

## A New Look at Fiber Fortification

By Kimberly J. Decker, Contributing Editor

Our understanding of the chemistry, physics and behavior of fiber has advanced considerably over the years. “Fiber is much more than what you think it is,” says Rajen Mehta, director of fiber applications, SunOpta Ingredients Group, Chelmsford, MA. Far from an impediment to successful product development—a limiting factor to design around—today’s fibers not only promise recognized and marketable health benefits, but function, too.

### Soluble salutations

Chicory root fiber is a label-friendly term for the fructo-oligosaccharide inulin. Extracted from foods like chicory, garlic, onion, agave and Jerusalem artichoke, inulin is something of a grab-bag term for a whole host of fructose polymers, which can range in size from thousands of fructose units down to fewer than a dozen, as is the case with the subgroup of inulin known as oligofructose. It’s easy to work with, inconspicuous in taste and texture, and a nutritional multitasker, with a soluble-fiber content of roughly 90 to 92 grams per 100 grams, according to Mar Nieto, Ph.D., senior principal scientist, TIC Gums, White Marsh, MD.

“Probably 60% to 70% of all the fiber fortification today is around inulin,” says Bill Bonner, senior vice president, R&D and technical sales, 21st Century Grain Processing, Kansas City, MO, whether an inulin syrup, powder or an expanded, crisped piece of inulin.

“The functionality and versatility of low-viscosity soluble fibers such as inulin has been instrumental in continuing to meet consumer demand,” says Wade Schmelzer, principle food scientist, Cargill Health & Nutrition, Minneapolis. “Inulin has also been known in the scientific arena as a prebiotic for many years. Prebiotics are beneficial for digestive health, but this benefit has not been effectively communicated to consumers in the past. This offers manufacturers the potential to differentiate their products from the competition and leverage more than just a fiber claim.”

Isomalto-oligosaccharide (IMO) shares some functionality with fructo-oligosaccharides, particularly its prebiotic effect and low calorie level (1.5 kcal per gram), but it has distinct differences. Inulin is a long-chain polysaccharide and “oligofructane consists of long chains of fructose units, having sweet taste up to 10% compared to that of sucrose/sugar,” explains Bruce Howe, CEO/president, Select Ingredients, San Diego. “However, the short-chain version available in market is FOS, which has 2 to 4 glucose units and sweetness of 30% to 50%. The maximum tolerable use per day is 15 grams. IMO is a short-chain oligosaccharide and oligoglucane, consisting of short chains of glucose units, which are linked through a specific alpha 1-6 linkage, that confer many functional and physiological health properties to the molecule. IMO is about 50% to 60% sweet compared to sucrose. The maximum tolerable use per day is about 45 grams without any adverse effect.”

The level that effectively provides prebiotic advantages is 8 to 10 grams per serving, according to Howe—a level that should not adversely affect finished-product viscosity or moisture. In addition to prebiotic prowess, he notes, IMO increases intestinal mineral absorption and regulates bowel movement to relieve constipation.

Larch arabinogalactan (LAG) fiber is also prebiotic. Bryan Rodriguez, technical marketing & scientific affairs manager, Lonza, Inc., Allendale, NJ, cites evidence showing that the highly branched LAG increases intestinal bifidobacteria and lactobacilli populations, while also contributing to the production of the short-chain fatty acids acetate, propionate and butyrate that help such microflora thrive. As for its formulation benefits, he says, LAG “retains moisture in baked goods and offers improved dough-handling characteristics while providing no insulin or glucose response.” With low viscosity in solution, it minimally affects mouthfeel, and its neutral taste makes it relatively “invisible.” Stability to a wide temperature and pH range leave few applications off limits, and in beverages, “it does not degrade or lose functionality, and will not hydrolyze,” he says “For example, when producing an orange juice, which has a low pH, a high temperature can be introduced to the product during processing.” While other fibers might break down under such conditions, LAG can withstand the pH level and the temperature, he notes.

In 1997, FDA approved a health claim linking an effective daily dose of 3 grams of oat-derived  $\beta$ -glucan (delivered in as many as four 0.75-gram servings) with cardiovascular benefits. Less than a decade later, it amended that authorization to include, as additional eligible sources, whole-grain barley and certain dry-milled barley ingredients. Ever since, processors have developed increasingly more-concentrated barley  $\beta$ -glucan products, like “a high-purity  $\beta$ -glucan” Schmelzer says, which contains 70%  $\beta$ -glucan and is “clinically shown to help lower cholesterol and enable formulators to target heart-health benefits in a wider array of both food and beverage applications than has previously been possible.”

Mehta cites one heart-healthy ingredient that contains more than 25%  $\beta$ -glucan. What sets it apart, he says—in addition to using high- $\beta$ -glucan barley varieties—is that, unlike most  $\beta$ -glucan sources, whose gumminess makes them difficult to handle in baked goods, this product uses a special fractionation technique to yield something more like a barley flour rather than a concentrated, viscous, soluble fiber. It does not grab water very rapidly or tenaciously and can be used at higher effective doses.

### All in the balance

“Soluble fibers differ in their health benefits, with some better as prebiotics than others, and others better for lowering cholesterol, slowing digestion and promoting satiety, slowing the absorption of blood glucose for diabetics, and so on,” says Nieto. Hitting upon the right balance, he says, lies in the blending. “Since many of these fibers are thick, their dose in the product is limited, and this problem is overcome by blending the right amount to enable higher usage and achieve a functional dose.” For example, his company blends fibers suitable for various health claims and applications, “such as fiber blends as prebiotics for digestive health, blends for lowering cholesterol, for satiety control, for slowing glucose absorption for diabetics, and for dysphasia diets.”

The easy functionality of some soluble fibers can make it all too tempting just “to put in a soluble fiber and be done with it, versus giving something that is a little more balanced,” Mehta says, such as balancing soluble and insoluble fibers.

Nieto notes that the *Code of Federal Regulations* recommends a 75:25 insoluble-to-soluble split. “That means that if our target is 25 grams of fiber per day,” he says, “18.75 grams should be insoluble and 6.25 grams soluble.”

Mehta also notes that other considerations—like respective soluble and insoluble health benefits, and the gastrointestinal distress that can come from too much of the former—argue in favor of pushing insoluble levels, too.

### Function follows form

“The oat material—and, similarly, other cellulosic kinds of material—has a combination of three different fiber constituents: cellulose, hemicellulose and lignin,” says Mehta. “What we do in our processing is remove different ratios of hemicellulose and lignin, and, as we do, the proportion of cellulose goes up, thereby increasing fiber porosity and flexibility.

“Essentially, the backbone remains unchanged—even in retorting, the strength isn’t changed at all,” continues Mehta. “The analogy I like to use is that, in the old days, a skyscraper was 15 stories. With more-sophisticated flexible steels that have strength, they can now go to 100 stories and more, and it’s the same with fibers.” These flexible fibers allow product developers to add strength to chips, crackers and breakfast cereals. “And that reduces the breakage and cracking in a wide range of applications,” he says.

Of course, there are limits to how much strength even these fibers can add. “For almost any material in which we’re trying to reduce breakage, we’re trying to increase both strength and flexibility by about 20%,” Mehta says. “Why not go further? Because then you start to have textural side effects.” For example, in increasing a taco shell’s flexibility by more than 20%, these strong-yet-flexible fibers might actually end up softening it.

At the other end of the spectrum, oat fibers with a higher ratio of lignin and hemicellulose add crispness to cereals and pizza crusts. “We have a lot of success in bakery products, taco shells and crackers—anything like that where you want crispness,” Mehta says. They even increased bowl life in a toasted-O cereal by two minutes, maintaining a crisp texture with higher-lignin fiber. Fibers on the flexible, porous end boosted bowl life, too, while adding crunch.

Incorporating insoluble fibers into taco shells and breakfast cereals is only obvious. But where functional insoluble fibers really stand out is in beverages—precisely because they don’t stand out. True, seamlessly fortifying beverages may be the toughest application for insoluble fiber to pull off. Soluble seems to be the choice here, Mehta says, “because it’s very easy to do—it just dissolves in.” But the challenge of insoluble is by no means insurmountable. “You just have to think through rationally and figure out a solution,” he says. Oat fibers with a small particle size and with cellulose-to-hemicelluloses/lignin ratios in the middle of the range have proven suitable at 2.2% use levels in all

types of beverages, even relatively clear sports drinks. He advises suspending these fibers with gellan gum at 0.01% to 0.03% levels.

### True to tradition

Ask Bonner which applications he thinks carry fiber best, and he'll be the first to admit: "Classic grain-based foods work best for fiber applications. Fiber supplementation is synergistic with whole grains and makes the whole delivery system credible." Furthermore, he says, "coated grains and clusters for hot and RTE cereals, baked goods, snacks, cereal bars, dairy toppings, granola bars, and so on are whole-grain-based ingredients that easily take this dynamic to the next level."

It's sort of like adding fiber on top of fiber, says Bonner. "You've got the two components: the dry material and the wet syrup that you're going to apply to it," he says.

As for the wet ingredients, they run to liquid sugars and corn sweeteners, but can also include soluble fibers. "Something else you can use in there is a resistant starch, where you're pulling in that particular fiber," says Bonner.

These fiber-enhanced grains and clusters make a noticeable difference in cereal bars. "The expanded, crisp, fiber-enhanced ingredients all add significant improvements centered on texture," Bonner says. Before the pieces became standard additions, "cereal bars didn't work well, as they compressed and that exacerbated the textural limitations of the product. Improvement in this application comes with the inclusion of expanded pieces to soften and aerate a bar, and these pieces themselves can now be formulated with significant levels of fiber through direct-expansion extrusion. You can make crisps with fiber levels above 50% now. We're at the point now where there are some pretty neat things available to the product developer."

### Choices, choices

All the product developer has to do is choose the right fiber. "Selecting the right fiber will depend on both the product and its manufacturing process," says Schmelzer. "Desired product attributes, such as final viscosity, clarity, solids level, pH and overall flavor profile, can be critical in deciding what fiber to use. Equally important are the targeted level of fiber and the overall serving size of the product."

Gum-derived fibers require water for activation, making a low-water-activity application like a nutrition bar or cereal incompatible. On the other hand, notes Nieto, "when gums are made into syrups for binding, the water activity of this syrup is much higher than the sugar syrups, and its use will alter product texture adversely." To clear that hurdle, a non-aqueous gum arabic and glycerin system both adds fiber and replaces the syrup binder. "Finally, in high-water-activity products, the restriction on the type of fiber depends more on its viscosity," he says, "and in this application, non-viscous gum fibers are preferred to achieve the functional dose."

But even in baked goods—fiber's classic companion—some options just don't work. Nieto notes that the more branched and negatively charged a gum, the more likely it is to disrupt disulfide bonding in a developing gluten structure. Gum acacia at high levels in risen dough contributes particularly to this

reaction, although it appears to cause little problem at normal use levels. Branched gums are also incompatible with whey and soy proteins under typical food pH conditions, he adds, and negatively charged gums, such as sodium alginate or xanthan, are also troublesome at high levels.

### Level with me

Fortunately, “high” levels aren’t necessary to achieve effective doses in most applications. “It’s easy to achieve a functional dose to claim an ‘excellent source’ of fiber per serving—up to around 6 grams per serving—with a non-viscous fiber such as gum arabic, inulin, larch, hydrolyzed guar gum and others,” says Nieto. When your gum choice is on the thicker side, he counsels blending it with thinner options to achieve a respectable dose.

It’s a struggle to get more than 5 grams of total dietary fiber into a serving with a single-source ingredient, notes Mehta. But, with a multi-fiber blend, you can top 9 grams per serving without surrendering mouthfeel or taste. “And you get the same texture effect, the same processing effect,” he adds. “Going to similar levels with a single fiber runs into issues of processing: Your dough doesn’t mix as well, you have to add too much water, and in beverages it doesn’t work at all because it’s either too grainy or without adequate body and texture if only one fiber type is used.”

So, blends may be the next frontier on the fiber-fortification horizon. “The challenge now is to push the frontiers,” says Mehta. “Currently, with the technology we have, you can get 50% of your daily serving of fiber in a 50-gram serving of bread. The challenge is how can you get to 100% per serving? How do you push the frontiers where you can go higher in fortification while maintaining, or even improving, the taste?”

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