | Muted flavor in comparison to control, but not off-putting |
| Filling Flavor | Slightly bland flavor; no significant difference to control |
| Overall Likability | Pasta is acceptable; filling is unacceptable due to pasty texture |

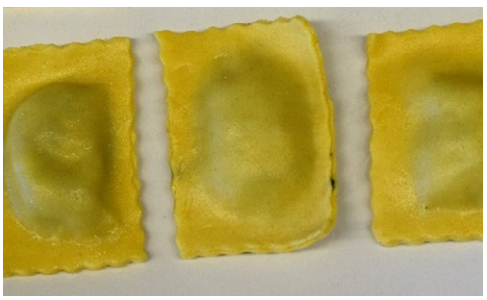
*Table 15*

Dough

Filling



Raw



Cooked

## POTATO FLAKES: FRESH PASTA

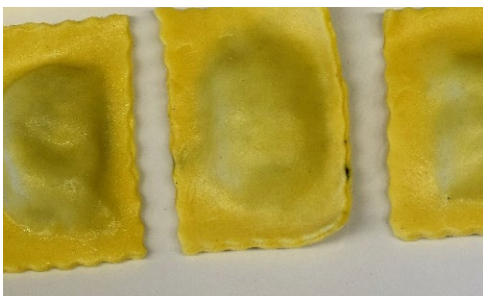
| Attribute | Results/Comments |
|---|---|
| Water Added to Dough | 20g water added to 700g batch (2.8%) |
| Dough Quality | Similar to control; crumbly in texture, but smooth once extruded |
| Filling Quality | More cohesive than control |
| **Sensory Attribute** | **Comments** |
| Pasta Appearance | Visible particulates that produce a whole-grain-like appearance, though not unappealing |
| Filling Appearance | More dense than control; not as light and fluffy |
| Pasta Color | Comparable to control |
| Filling Color | Comparable to control |
| Aroma | Muted aroma in comparison to control, but not off-putting |
| Pasta Texture | Firmer than potato flour and granule tests, but not as firm as control |
| Filling Texture | Granular and dense texture; pasty mouthfeel that eats like mashed potatoes |
| Pasta Flavor | More flavorful than potato flour and granule tests, but not as flavorful as control |
| Filling Flavor | Mild potato flavor; similar to control |
| Overall Likability | Pasta and filling are both acceptable; most comparable sample to control and highest rated by panelists |

*Table 16*

Dough

Filling

Raw



Cooked

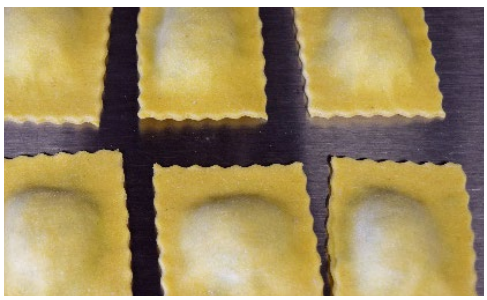
## LP/LL POTATO FLAKES: FRESH PASTA

| Attribute | Results/Comments |
|---|---|
| Water Added to Dough | 30g water added to 700g batch (4.2%) |
| Dough Quality | Similar to control, crumbly in texture but smooth once extruded |
| Filling Quality | More cohesive than control |
| **Sensory Attribute** | **Comments** |
| Pasta Appearance | Most similar to control; slightly less smooth in texture |
| Filling Appearance | More dense than control; not as light and fluffy |
| Pasta Color | Comparable to control |
| Filling Color | Comparable to control |
| Aroma | Muted aroma in comparison to control, but not off-putting |
| Pasta Texture | Similar to control; firmest texture of the potato test formulas |
| Filling Texture | Slightly drier than control; acceptable in texture to panelists |
| Pasta Flavor | Comparable to control |
| Filling Flavor | Mild potato flavor in comparison to control |
| Overall Likability | Pasta and filling are both acceptable |

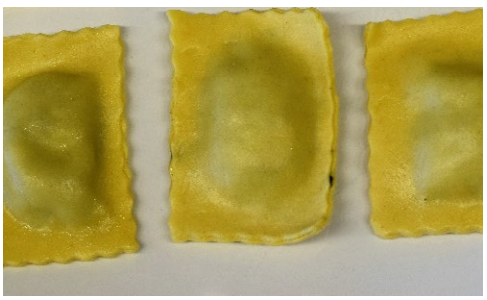
*Table 17*

Dough

Filling



Raw



Cooked

# CONCLUSIONS

## POTATO FLOUR

### CONCLUSIONS

Potato flour required additional water in both dried and fresh pasta dough to mimic the texture of control. While the texture was slightly softer than control, the differences would likely be negligible in preparation by consumers.

Potato flour showed multiple functional benefits in dried pasta, including:

- Reduced breakage
- Enhanced pasta flavor
- Appealing yellow color
- Slightly rough texture

Potato flour in fresh pasta was slightly muted in flavor and the filling was slightly gummier than control; however, the differences were slight. Functional benefits include:

- Cost reduction of pasta filling by replacement of ricotta and panko breadcrumbs

### RECOMMENDATIONS

Potato flour is recommended for use in dried pasta, starting at 5–10% replacement of semolina flour. Potato flour would be beneficial in dried pasta where a slightly rough texture is desired, particularly for better adhesion of smooth sauces. Potato flour may be added to fresh pasta and fillings starting at 10% for cost reduction without significant organoleptic changes. Water may need to be adjusted for extrusion and sheeting.

## POTATO GRANULES

### CONCLUSIONS

Potato granules required additional water in both dried and fresh pasta dough to mimic the texture of control. The color of dried pasta made with potato granules was paler than control, but panelists found the texture to be improved. The functional benefits of dried pasta with added potato granules included:

- Better shape retention
- Reduced breakage
- Improved texture integrity

Potato flour in fresh pasta was slightly muted in flavor and more tender and slightly gummy, but the differences were slight. The cheese filling made with added potato granules was pasty in texture, deemed unacceptable by panelists.

### RECOMMENDATIONS

Potato flour is recommended for use in dried pasta, starting at 10% replacement of semolina flour. Pasta made with potato granules may be better suited to dried pasta extruded through a larger die for easier extrusion. Water may need to be adjusted for extrusion and sheeting. Potato flour may be used in fresh pasta dough, but is not recommended for use in cheese fillings for pasta as it contributed a pasty texture that did not improve the eating qualities.

## STANDARD POTATO FLAKES

### CONCLUSIONS

Standard potato flakes required additional water in both dried and fresh pasta dough to mimic the texture of control. Panelist commentary was positive, as the potato flake pasta showed multiple functional benefits, including:

- **Reduced breakage**
- **Appealing yellow color**
- **Improved texture integrity**

Potato flakes in fresh pasta was slightly muted in flavor and the filling was dense and pasty in comparison to control; however, the differences were slight. It was the most appealing to panelists of all the potato tests. Functional benefits include:

- **Cost reduction of pasta filling by replacement of ricotta and panko breadcrumbs**

### RECOMMENDATIONS

Standard potato flakes are recommended for use in dried pasta to improve color and texture, starting at 10% replacement of semolina flour. Potato flakes may be added to fresh pasta and fillings starting at 10% for cost reduction without significant organoleptic changes. Water may need to be adjusted for extrusion and sheeting.

## LP/LL POTATO FLAKES

### CONCLUSIONS

LP/LL potato flakes did not perform as well in dried pasta as other dehydrated potato ingredients. While the color of dried pasta was improved, the muted flavor and slightly softer texture was deemed less desirable by panelists.

LP/LL potato flakes performed better in fresh pasta and filling, with functional benefits including:

- **Improved texture integrity**
- **Cost reduction of pasta filling by replacement of ricotta and panko breadcrumbs**

### RECOMMENDATIONS

LP/LL potato flakes are not recommended in dried pasta; however, they are recommended for use in fresh pasta and fillings starting at 10% for cost reduction without significant organoleptic changes. Water may need to be adjusted for extrusion and sheeting.

# OVERALL CONCLUSIONS

Formulators must determine the best ingredients for pasta formulas through hands-on testing on the bench and in the plant to achieve the desired results, balancing flavor with functionality. Ultimately, that may mean using a combination of dehydrated potato ingredients for pasta and filling that offer improved texture integrity and possible cost savings through the reduction of higher priced cheese and breadcrumbs.

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