Baking for the Diabetic

The theme of this issue of Cereal Foods World is Snack and Breakfast Foods. This is what baking is all about. This is what we do—fresh warm muffins, doughnuts, Danishes, cinnamon rolls, cookies, pies, sweet breads, and, a favorite, warm bread just out of the oven. As the son of a baker, this is what I grew up with. Exciting? After listening to a few presentations at various conferences and talking to a few experts in the field on the rise of type 2 diabetes in the U.S. population, it may not be so exciting. Is there some way to mitigate the negative health effects of baked goods?

The incidence of diabetes is growing. The three most prevalent types of diabetes are:

- **Type 1:** The body stops producing insulin altogether; the individual is insulin dependent, requiring injections. This type of diabetes usually manifests itself in younger individuals.
- **Type 2:** Generally, the body becomes desensitized to insulin due to environmental factors related to diet, exercise, body weight, and other factors. This type of diabetes typically occurs later in life, but its occurrence is starting to increase in younger individuals.
- **Gestational:** Occurs only during pregnancy. The body becomes insulin resistant, typically during the later stages of pregnancy.

The American Diabetes Association (ADA) puts the number of diagnosed diabetics in the United States at more than 25 million, and the number of undiagnosed diabetics at approximately 7 million. The ADA estimates the number of individuals in the United States who are prediabetic, primarily type 2, at 79 million—three times the number currently diagnosed with diabetes.

Diabetes is caused by high blood glucose levels resulting from an insufficient or erratic supply of insulin in the body (insulin lowers blood glucose by converting it to glycogen). Blood glucose levels fluctuate based on the number of calories consumed and the level of physical activity. Carbohydrates are the most significant components that cause fluctuations in blood glucose levels because they are readily converted to glucose. Fluctuations in blood glucose can lead to either hyperglycemia (high levels of blood glucose) or hypoglycemia (low blood glucose) if physical activity is high and/or too few calories are consumed. In diabetics, these conditions can manifest themselves in different ways depending on the type of diabetes. Symptoms can range from confusion, unresponsiveness, coma, and death to longer term cardiovascular and neurological issues.

How Do You Have Your Cake and Eat It Too?

What are the signs an individual is prediabetic? Some typical signs include cuts or bruises that heal slowly, tingling in the outer extremities (neuropathy), frequent infections, frequent urination, extreme thirst, tiredness, and irritability. How can you dodge this bullet and still enjoy your cake? Exercise, eating healthy foods, and keeping calorie intake in balance with activity levels can allow you to enjoy that piece of cake. Moderation and balance are the keys: moderate consumption balanced with the appropriate level of activity. Easily said—hard to do, for sure.

We could discuss all the good-for-you ingredients and why they are good for you, such as the antioxidants in fruits and nuts and the complex carbohydrates and micronutrients in whole grains, as well as different fibers from a myriad of sources—some more traditional, like good old roughage, and others more recently recognized through our improved understanding of organic chemistry. However, let’s restrict our discussion to the practical side of baking, to the basics. How do you minimize or replace components with negative health effects such as carbohydrates?

Is the Market There?

“The incidence of diabetes is growing and there is a demand for good baked products for diabetics,” according to Marta L. Busken, M.Ed., MBA, registered dietitian, certified diabetes educator, mother of a type 1 diabetic, and my wife. In the late 1990s “sugar-free” products were a big deal. Then, came the Atkins Diet, and sugar-free went away for the most part and has not returned. With the explosion in the number of diabetics in the United States, the need for sugar-free and reduced-sugar products should grow as well. The challenge is to make these products taste good.

What Do We Have in the Tool Box to Meet This Challenge?

The challenge is to make a baked product that is lower in carbohydrates but that still tastes good. Hopefully, the carbohydrates that remain are low on the glycemic index (GI) scale and taste good. Components are still needed to create a product—if not carbohydrates, then protein, fat, and/or water. To reduce the number of calories, a product must be higher in protein and/or moisture and lower in carbohydrates. To utilize moisture effectively, you must have the option of frozen or refrigerated storage and distribution for items with water activities over 0.680 to negate the possibility of mold. Fat is questionable as a substitute ingredient in that it contributes 9 cal/g versus the 4 cal/g contributed by carbohydrates and protein.
However, fat does not have the immediate impact on blood glucose levels that carbohydrates do. The last qualities, which are probably the most important and most difficult to attain in a product, are taste and affordability.

**Carbohydrate Choices**

Typical baked products contain high amounts of carbohydrates. In this case, we will focus on chemically leavened products. Carbohydrates make up the majority of the two major components used in baked goods: sugar and flour. Sugar provides sweetness, of course, but also tenderness by diluting the flour, which in turn allows the product to expand and gives it a desirable texture. So, what are some ingredients that can be used in place of sugar that would lower the GI rating and number of calories in a product and function like sugar?

Soluble fibers include inulins, polydextrose, maltodextrin, and polyols. There are many different sources of inulins with a variety of chain lengths. The most commonly utilized sources are chicory root and inulin produced using enzymes. Inulins function similarly to sugar in that those with shorter chain lengths (2–6 glucose units) provide some sweetness, and they dissolve similarly to sugar, although they will clump in some mixing scenarios. In baked products, inulins do not seem to produce the same tenderness as sugar. However, they do tend to contribute fewer calories than sugar and have a lower GI rating. Inulins generally help retain moisture in products. Finally, based on my experience, inulins may cause some digestive discomfort.

Polydextrose dissolves readily but does not provide any of the sweetness or tenderness provided by sugar. It is generally considered to contribute zero calories and is fairly economical to use compared with other soluble fibers. Polydextrose also may help retain moisture in products. On the down side, polydextrose seems to interrupt structural components in products, making them more gummy. Based on personal experience, polydextrose causes only slight digestive discomfort. Maltodextrin dissolves well but does not provide much sweetness or tenderness in a product. However, it doesn’t seem to cause as many digestive issues, and it does help retain moisture in products.

Polyols (sugar alcohols), the most common of which are maltitol, sorbitol, and erythritol, function similarly to sugar and provide varying degrees of sweetness. They can be purchased in syrup forms that function similarly to corn syrups. They have lower GI ratings and contribute fewer calories than sugar. Maltitol and sorbitol can cause digestive discomfort when consumed at moderate levels, while erythritol is generally well tolerated. Polyols generally are more expensive than other soluble fibers and can be hard to source.

Insoluble fibers generally cause textural issues such as grittiness in baked products, and they absorb more water, which can throw the rheology of a dough off kilter. However, a small amount of insoluble fiber can be used to help increase the amount of fiber contained in a finished product.

**Flour Alternatives**

Replacing flour in a baked product is a bigger challenge than replacing carbohydrates. Most, if not almost all, substitutes for flour are equal to flour with respect to their carbohydrate content. Using whole grains typically adds a similar amount of carbohydrates; however, some of these carbohydrates are in the form of dietary fiber and will produce a lower GI rating. One alternative to flour is resistant starch, which counts as both a carbohydrate and a dietary fiber and has absorption properties similar to flour. Another method of reducing carbohydrates is to replace the flour with something like resistant starch that provides little structure and then increase the protein content to provide structure. The number of calories may not change much, but the quantity of carbohydrates and the overall GI rating will drop. Unfortunately, product costs are likely go up.

It is a challenge to find proteins that taste good and also absorb water at a level similar to flour. Most have an absorption rate that is too high, which, as with insoluble fibers, can throw the dough rheology off kilter. Proteins can also have undesirable flavors, which can worsen with baking. The most commonly utilized sources of protein are whey, milk, soy, and egg whites.

**Fats and Emulsifiers**

The last major component in a baked product is fat—increase the fat content and you can lower the carbohydrate content. Sugar tenderizes as does fat, thus some of the sugar carbohydrates can be replaced with fat. This increases the number of calories as well as produce costs but typically not as much as protein. There are medium-chain triglyceride (MCT) fats that are lower in calories but significantly higher in cost. Another formulation strategy is to utilize higher levels of fat, lower levels of flour, and higher levels of protein. This results in a net reduction in carbohydrates but an increase in the number of calories.

Emulsifiers such as monoglycerides, propylene glycol of monoesters (PGME), and polyglycerol esters (PGE), to name just a few, can be used to increase product tenderness above what can be achieved using fat alone. There are a myriad of emulsifiers to choose from that have different effects and interactions in products. Application research has just scratched the surface of possible benefits, interactions, and uses of emulsifiers. I believe there is much to learn in this area of food science.

The challenge is to put all the components together and attain a reduced-carbohydrate baked product that tastes as good as those items coming out of the oven with a full measure of carbohydrates. Is it possible? I don’t know, but I believe we can do better. There is also that other route to blood sugar control—moderation, balance, and exercise, so you can have that hot loaf of bread just out of the oven, just not the whole loaf.


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