POTATO APPLICATION

GLUTEN-FREE SUGAR COOKIES




Potatoes USA

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INTRODUCTION

The purpose of this study was to provide formulation and application information on the use of potato ingredients in gluten-free sugar cookies for food manufacturers. Due to the known multifunctionalities of dehydrated potato ingredients, it was hypothesized that the potato ingredients would be able to 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 gluten-free sugar cookies resulted in:

ENHANCED BROWNING

Gluten-free baked goods do not brown as well as wheat-containing products; the addition of potato ingredients improved browning and color development.

INCREASED OR DECREASED SPREAD

All of the potato ingredients tested resulted in changes to cookie appearance; potato flour, standard potato flakes and low-peel/low-leach potato flakes (LP/LL) resulted in decreased spread and increased rise, whereas potato granules were the only dehydrated potato ingredient to result in increased spread.

SOFTER, CAKIER TEXTURE

Potato flour increased softness and produced a cakier texture with crisp, friable edges. It is suggested for starting usage at 5–10% of the formula and is also recommended for use in other baked goods with a crunchy, crumbly texture, such as shortbread or biscotti.

REDUCED GRITTINESS

Potato granules provided great texturizing qualities, decreasing the gritty and gummy texture associated with gluten-free baked goods. It is suggested for starting usage at 5–15% of the formula and is recommended in any gluten-free baked good.

CHEWY, FLAKY TEXTURE

Potato flakes made for softer, chewier cookies, with a crunchy bottom crust and flaky texture. It is suggested for starting usage at 5–10% of the formula and is also recommended in other baked goods with a flaky texture, such as biscuits, scones and pie crust.

EXTENDED SHELF LIFE

LP/LL potato flakes resulted in a softer, chewier mouthfeel with reduced grittiness and gumminess. The cookies staled slower than those made with other gluten-free starches and flours. LP/LL flakes are recommended in any gluten-free baked good, particularly those where a savory potato flavor would be beneficial, such as bread, pizza crust and snacks. It is suggested for starting usage at 10–15% of the formula.

APPLICATION OVERVIEW

BACKGROUND

There are infinite varieties of cookies, with many different textures, flavors, fillings, inclusions, sizes and shapes. According to IRI, cookie sales totaled $8.5 billion in 2018, up 2.7%.[1] Gluten-free product launches have increased significantly in recent years, with an average growth rate of 24% of total food and beverages globally.[2] Most cookies contain only a few simple ingredients, including flour, sugar, eggs, fat, leaveners and any number of flavoring ingredients. Gluten-free cookies rely on a combination of various gluten-free flours to replicate the properties of wheat flour. The types of ingredients used, formulation, mixing method and baking procedure all play important roles in the eating quality and shelf life of the finished baked good.

TYPES OF COOKIE FORMULAS

Most commercially made cookies can be categorized into four types by the method of manufacture: wire cut, rotary molded, deposited and sheeted.[3] Each cookie type is different not only in the way it is shaped, but also in formula makeup. Wire-cut and deposited/extruded cookies have higher sugar and fat content and are referred to as “rich cookies.” Conversely, rotary and sheeted cookies, having lower sugar and fat content, are “lean cookies.”

SELECTED COOKIE APPLICATION

Wire-cut cookies include chocolate chip, peanut butter, oatmeal raisin and sugar cookies—baked soft/cakey, chewy or crisp textured. Because gluten-free sugar cookies are both commonly available and mild in flavor, they were selected to assess various potato ingredients in application.

INGREDIENTS AND FUNCTION

STARCHES AND FLOURS

Starches and flours form the majority of a sugar cookie formula, playing an integral role in the formation of structure and eating qualities. In gluten-free baked goods, a combination of starches and flours are used to replicate the functional properties of gluten-containing wheat flour. Starches are made of two polymers that differ in structure: amylose is a linear chain of polysaccharides and amylopectin is branched. Amylopectin forms a gel or paste and swells in water, whereas amylose does not. The types and ratios of the starch molecules are one of the most important factors in determining appearance, spread, texture, flavor and shelf life of gluten-free cookie formulas. In the control sugar gluten-free cookie formula used in this study, the following starches and flours were used:

WHITE RICE FLOUR is neutral in flavor and a cost-effective ingredient as the bulk flour of gluten-free bakery formulations. However, when used without a combination of supporting starches, the texture can be gritty due to the high amylose starch content.

SWEET WHITE RICE FLOUR is made from short-grain or "glutinous" rice and is higher in starch than medium-grain white rice flour; the starch contains more amylopectin than amylose and contributes to better eating qualities and extended shelf life.

TAPIOCA STARCH is also high in amylopectin, which gelatinizes at a lower temperature than other starches, requiring less water and making a moister, denser, chewier cookie. It is more freeze-thaw stable and stales more slowly than high amylose starches.

EGGS

The gluten in wheat flour contributes structure in most cookies; however, in gluten-free cookies, the starches and flours used contain little protein themselves and, as such, the proteins in eggs are particularly important in building structure. Egg white contains albumin, which are proteins that, when physically mixed and eventually heated, begin to unfold or denature. These proteins form a cross-linked network to hold in gases, creating a relatively stable foam of tiny air bubbles, which help to create the crumb structure in the baked cookies.[3] Egg yolks contain lecithin, an extremely effective natural emulsifier that helps to create a tender, short texture that is pleasant to chew. Lecithin also extends shelf life by interfering with starch molecule crystallization, the cause of staling. The inherent moisture in liquid eggs serves as a moistener, hydrating the dry ingredients and allowing them to partially gelatinize in the heat of the oven and dissolving the chemical leaveners, allowing them to start reacting.[3]

SWEETENERS

Sweeteners serve as multifunctional ingredients in cookie formulas; they act as humectants to help retain moisture and extend shelf life by preventing staling.[4] They also act as tenderizers and contribute to sweetness, browning and flavor development. Both granulated sugar and tapioca syrup solids were used in formulation for this study. Granulated sugar primarily provides sweetness and promotes aeration of the dough; the granules have a sharp, crystalline structure that cuts into the fat during creaming and allows air to be incorporated, which helps to leaven the cookies during baking. Tapioca syrup solids have humectant qualities that keep the cookies moist, chewy and soft throughout shelf life.[3] Both sweeteners also affect cookie shape and spread as they melt during baking.

FATS

Fats such as butter, margarine, shortening and oil contribute several functions to cookies. Fats help to provide a tender texture, moist mouthfeel, good flavor and also help to prevent staling.[4] Butter is preferred for sugar cookies, and it contributes to both flavor and dough aeration by entrapping tiny air bubbles during the mixing process. The yellow hue of butter and some margarines can also affect the color of cookies.

SALT

While salt is a minor ingredient in cookie formulas, it serves an important function as a flavor enhancer. Without it, the baked cookies may taste dull or flat and less sweet.[4]

LEAVENING

Leavening ingredients are essential to cookie formulas and help to lighten the texture of the cookie. They include chemical leavers, such as baking powder and baking soda (which react with each other, water, acid or heat to form gases), and the incorporation of air during mixing and the expansion of air during baking.[4] Chemical leaveners affect the spread, height, shape, color and flavor of cookies.

FLAVORS

Beyond the inherent flavors of butter, flour, eggs and sugar, other flavors and extracts such as vanilla may be added.[4] In addition to providing characterizing flavors, they help to offset any undesirable flavors from gluten-free starches and flours, such as doughy, vegetal, cardboard-like or artificial notes which can be off-putting.

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 (damage) 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.[5] 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.[6] 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.[6] 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.[7]

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.[6]

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).[8] 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.[9]

Dehydrated potato ingredients typically contain between seven to nine grams of protein per hundred grams.[10]

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 the manufacture and storage of dehydrated potato products.[6]

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 they 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)

FORMULAS

A control gluten-free sugar cookie formula (Table 2) was created to compare with test formulas containing potatoes. Test formulas were created with potato ingredients, replacing 50% and 100% of the medium-grain white rice flour (Table 3 and Table 4, respectively) with one of four dehydrated potato ingredients: flour, granules, flakes or LP/LL flakes.

CONTROL COOKIES

Ingredient	Percent	Batch (g)
Sugar, granulated	29.50	221.25
Butter, unsalted	23.05	172.88
White rice flour, medium grain	20.00	150.00
Potato ingredient	0.00	0.00
Tapioca starch, instant	9.00	67.50
Whole egg, liquid	9.00	67.50
Tapioca syrup solids	5.00	37.50
White rice flour, sweet, fine grain	2.75	20.63
Baking soda	0.70	5.25
Vanilla extract	0.50	3.75
Salt	0.30	2.25
Xanthan gum, 200-mesh	0.20	1.50
Total	**100%**	**750.01**

Table 2

TEST COOKIES: 50% WHITE RICE FLOUR REPLACEMENT

Ingredient	Percentage	Batch (g)
Sugar, granulated	29.50	221.25
Butter, unsalted	23.05	172.88
White rice flour, medium grain	10.00	75.00
Potato ingredient	10.00	75.00
Tapioca starch, instant	9.00	67.50
Whole egg, liquid	9.00	67.50
Tapioca syrup solids	5.00	37.50
White rice flour, sweet, fine grain	2.75	20.63
Baking soda	0.70	5.25
Vanilla extract	0.50	3.75
Salt	0.30	2.25
Xanthan gum, 200-mesh	0.20	1.50
Total	**100%**	**750.01**

Table 3

TEST COOKIES: 100% WHITE RICE FLOUR REPLACEMENT

Ingredient	Percentage	Batch (g)
Sugar, granulated	29.50	221.25
Butter, unsalted	23.05	172.88
White rice flour, medium grain	0.00	0.00
Potato ingredient	20.00	150.00
Tapioca starch, instant	9.00	67.50
Whole egg, liquid	9.00	67.50
Tapioca syrup solids	5.00	37.50
White rice flour, sweet, fine grain	2.75	20.63
Baking soda	0.70	5.25
Vanilla extract	0.50	3.75
Salt	0.30	2.25
Xanthan gum, 200-mesh	0.20	1.50
Total	**100%**	**750.01**

Table 4

PROCESSING

PRODUCTION

Consistent batching, portioning and baking procedures were used to limit variables. Each test was batched in the same mixer using standardized mixing procedures. The baking sheets used were identical and each was prepared for portioning in the same manner. Bake 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 wire-cut cookies, the dough is forced through a hopper down to a small opening where a thin wire cuts the dough into appropriate-sized pucks, which then drop down onto a tray or directly onto a band for baking in a continuous process.

For this this study, a modified benchtop processing method using a six-quart standing KitchenAid mixer with a paddle attachment was used:

1. Combine sugar and butter. Mix 1 minute on medium (speed 4).
2. Add the eggs and vanilla, and mix for 1 minute on medium (speed 4).
3. Mix the dry ingredients together.*
4. Add dry mix to sugar mixture. Mix for 1 minute on low (speed 2).
5. Using a #30 scoop, portion 40 grams of dough onto ungreased parchment.
6. Bake at 325°F for 13 minutes, rotate after 6 minutes.
7. Allow to cool on sheet pan for 10 minutes before removing to a wire rack to cool completely.

Note: Dough temperature target was 70–75°F.

*Potato ingredients were added with the dry ingredients in Step 3.

ANALYTICAL MEASURES AND NOTES

Cookies were all baked in the same conditions, in the same oven, on the same day. Both the dough and cookies were analyzed using industry standard, cookie-specific evaluation methods.

PROCESSING NOTES

In production, the dough needs to be firm enough to withstand extrusion through a hopper and wire cutting; it can't be too firm, crumbly or dry, nor too wet, sticky or soft. Once fully mixed, the dough should be cohesive, soft, slightly sticky and pale yellow.

WATER ACTIVITY

Cookies with good eating qualities should be moist, but not so moist that they encourage microbial growth. Water activity (Aw) is defined as the ratio of vapor pressure of the moisture in the product to the vapor pressure of pure water and is a common analytical measure to determine the water available for participation in microbial activity. Even a small change in water activity can greatly increase or decrease microbial growth because most microorganisms require relatively high humidity to proliferate.[11] The target Aw for shelf-stable cookies is 0.70. Room temperature samples were tested on day one only, measured with an Aqualab Paw Kit Water Activity Meter.

RISE AND SPREAD MEASUREMENTS

Cookies were measured with scientific calipers, in stacks four cookies high, and the average height calculated.

SENSORY EVALUATION

Sugar cookie samples were evaluated by panelists and sensory commentary was recorded. Cookie samples were evaluated on days one and seven to document changes over time. The following attributes were assessed:

APPEARANCE

The visual appearance of the cookies was noted, with the following areas considered: color hue, browning, cracking, symmetry and evenness of the rise and spread.

AROMA

Sugar cookie aroma should be mild and pleasant, with a prominent vanilla and sugar scent. There should be no strong chemical or artificial notes. Aroma intensity and likability were assessed.

TEXTURE

The texture of cookies is very important to eating quality. Cookies that are either too firm, chewy or dry are unacceptable, as are cookies that are too soft, tender or moist. Chewiness, moisture and mouthfeel were assessed.

FLAVOR

Sugar cookie flavor is mildly sweet and fairly neutral, with a traditional "sweet baked good" and slightly eggy flavor. Off flavors include, but are not limited to, chemical or artificial notes, overly starchy, pasty, doughy flavors. Flavor intensity and likability were assessed.

OVERALL LIKABILITY

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

RESULTS

The results of this study, including processing notes, analytical measures, sensory commentary and photographs are summarized below in Tables 5–13.

CONTROL SUGAR COOKIE

Attribute	Results/Comments	
Dough Quality	Soft, cleans the bowl, slightly sticky, pale yellow color, smells buttery	
Average Height	0.76 inches	
Average Width	2.72 inches	
Water Activity	0.71 (16.9°C) ± 0.2	
Sensory Attribute	**Day 1**	**Day 7**
Appearance	Domed, even cracking, some holes in interior	No change
Color	Brown edges, pale center, evenly browned on bottom. Pale color is somewhat unappetizing and makes it appear undercooked (although that may be only because it sits next to the others)	No change
Aroma	Mild, sweet, vanilla, butter	No change
Flavor	Mild, sweet, buttery vanilla, salt; as expected	Muted but acceptable
Texture Visual	Soft, balanced between chewy and cakey. The soft squishiness from the outside almost implies a more commercial product versus a natural, homecooked one	No change
Texture Eating Qualities	Chewy, moist, slightly gummy, slightly gritty texture that sticks to the teeth; acceptable for a GF cookie	Still appetizing, drier than Day 1 but acceptable
Overall Likability	As expected	Acceptable

Table 5

POTATO FLOUR SUGAR COOKIE: 50% WHITE RICE FLOUR REPLACEMENT

Measure	Results/Comments	
Dough Quality	Firmer than control, stiff, less sticky	
Average Height	1.01 inches	
Average Width	2.64 inches	
Water Activity	0.67 (17.2°C) ± 0.2	
Sensory Attribute	**Day 1**	**Day 7**
Appearance	Domed/rounded, less spread and cracking. Many more holes in interior as compared to control	No change
Color	More golden-brown exterior, more yellow interior, deeper brown on bottom as compared to control	No change
Aroma	Similar to control but slightly muted; nuttier and floury	No change
Flavor	Noticeable potato flavor, but not unappealing. Sweetness the same as control	Noticeable potato flavor
Texture Visual	A little harder to break than control. Cakier, less chewy	No change
Texture Eating Qualities	Softer, cakier, nice friable edges	Crumbly, dry, some chewiness
Overall Likability	Different eating qualities than control. Less like a traditional sugar cookie, more like a crisp biscotti	May be acceptable, but too dry for sugar cookie

Table 6

POTATO FLOUR SUGAR COOKIE: 100% WHITE RICE FLOUR REPLACEMENT

Measure	Results/Comments	
Dough Quality	Firmer than control, similar to 50% potato flour replacement	
Average Height	1.03 inches	
Average Width	2.56 inches	
Water Activity	0.62 (20.2°C) ± 0.2	
Sensory Attribute	**Day 1**	**Day 7**
Appearance	More domed and less spread than 50% potato flour replacement. Looks like it retained appearance of scoop, puck-like. Large air pockets	No change
Color	More yellow, more appealing golden-brown than control	No change
Aroma	Mild potato, less butter aroma compared to control	No change
Flavor	More muted, slight potato flavor as compared to control	Unpleasant flavor
Texture Visual	More crust, firmer, not as chewy, looks like a biscuit texture	No change
Texture Eating Qualities	Crumbly, chewier, moister than 50% potato flour	More crumbly, dry, staling faster than 50% potato flour
Overall Likability	Very cakey, not as chewy as control	Not acceptable, too stale

Table 7

POTATO GRANULES SUGAR COOKIE: 50% WHITE RICE FLOUR REPLACEMENT

Measure	Results/Comments	
Dough Quality	Slightly stiffer and less sticky than control, but not as stiff as potato flour	
Average Height	0.74 inches	
Average Width	3.03 inches	
Water Activity	0.70 (18.5°C) ± 0.2	
Sensory Attribute	**Day 1**	**Day 7**
Appearance	More cracked all over and flatter; the most appealing of all samples	No change
Color	More yellow in hue and more browning on the edges than control	No change
Aroma	Smells less sweet than control, but enhanced butter aroma	No change
Flavor	More browned/caramelized tasting, with a balanced sweet butter flavor that was stronger in comparison to control	Slightly muted, off flavors
Texture Visual	Feels like control	No change
Texture Eating Qualities	Friable edges with a chewy center, very pleasant. Reduced grittiness compared to control and less pasty in the mouth	Center and edges have equilibrated; drier, slightly crumbly texture
Overall Likability	More appealing than control. Better appearance, mouthfeel and flavor	Stale texture is not appealing

Table 8

POTATO GRANULES SUGAR COOKIE: 100% WHITE RICE FLOUR REPLACEMENT

Mesure	Results/Comments	
Dough Quality	Similar to 50% potato granules, not as firm as 100% potato flour	
Average Height	0.51 inches	
Average Width	3.25 inches	
Water Activity	0.61 (20.5°C) ± 0.2	
Sensory Attribute	**Day 1**	**Day 7**
Appearance	Looks more appealing, most spread out of any sample	No change
Color	More brown on top and bottom than 50% potato granule replacement. Edges and center more uniform in comparison to control	No change
Aroma	Slightly reduced baked good aroma compared to control	No change
Flavor	More muted butter flavor than control, but not unappealing. Has a fuller, more rounded and nuanced flavor. Nice nuttiness from browning	Slightly muted
Texture Visual	Soft chewiness when broken, less cakey than control	No change
Texture Eating Qualities	Chewy center, crisp friable edges	Equilibrated texture, crumbly edges, dense and chewy center
Overall Likability	Prefer 50% replacement for better appearance, flavor, texture	Not as appealing as Day 1

Table 9

STANDARD POTATO FLAKES SUGAR COOKIE: 50% WHITE RICE FLOUR REPLACEMENT

Measure	Results/Comments	
Dough Quality	Not as cohesive as control, slightly crumbly, can see and feel potato flakes. Stickier and softer than control as the potato flakes have not hydrated fully	
Average Height	0.90 inches	
Average Width	2.76 inches	
Water Activity	0.67 (18.8°C) ± 0.2	
Sensory Attribute	**Day 1**	**Day 7**
Appearance	Did not spread as much as control, domed appearance. Similar to potato flour	No change
Color	Pale brown in center, brown around edges, deeply browned on bottom	No change
Aroma	Similar to control but slightly muted	No change
Flavor	Slightly muted, but no off flavors	No change
Texture Visual	Very rough appearance, craggy with ridges, grooves, cracks and more air pockets than control	No change
Texture Eating Qualities	Drier, more cohesive than control. Dense and chewy with a crust and crisp edges. Some noticeable pulpy potato flake texture. Maintains the soft bite inside, but crunchy on the outside that greatly improves the crumb and mouthfeel	Not acceptable, stale
Overall Likability	Appealing texture, but different than control	Not acceptable

Table 10

STANDARD POTATO FLAKES SUGAR COOKIE: 100% WHITE RICE FLOUR REPLACEMENT

Measure	Results/Comments	
Dough Quality	Not as cohesive as control, crumblier than 50% potato flake replacement, can see and feel potato flakes. Stickier and softer than control as the potato flakes have not hydrated fully	
Average Height	1.11 inches	
Average Width	2.48 inches	
Water Activity	0.66 (20.8°C) ± 0.2	
Sensory Attribute	**Day 1**	**Day 7**
Appearance	Deep fissures and uneven texture. Most domed and least spread of all samples	No change
Color	Brown all over, very dark browning on bottom	No change
Aroma	Noticeably different from control, less sweet aroma	No change
Flavor	Undesirable, tastes of potato	Strong potato flavor
Texture Visual	Sturdy crust, crumb is soft and dense with large crumbs	No change
Texture Eating Qualities	Very uneven texture, bottom almost has a fried potato texture	Staler than potato flour test, but texture is better than on Day 1
Overall Likability	Undesirable textural changes that were out of place in a cookie	Not acceptable

Table 11

LP/LL POTATO FLAKES SUGAR COOKIE: 50% WHITE RICE FLOUR REPLACEMENT

Measure	Results/Comments	
Dough Quality	Soft and similar to control, less sticky, some potato aroma	
Average Height	0.81 inches	
Average Width	2.90 inches	
Water Activity	0.65 (19.3°C) ± 0.2	
Sensory Attribute	**Day 1**	**Day 7**
Appearance	Similar in shape to control, some deeper cracks and ridges	No change
Color	Color is more appealing, yellow golden brown, but not overly browned; control looks pale and gray in comparison	No change
Aroma	Similar to control, with an appealing buttery aroma	No change
Flavor	Similar to control, with a slightly stronger profile	Slightly muted sweetness
Texture Visual	Softer than all of the tests, but firmer than control	No change
Texture Eating Qualities	Softer, less chewy than some of the other samples. More even texture and less grittiness than control. Less moist but acceptable, not as gummy	Very good, comparable to control
Overall Likability	Improvement in texture and better mouthfeel compared to control	The only appealing cookie sample on Day 7, including control

Table 12

LP/LL POTATO FLAKES SUGAR COOKIE: 100% WHITE RICE FLOUR REPLACEMENT

Measure	Results/Comments	
Dough Quality	Similar to 50% LP/LL replacement	
Average Height	0.85 inches	
Average Width	2.95 inches	
Water Activity	0.63 (20.9°C) ± 0.2	
Sensory Attribute	**Day 1**	**Day 7**
Appearance	Intensely browned ridges and fissures, with bigger voids and air pockets	No change
Color	Looks overly browned, especially on the edges and bottom	No change
Aroma	Slightly noticeable potato aroma	No change
Flavor	More muted sweetness than control	Noticeable potato flavor
Texture Visual	More firm and crusty, less soft than control	No change
Texture Eating Qualities	Falls apart more readily in the mouth, seems a little greasy, more gelatinous, packs in teeth. Rough-textured edges	Dry, crumbly, dense
Overall Likability	Not acceptable	Not acceptable

Table 13

CONCLUSIONS

POTATO FLOUR

CONCLUSIONS

Potato flour used at 10% of the sugar cookie formula (50% white rice flour replacement) showed multiple functional benefits, including:

- **Enhanced exterior browning**
- **Appealing golden-yellow, buttery interior crumb color**
- **Nutty aroma (although slightly muted overall in comparison to control)**
- **Stronger nutty and caramelized flavor notes (due to browning)**
- **A cakier texture that was softer and less chewy than control, with friable, crisp edges**

Overall, the samples made with potato flour had very different eating qualities from control. Depending on the desired product attributes, these differences could be considered positive or negative, such as a more domed, puck-like shape that did not spread much in the oven.

At the higher usage rate of 20% of the cookie formula (100% white rice flour replacement), the positive attributes listed above were overshadowed by some undesirable textural changes.

RECOMMENDATIONS

Potato flour would be beneficial in a cookie where a crisp, crumbly texture is desired, such as a crisp sugar cookie, shortbread or biscotti. Other bakery applications that could benefit from by adding potato flour to formulas include biscuits, scones and pie crust, where a crumbly yet moist texture is expected. It is not recommended to exceed 10% of formula, as this promotes faster staling. Due to enhanced browning, oven temperatures and cook times may need to be adjusted, depending on equipment.

POTATO GRANULES

CONCLUSIONS

Potato granules used at 10% of the sugar cookie formula (50% white rice flour replacement) showed multiple functional benefits, including:

- Appealing appearance, with desirable fissures and cracking
- Slightly increased spread and decreased rise, less domed appearance
- Enhanced exterior browning
- Appealing golden-yellow, buttery interior crumb color
- Enhanced buttery aroma
- Improved flavor profile, contributing buttery, nutty and caramelized flavor notes
- Great texturizing qualities including increased chewiness with less gritty and gummy in the mouth in comparison to control
- Overall, improved and preferable to control sugar cookie samples

At the higher usage rate of 20% of the cookie formula (100% white rice flour replacement), the positive attributes listed above were overshadowed by some undesirable textural changes that were out of place in a cookie.

RECOMMENDATIONS

Potato granules are highly recommended in gluten-free baked goods and suggested for replacement of other starches and flours at 5–15% of the formula, not to exceed 20%. Due to enhanced browning, oven temperatures and cook times may need to be adjusted, depending on equipment.

STANDARD POTATO FLAKES

CONCLUSIONS

Standard potato flakes used at 10% of the sugar cookie formula (50% white rice flour replacement) showed multiple functional benefits, including:

- A more natural, irregularly textured appearance, which panelists commented looked more like a homestyle cookie and less processed than control
- Enhanced exterior browning
- Appealing golden-yellow, buttery interior crumb color
- Great texturizing qualities, including both increased softness and chewiness, along with a crunchy, crisp crust on the cookie edges

At the higher usage rate of 20% of the cookie formula (100% white rice flour replacement), the positive attributes listed above were overshadowed by some undesirable textural changes that were out of place in a cookie.

RECOMMENDATIONS

Although standard potato flakes performed well in this chewy sugar cookie application, the texture attributes would be especially beneficial in a crisp cookie, such as shortbread or biscotti. Beyond cookies, the textural properties would benefit any baked good with a flaky texture, such as biscuits, scones, pie crusts, empanada and hand-pie crusts, pastries such as croissants and Danishes, and crusty loaf breads and pizza crusts. It is recommended for replacement of other starches and flours at 5–10% of the formula in baked goods. Due to enhanced browning, oven temperatures and cook times may need to be adjusted, depending on equipment.

LP/LL POTATO FLAKES

CONCLUSIONS

LP/LL potato flakes used at 10% of the sugar cookie formula (50% white rice flour replacement) showed significant functional benefits, including:

- Improved appearance
- Noticeably increased spread and decreased rise, for a less domed shape
- Enhanced exterior browning
- Appealing golden interior crumb color
- Richer and more nuanced flavor
- Softer and chewier mouthfeel with reduced grittiness and gumminess
- Slowed staling better than other potato products and white rice flour
- Overall, improved and preferable to control sugar cookie samples and one of the best performers of the potato tests

At the higher usage rate of 20% of the cookie formula (100% white rice flour replacement), the positive attributes listed above were overshadowed by undesirable textural changes and a strong potato flavor that was out of place in a cookie.

RECOMMENDATIONS

The negative sensory attributes of sugar cookies made with the increased potato flakes should not be dismissed; rich potato flavor out of place in a sweet cookie would be appropriate and even desirable in savory bakery or snack applications, and the crusty texture would be beneficial in a gluten-free bread or pizza crust. LP/LL potato flakes at lower levels are highly recommended for use in gluten-free bakery applications, particularly sugar cookies. Recommended starting usage rate in cookies at 10–15% of the total formula. Due to enhanced browning, oven temperatures and cook times may need to be adjusted depending on equipment.

OVERALL CONCLUSIONS

Formulators must determine the best ingredients for gluten-free sugar cookies 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 with other starches and flours in gluten-free sugar cookie formulations that offer an eating quality as good as or even superior to gluten-containing cookies.

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