Gluten-Free Product Development

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Clinically diagnosed celiac disease (CD) is distinguished by the permanent intolerance of gluten, forcing people who suffer from it to follow a strictly gluten-free diet for their whole lives. Gluten is a protein contained in certain cereals such as wheat, rye, barley, triticale (a hybrid of wheat and rye), and possibly oats. For sensitive individuals, eating gluten causes the villi of the intestine to atrophy, which prevents food from being absorbed and produces an inflammatory reaction. It affects individuals genetically predisposed to the condition and is found in both children and adults.

Some research indicates that CD currently affects approximately 1% of the population in the United States, or about 3 million individuals. The number of CD patients within the population is growing rapidly, thus significantly increasing the number of consumers who potentially derive a benefit from gluten-free products. Additionally, a number of consumers choose to limit the gluten in their diet.

The number of people diagnosed with food allergies, including CD, is growing rapidly, and the development of healthy food alternatives is becoming increasingly important. A trip to the grocery store shows the significance that food marketers are now placing on the gluten-free category. Labels on new products tout this characteristic on front panels throughout the regular grocery aisles.

The developer of a gluten-free product needs to focus on two aspects of the process. The first is utilizing technology to replace the functionality of gluten with ingredients that do not contain gluten. The second is jumping the hurdles that must be overcome during commercialization of gluten-free products in the manufacturing environment.

Gluten Functionalities—Bread

Gluten-based ingredients such as wheat are well known to society and have been used in bread since ancient times. The gluten component contributes heavily to the primary characteristics of bread, such as the volume of the rise, the chewy texture of the loaf, and the development of the texture and flavor of the crust. We find that a piecemeal approach is useful when attempting to replace these functions with ingredients that do not contain gluten.

Our target for development was to develop a gluten-free bread suitable for the CD patient with a taste and texture similar to those of bread made with whole wheat flour—that is, a spongy center and a "normal" volume—as well as a unique taste that would set it apart from existing products.

To achieve a spongy texture and uniform air structure similar to those of regular whole wheat bread requires attention to the structural contribution delivered by the gluten in whole wheat flour. Specifically, the dough (flour, water, yeast, and salt) is mixed for a controlled mixing time and intensity to permit the gluten to hydrate. The hydrated gluten forms elastic films around, and bonds between, the starch granules of the flour. This elastic matrix traps the leavening gases produced by the yeast and holds them within the dough structure.

The first challenge is to develop an elastic film that is sticky enough to coat and suspend starch granules, to retain the leavening gases, and further, to permit the dough to expand in volume before baking. Ingredients that help to mimic these functions are basically film-forming ingredients like rice flour, gluten-free starches (both instant and cook-up), and gums. It remains critical that the blending process be controlled to ensure proper hydration of these ingredients and the proper sequence of mixing to yield an elastic and sticky dough.

The specific contribution of gluten to texture relates to the strength of the dough, the size and uniformity of the air cells within the dough, and the presence of a heterogeneous matrix within the dough. A weaker dough yields larger and less uniformly sized air cells. Weaker dough also exhibits greater heterogeneity and yields a longer, chewy texture. Stronger dough has smaller and more uniformly sized air cells and exhibits a less heterogeneous appearance. The strength of the gluten replacement system is critical to mimicry of the targeted bread product.

The physical space that the gluten occupies within the dough in a whole wheat bread also requires compensating adjustments. An effective replacement method must ensure that the volume and weight contributed by the gluten protein are replaced with a gluten-free alternative ingredient.

The gluten-replacing ingredient must help with water management in a similar manner. Water must be controlled in order to postpone the rate of staling and to prevent mold. The shelf life of a gluten-free product tends to be equal to or less than that of a typical wheat-based product, depending on what the product is and how it is stored. The strategic application of sugars helps to bind water and manage such changes during storage.

The flavors and textures of gluten-free ingredients generally do not result in a product that would be considered acceptable when compared with a refined-flour product such as commercial U.S. white pan bread. However, the likelihood of success in mimicking the flavors and textures of whole wheat, whole grain, or brown breads is far greater.

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In our work, we have successfully used, in combination, the following ingredients to deliver the listed functionalities:

- Rice flours, brown and white, to replace wheat flour,
- Rice proteins, for water binding,
- Rice starch, instant or cookup, for elasticity and adhesion,
- Tapioca starch, instant or cookup, for elasticity and adhesion,
- Nonhydrogenated vegetable oils, for tenderizing,
- Xanthan gum, for film forming and water binding,
- Guar gum, for film forming and water binding,
- Sugar, e.g., sucrose, for water binding,
- Water.

Ingredients that are best to avoid in gluten-free formulations are ingredients from the wheat family (flour, starch, etc.), corn, rye, spelt, and soy. Although gluten intolerance is based on wheat, people who suffer from gluten intolerance also tend to avoid corn- or soy-based alternatives.

Controlling rise, volume strength, crumb texture, and resistance to staling is a challenge of balancing. The proper sequence that develops the proper dough characteristics is dependant on the blending and baking equipment and processes used. Gluten-free dough is more fragile and more susceptible to overworking. Chemical leavening and proofing conditions are directly linked to formulation. Oven temperatures generally need to be lower, while baking times are longer. The ability to control atmospheric pressure may positively influence the performance of gluten-free dough during baking. Moisture content can affect the performance of the dough while it is being mixed. Understanding and controlling these variables is key to gluten-free formulation and ultimate success in commercialization.

It is very important to the growing number of CD patients that their foods be free not only of gluten, but of several other ingredients as well. Because of the debilitating effects of CD, it is critical to develop a safe, healthy product for this highly selective consumer. The Codex Alimentarius has a guideline defining "gluten-free" as containing gluten at <200 ppm if the food is cereal-derived or <20 ppm for non-cereal-derived foods. It behooves the developer to provide a guarantee of compliance, if the claim of "gluten-free" is made.

Commercialization Concerns

Because of cross-contamination issues, it is necessary to have a facility that is completely separate from any other production facility that handles materials containing gluten. It is equally important to have decontamination points surrounding the plant. All employees have the potential to contaminate the plant. Gluten could come from their hands, clothing, or shoes. The plant should be designed to eliminate the chance of any person entering the plant before meeting appropriate standards. Any persons entering the plant should dress in appropriate uniforms, visitors included. Cleaning of hands and footwear is required before entering the processing areas, minimizing any chance of gluten entering the plant on a person's clothing. Any and all outside food is completely prohibited in a gluten-free food plant. Direct access to the plant from the lunch room should not be available

In this environment, it is absolutely necessary not to allow gluten inside the plant. A program to monitor all incoming shipments and a quarantine area are necessary. All inbound shipments should be visually inspected for gluten contamination from any raw material that may have been spilled or improperly shipped. Effective cleaning of ingredient packages and replacement of pallets must be completed before incoming materials are released into the warehouse or production areas. Having full isolation and wash-down abilities in this area is crucial.

Supplier guarantees of gluten content are required for all ingredients and must be on file at the plant. The facility's HACCP plan must show the integration of the gluten-restrictive policy and procedures, with the appropriate control documentation. All shipments received and refused should be documented. Sensitive raw materials need to be assayed for gluten content before receipt into the plant. Additional routine testing of all ingredients is recommended to verify supplier performance and compliance.

Used equipment requires special precautions. To fully clean food-contact surfaces in used equipment, it is necessary to tear down and remove key components of each machine. Special attention must be paid to drive belts, bearings, machine guards and housings, and other enclosed areas in which potentially contaminated dusts may accumulate. Food-contact surfaces must be fully cleaned with an acid soap, rinsed, and sanitized with a method appropriate for the removal of microbial contaminants. As in any food-processing operation, routine inspection, washing, and sanitizing of food-contact surfaces is necessary.

Do not overlook non-food-contact areas of used machines. The interiors of control panels, undersides, and bottom areas also may harbor dust residues that may be released into the plant environment during servicing. If left unchecked, any gluten-containing contaminants so released have the potential to compromise the gluten-restrictive program. It is best to fully decontaminate all areas of any used equipment before installation.

There can be no compromises. In the case of CD, there is always a major health risk.

Educating all employees in the company is crucial. All employees must be aware of how harmful the potential contamination of a plant can be. Chances of contamination can be greatly reduced by continuous employee education.

Vigorous testing of raw materials, finished goods, and the plant environment is required, and compliance with specification is essential. Monitoring for good manufacturing practices, along with having an effective HACCP plan in place, further reduces the potential risk of contamination.

This is the basic structure we have used to successfully design and commercialize dozens of food products in national distribution at this time. A holistic approach is the only way to accomplish this task and make safe and wholesome gluten-free alternatives for the CD patient.

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