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An Exclusive Digital-Only Issue

Functional Foods

Inside:

- Ensuring Efficacy
- Healthy Energy
- The Cereal Nutrition Re-Evolution
- Omega-3: A World of Possibilities

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Formula for Healthy Product Sales

LYNN A. KUNTZ

The functional foods and beverage category offers much market potential for manufacturers, but at the same time is fraught with pitfalls from both a technical and a marketing standpoint. As it is with so many products on the market, it takes expertise and authoritative information to break through the barriers and develop a successful product.

A recent IRI Consulting executive briefing, "What's in Store for Health & Wellness," highlights the complexity of the marketing issues surrounding these products. The report notes that, while sales of some products with individual health-and-wellness claims have dropped off recently, products touting "a holistic approach that advances general health and well-being are gaining market traction." The report says that six of the top 20 health-and-wellness products did achieve a sales growth rate higher than the food and beverage industry average of 3.4% in 2009 to 2012. However, only three kept pace in 2012, indicating a significant slowdown. One of the segments cited for a slowdown was "natural," particularly natural sweeteners. (While I'd be the first to argue that "natural" does not a functional, or even healthy, food make, as they say "perception is reality.")

To reverse this trend, "it is critical that manufacturers of health-and-wellness products peg their value proposition to comprehensive health and well-being, an umbrella that covers multiple attributes like natural, low calories per serving and organic," says Krishnakumar (KK) Davey, Ph.D., managing director, IRI Consulting. "Products with 'one-off' claims are much less likely to succeed. CPG marketers must focus on several factors that impact health and wellness to achieve long-term, sustainable success."

According to IRI, these factors include a focus on demographic cohorts, message clarity, communication of general "well-being" versus a single specialized claim, competitive pricing, innovation and an awareness of regional trends.

However, while marketing can make or break a new product, it shouldn't overshadow the role of product development. The technical demands of a functional food greatly surpass those of a product that exists merely to feed hunger or follow a trend. After marketers identify the target market, product designers need to identify the ingredient(s) that address the appropriate health concern, research their physiological effects and efficacy, investigate their safety, ensure the efficacy remains after processing and throughout shelf life, and address any regulatory issues. Oh, and did I mention they have to make sure the end product tastes good, too?

The hurdles are many: Much conflicting information exists, even on well-researched ingredients like omega-3s and vitamins, and it's subject to change as more research occurs. (Remember beta-carotene, smokers and cancer?) What seems fairly innocuous in small quantities might not be so benign as consumers overindulge. (Cue the current caffeine controversy.) And, as the base product becomes more healthy, does it still lure people to buy the new, improved version, or do they still need a spoonful of sugar to make the medicine, or rather functional food or beverage, go down?

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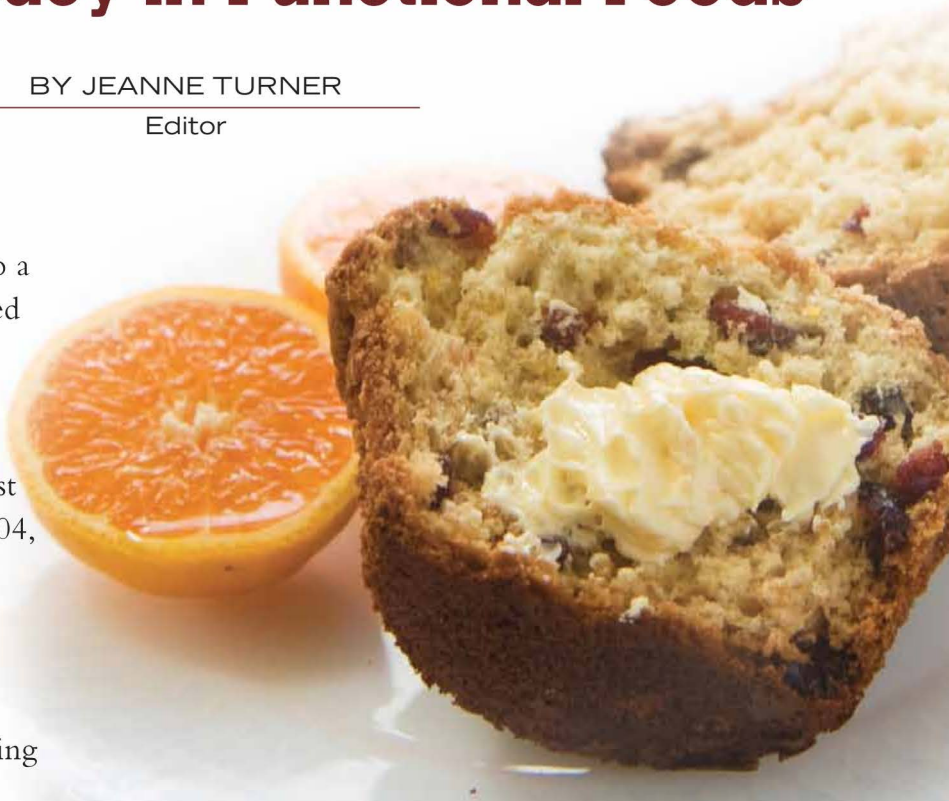
EDITORS' REVIEW

- The power of anthocyanins and tackling the issues of stabilization.
- What level of probiotic ensures efficacy in a product, and is this strain specific?
- Identifying ingredients that help promote health benefits consumers look for in foods and beverages.

Ensuring Efficacy in Functional Foods

BY JEANNE TURNER
Editor



Improper nutrition or, in some cases, an excess of nutrition, is cause for global concern due to a number of chronic conditions linked to dietary factors. Although the documentary "Super Size Me," depicting the health perils of consuming a poor diet fueled by fast food, was released in the U.S. in 2004, many consumers clearly haven't heeded its message. We continue to "super size" ourselves and neglect nutrients critical for good health.

Functional foods, or foods targeting health and wellness, present one possible solution to help combat growing disease perils or to help improve or sustain body functions. Euromonitor International, Chicago, estimates global health-and-wellness sales to hit U.S. $1 trillion by 2017. Overall, Packaged Facts, Rockville, MD, estimates that North America accounts for roughly 40% of new targeted health-and-wellness food and beverage stock-keeping units (SKUs) being introduced into the global market. In terms of product positioning, immunity, women's health, diabetes, heart/circulatory health and cholesterol each account for more than one-tenth of these new SKUs being introduced.

The medical and scientific community, including the Institute of Food Technologists in an expert report, define functional foods as "foods and food components that provide a health benefit beyond basic nutrition (for the intended population). Examples may include conventional foods; fortified, enriched or enhanced foods; and dietary supplements." Moving from definition to market, however, is a lengthy process.

Key steps

In a 2009 article in *The Soy Connection*, "Increasing Health Concerns Drive Food Science, Nutrition Interaction," Connie Weaver, Ph.D., distinguished professor

and department head, Department of Nutrition Science, Purdue University, West Lafayette, IN, lists the main considerations when developing a functional food or beverage. First, she emphasizes functional-food development requires cooperation between food scientists, nutritionists and health professionals to a level or degree that regular food formulation does not demand. These professionals need to be involved in the process at all stages.

> Functional-food development requires cooperation between food scientists, nutritionists and health professionals to a level or degree that regular food formulation does not demand.

Five primary considerations, according to Weaver, include: proper selection of the bioactive components and the food matrix; determining optimal processing and storage conditions; assessing and quantifying bioavailability (amount of ingested bioactive available at site of action) and bioaccessibility (amount of ingested bioactive available for absorption after digestion); confirmation of health benefits; and, finally, food safety. The methods for determining many of these factors are often similar to pharmaceutical research.

Plays well with others

Other researchers echo Weaver's emphasis that functional foods demand cooperation between food scientists, nutritionists and medical professionals.

Mary Ann Lila, Ph.D., director of the Plants for Human Health Institute, Department of Food, Bioprocessing and Nutrition Sciences, North Carolina State University (NCSU), Kannapolis, NC, says that, in this instance, "Clinical trials are critical. They're the gold standard. Testimonies are great, but you need to show it quantitatively."

Lila says a disconnect has existed between the functional food and medical community for years. "Doctors don't even have to take a nutrition course to get a medical degree," she says. "When we can demonstrate conclusively how a functional food component behaves, with clinical evidence, doctors realize this isn't just folklore."

And convincing doctors of a product's health benefits is important to consumers. That Packaged Facts survey indicated one-quarter of shoppers say a recommendation by a health professional is an important factor when buying grocery products targeting a specific health concern.

Plant-based benefits

Part of the reason for this disconnect could be that folklore can play a role when guiding researchers or companies to look to certain plants or fruits to source bioactive components. Their task is to scientifically establish physiological benefits in a situation with empirical evidence and/or a rich folkloric history.

P.L. Thomas, Morristown, NJ, for example, introduced an extract in 2012 based on a the South African herb *Sceletium tortuosum*. This self-affirmed GRAS ingredient claims calming or relaxation properties and enhances cognitive function.

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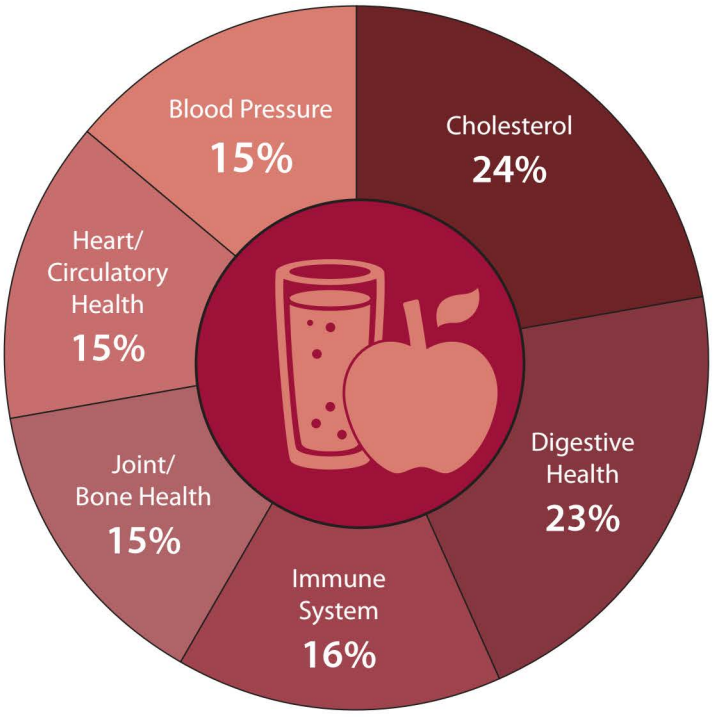
Shopping for Health

According to a March 2012 Packaged Facts report, "Targeted Health and Wellness Foods," nearly two-thirds (63%) of U.S. grocery shoppers have purchased a food or beverage in the past year to address one or more of 22 common health-and-wellness concerns, including:



"We knew from anecdotes and papers dating back to the 1700s this plant was used for children who were teething or for other calming situations," says Rodger Jonas, director of national sales, P.L. Thomas. "But, realistically, it was never studied clinically; it was always passed on by word of mouth.

"We had to run multiple clinical trials," continues Jonas, citing a recent unpublished trial conducted by researchers from the University of Western Ontario, London, Ontario, Canada, testing whether a 25 mg daily dose of this ingredient enhanced cognition in healthy, non-depressed individuals.

"It produces an effect we call 'alert serenity,'" says Jonas. "People who take it describe its effect as taking out white noise. And we believe you may be able to, based on your specific formula, reduce some of the caffeine used in products due to the impact of the ingredient."

Fruitful research

Another empirical tale concerns the beneficial effects of cranberry juice on urinary tract infections. One group studying cranberries and the entire genus *vaccinium,* including blueberries, cranberries, huckleberries and lingonberries, is Lila's research team at NCSU. "This genus grouping is powerful because it has the anthocyanin pigments, but also has proanthocyanins," she says. "The reason why they can prevent urinary tract infections is because proanthocyanins are anti-infective."

However, there are 20 different anthocyanins in a blueberry alone, each with its own unique potential. This quantity and variety of anthocyanins makes fruit a tricky

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research subject. In addition, fruits and vegetables are living organisms and subject to a host of factors outside of lab conditions that can make them difficult to standardize.

Take blueberries, for example, one fruit the team is studying. "We can find differences in biological efficiencies in a food you eat from a plant, such as the variety of blueberry or the environment the blueberry grew in this year," she says. "It is a difficult thing to quantify, but we're getting there with extremely sophisticated expertise and technology, using bioinformatics. It quantifies the biological effects from foods you eat that impact human health."

And, Lila says, unlike a drug, which has one new chemical entity that a researcher can follow on a high throughput screen, "fruits (or vegetables) exert health benefits through the interaction of multiple phytoactive compounds that coexist in the food. Several chemicals together can act synergistically to bolster human health. Or, the phytochemicals may actually interfere with each other." In terms of bioactive possibilities in fruits and vegetables, "we have only scratched the surface," she says.

Despite these obstacles, however, Lila says, "We have absolutely established efficacy in vitro, in vivo and clinically.

"Anthocyanins dramatically reduce blood glucose levels after six hours post ingestion, for example," Lila continues. "They can protect against neurodegeneration, according to both in vitro and animal bioassays. But the levels (of anthocyanin inclusion) are different depending on the health condition being addressed.

"Levels of efficacy have been established for diabetes, for cardiovascular disease, for neurodegeneration, for metabolic syndrome, for satiety," Lila says. "Levels have not been that well established for prevention of cancer—that is a tough one to quantify. For most situations, we recommend the equivalent of 'one to two servings of anthocyanin-rich fruit or vegetable'—that usually falls in the efficacious range. But of course there is variation, depending on the disease condition under survey."

Supplements are another matter. Lila says it is difficult to assess the level of anthocyanins in most supplements or whether those anthocyanins retained their efficacy. "Another trouble is it isn't well-regulated, so we have people getting away with selling products that don't do anything."

Fruits and vegetables are living organisms and subject to a host of factors outside of lab conditions that can make them difficult to standardize.

As a first step, her team worked to find a way to stabilize these flavonoids so they can be used in a functional food product without degradation. At issue is the processing used to spray-dry these components to use as ingredients. She says current methods "obliviate the anthocyanin pigments."

Lila's team created a method to bind the anthocyanins to an edible protein matrix that doesn't use heating or drying. "We can capture the bioactive principals from fruits and

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The American Dietary Guidelines 2010 state "Choose foods that provide more potassium, dietary fiber, calcium, and vitamin D, which are nutrients of concern in American diets." And since 75 percent of U.S. adults do not meet the Daily Reference Value for dietary fiber, the demand for beverages that are an "excellent source of fiber" will continue to increase.

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vegetables and keep them stable for over a year in a dry form," she says. The process is currently being commercialized.

As far as this functional ingredient process, "We indeed have extensive tests (and five publications) in animal models and one very successful clinical trial now in review. We have very conclusively established superior efficacy in the protein matrix as compared to ingestion of the bioactive plant extract in free form," Lila says.

As an example, in one study, Lila finished a clinical trial with high-performance athletes testing a supplement of blueberry and green tea, sorbed onto the protein, to determine its bioavailability and activity. After supplementing the diet of these athletes for 17 days, and then having the athletes perform exhaustive exercises, her team detected a "very good flavonoid signature in the athletes, so it was bioavailable even bound to the protein." The result of this blueberry/green tea supplement was to increase fat burning. The study is in final review for future journal publication.

The process Lila is commercializing uses edible protein matrices (powders—like a defatted protein-rich flour or protein isolate) to sorb phytoactives (like bioactive flavonoids and/or anthocyanin pigments). This process uses no heat or very little heat (the latter only in drying it down). "It takes advantage of the natural binding affinity of a medium polarity phytoactive molecule to proteins," says Lila.

The phytoactives (which normally would degrade or become inactivated over time, such as when the fruit source rots) are protected and stabilized in the edible protein matrix. The protein matrix (which acts as the sponge) is preroasted. "Therefore, this ingredient can easily be used in a bar, smoothie, crisp, etc., with minimal 'cooking,' if any," Lila says.

The value of stabilizing bioactive components locked within fruits and vegetables extends beyond the consumer seeking a casual snack in the afternoon. Certain groups have trouble carrying or keeping fresh fruit viable for long periods of time, such as the military. "You can't put apples in an army ration pack, but you can put its benefits into a power bar and provide immune-protective bioactives to our combat troops," says Lila.

Plants for heart health

While anthocyanins might be tricky to quantify, plant sterols, commercially sourced from soy and sunflower crops, do have established standards and a proven health claim to combat heart disease.

Carol Lowry, senior food scientist, Cargill, Wayzata, MN, says plant sterols constitute an exciting discovery in the fight against heart

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disease. However, "I feel there is a low awareness of this particular nutritional ingredient," she says.

Including 0.4 or 0.5 grams sterols in orange juice can help block cholesterol from entering the blood stream. The sterol is blended into the orange juice and results in a suspension of the sterol in the juice, however, the beverage would need to be shaken before consuming, according to Lowry. She explains: "Plant sterols possess a molecular structure similar to cholesterol, but there is a 'tail' on the end of the molecule that makes it different, and different forms of sterols have different tails on a molecular level."

For the most part, the major vegetable oils contain three main sterols. "The difference between sources is reflected in the ratios of these three sterols, which are unique to each oil," says Steve O'Brien, product manager, ADM Natural Health & Nutrition, Decatur, IL. However, "with respect to their cholesterol-lowering properties, many studies have shown that the effect is the same, regardless of the ratio of sterols, because as a group these major sterols are all similar in structure to cholesterol itself," he says.

In the large intestine, when a person ingests foods containing cholesterol, the cholesterol molecules will go to receptor sites in the large intestine, latch onto a receptor and pass through it into the bloodstream. "A plant sterol is like a key that fits into a lock, but when the plant sterol attaches to the receptor site, the tail of the sterol differs from the cholesterol so the key doesn't turn," says Lowry. "It doesn't enter the bloodstream and blocks the cholesterol from entering, as well."

Other health effects of sterols have not been studied as much as their cholesterol-lowering properties; however, "some studies have shown beta-sitosterol, the predominant form in soy, is beneficial for prostate health," says O'Brien, citing a review published online in *Clinical Evidence.*

The plant sterol doesn't remain attached to the receptor site permanently, so consumers are advised to ingest foods containing plant sterols up to three times per day at different times to maximize the cholesterol-lowering benefits.

Consumers are advised to ingest foods containing plant sterols up to three times per day at different times to maximize the cholesterol-lowering benefits.

This shouldn't prove a challenge as sterols have moved beyond their initial introduction in the late 1990s in spreads and margarines to incorporate a wide swath of FDA GRAS-approved categories. According to O'Brien, ADM has 19 approved categories for its portfolio of sterol ingredients. In terms of incorporation, he says that, due to the nature of the ingredient, low-fat, no-fat foods and beverages provide the biggest challenge, while incorporating sterols into baked goods, he says, is rather simple.

Free sterols are "extremely stable," says O'Brien. "In products that incorporate them, such as breakfast bars or cereals, there is no decrease in shelf life (of the sterol). Sterol esters are less stable due to the ester part and, depending on the product, could cause a reduction in shelf life."

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Tiny bugs, big impact

Formerly found only in the chilled confines of the dairy case, probiotics have expanded their repertoire into, of all things, hot beverages when Ganeden Biotech, Cleveland, OH, released a probiotic based on *Bacillus coagulans*, a spore-former that is better able to withstand environmental stress than other types, such as *bifidobacteria*. According to MaryEllen Sanders, Ph.D., consultant with Dairy and Food Culture Technologies, Centennial, CO, "When a spore-former is exposed to stress, it creates a resistant kernel inside the cell that allows it to survive."

Although we're witnessing the expansion of probiotic use well beyond the dairy case, different probiotics, according to Sanders "have different quantities of information known about them." In addition, each genus or species of probiotic may perform a different function, ranging from gut responsiveness to immune functions. The evidence of efficacy, she says, depends on the strain. "Over the past 10 or 15 years there have been a lot more controlled human studies performed to determine probiotic efficacy," she says.

However, these studies are not yet sufficient to convince some food authorities to authorize claims. "In Europe, all claims on foods have to be approved," says Sanders. "There is not a single probiotic claim that has been accepted by European authorities. They have imposed a high benchmark for evidence and very restricted scope for claims on foods."

And when the rule of "perform a clinical trial" is cited in terms of proving efficacy of functional foods, some clinical trials are worth more than others. According to Sanders, if a group performs studies on people with special diseases, such as ulcerative colitis or infectious diarrhea, "the regulators will throw all those studies out. Your claims have to be associated with the healthy population."

Ingredient interactions are a concern in terms of efficacy, as well. "The reality of food production is that change is common," says Sanders. "If you're a yogurt company and you've invested $2 million to have your yogurt tested with a probiotic shown to enhance immune function, when you decide to switch to a nonnutritive sweetener or introduce mango flavor instead of vanilla, you shouldn't have to pay to do it all over again. But we need a scientific approach to determining what changes in processing or food format would trigger the need for new clinical trials."

Then, in human terms, our digestive systems are going to vary from one person to another. "You and I are extremely different in terms of the microbes we harbor," says Sanders. "And these differences from one person to another may very well be greater than the differences between mango and strawberry, or even the same probiotic delivered in yogurt versus cereal."

Somewhere along the line, Sanders says, with the expense of running these tests, we have to bring some reason into the mix. Science is still "grappling" with the differences individuals bring to bear on ingredients and efficacy in our personal response to functional foods, she says.

"The bottom line is we do know that microbes are important to health," Sanders says. "The big question becomes, how can you

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manipulate our resident microbes to achieve a greater state of health?" Microbiome research is moving fast and furious right now, she says, and researchers have discovered important roles for microbes in an array of health parameters, including brain and immune functions, skin disorders, allergies, and even obesity and metabolic syndrome. "We are on the cusp of a greater understanding of microbes and health," she says.

Peggy Steele, global business director, DuPont Nutrition and Health, Madison, WI, says regulatory standards for incorporating probiotics (or any other functional ingredient) into food, beverages and dietary supplements has become a key point of discussion and controversy in recent years. "There is a strong indication that the word 'probiotic' implies a health benefit to consumers. And so the issue becomes one of misleading consumers when a product is marketed with 'probiotic' on the label yet does not contain levels or types of probiotics that would be considered efficacious."

"In a 100-gram serving of yogurt, a 10^7 dose of probiotic—or one billion dose—is most efficacious," she says. "But what really matters is what has been proven to deliver a health benefit through well-designed clinical trials."

The amount of inclusion necessary for efficacy will differ per strain. "*Bifidobacterium lactis* (genus and species) is a very common probiotic you will find in the consumer product market. An example is Activia® yogurt," says Steele. "Yet different strains of *Bifidobacterium lactis* can be shown to have different potential to affect health. For example, at DuPont we have one strain of *Bifidobacterium lactis* shown to have a tremendous benefit in improving regularity, sometimes called colonic transit time, while we have another strain shown to have important benefits in reducing the incidence of cold and flu. Very different results for probiotics with the same genus and species. This reinforces the importance of health benefits being bound to strain and dose," says Steele.

The first criteria used in the selection of a probiotic is to screen the strains for acid and bile tolerance to make sure the strains can survive to the intestinal tract. Then the next step is clinical studies showing the strain can be found in feces following consumption. At DuPont, all of the probiotics sold in the range have been shown to survive GI passage. "I believe clinical proof helps us to build credibility with customers and will be important to the long-term success of probiotics," says Steele.

The United States has seen tremendous growth in the last five years for probiotics. The International Food Information Council (IFIC) released survey results in 2011 indicating 81% of respondents were aware probiotics may be beneficial for the digestive system. "Five years ago, that level of recognition was less than 30%," according to this same survey.

And, in another five years, we might see a new spate of functional ingredients that are currently winding their way through the FDA approval pipeline. "Overnight success is accounted in years," Jonas says. P.L. Thomas assisted Ganeden Biotech with its probiotic introduction. It took more than two and a half years to gain approval after initial contact with FDA and after conducting rigorous clinical trials. "That's quick in my book," he says.

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EDITORS' REVIEW

- The pros and cons of the ingredients used in the current crop of energy products on the retail market.
- Taking a different approach to boosting physical and mental energy with new ingredients and a new perspective on what energy means.
- Exploring low-calorie, low-glycemic alternatives to traditional sweeteners that bring a heavy caloric load to many energy products.

Healthy Energy

BY TERESA ESQUIVEL

Managing Editor

It's safe to say that causing harm, or worse, is not the intent of any food or beverage manufacturer. But when a string of deaths and health incidents are linked to a particular category, it may be time to take a different approach. Such is the case with energy products.

"Historically, the goal of the energy market has been to achieve that instant rush," says Wade Schmelzer, sweeteners principal food scientist, Cargill, Inc., Minneapolis. "Obviously, there has been continued press and pressure on some of these types of products, but they still have a strong following in the market, so we need to look at the evolution of that market. Is there a next generation that brings a different story to the world of energy?"

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Energy drinks, in particular, have taken the biggest hit; by the end of 2012, they had been linked to more than 15 deaths in the United States and Canada. With the eyes of regulatory bodies and consumers trained hard on these products, the entire category has, in turn, been called into question. Close on the heels of Wrigley's launch of a caffeinated energy gum, for example, FDA released a statement saying the agency was going to take a "fresh look" at the impact of added caffeine on children and adolescents.

"The only time that FDA explicitly approved the added use of caffeine in a food was for cola and that was in the 1950s," Michael Taylor, FDA deputy commissioner for foods and veterinary medicine, said in the statement. "Today, the environment has changed. Children and adolescents may be exposed to caffeine beyond those foods in which caffeine is naturally found and beyond anything the FDA envisioned when it made the determination regarding caffeine in cola." In the wake of the announcement, Wrigley "paused" production, sales and marketing of the gum just weeks after its launch.

In addition to beverages and chewing gum, added caffeine can be found in a range of food products, including bars, trail mixes, potato chips, ice cream and candy.

"Most energy products out there rely on some sort of stimulant, whether that be caffeine, whether that be guarana, even sugar can act as a stimulant," says Tom Vonderbrink, president, Bioenergy Life Science, Inc., Ham Lake, MN. "Everybody relies on stimulants. You can feel them. You drink a cup of coffee, you drink an energy drink and you can feel the difference; you're awake you're more alert. Overall, stimulants are good if used correctly."

Consumers seem to think so, too. Mintel, Chicago, estimates market sales of energy drinks and energy shots at $8.1 billion for 2011 ("Energy Drinks and Energy Shots - U.S. - June 2012"), and selling cup after cup of joe brought Starbucks more than $3 billion in revenue in 2012.

Those are numbers any business would find hard to ignore. They show that consumers are looking to energy products in general, and caffeine in particular, to help them attain the energy they need.

The only time that FDA explicitly approved the added use of caffeine in a food was for cola and that was in the 1950s.

What kind of energy that is depends on the person. The energy needs of an athlete, for example, are not the same as those of, say, a food scientist.

"Energy means different things to different people," says Barbara Davis, Ph.D., R.D., director, medical and scientific affairs, P.L. Thomas, Morristown, NJ. "Some may be looking for more physical energy while others want increased mental energy."

According to a 2013 report, "National Study of Public Attitudes and Actions Toward Shopping and Eating," from HealthFocus International, St. Petersburg, FL, consumers are looking for long-lasting physical energy (37%), as well as mental energy (29%).

"People are looking to food and beverages to provide that energy, which accounts for the proliferation of energy products," Davis says.

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Current crop

Looking toward a new generation of energy products first requires a look at the current crop of products to determine what's so wrong, if anything, with their ingredient makeup.

"The three ingredients that are most common across most energy products—and this isn't a universal definition—are taurine, glucuronolactone and caffeine," says Rob Paul, Ph.D., a clinical neuropsychologist and founder of Nawgan, St. Louis. "Then different brands add various mixtures of ingredients to differentiate themselves from a labeling perspective, but in reality those three make up the trifecta of energy ingredients."

Products might, for example, include caffeine from guarana, yerba mate or green tea, perhaps some B vitamins, ginseng or ginkgo biloba, and certainly a sweetener.

As for the energy trifecta Paul describes, caffeine is not necessarily the culprit it's made out to be.

"Caffeine is an easy target," he says. "People know what it is and so it's easier to create a dramatic story about it, particularly when it's so ubiquitous. From the science perspective, caffeine is not a problem child. High doses of caffeine can, of course, create insomnia and anxiety symptoms that disrupt sleep architecture, so high doses are not healthy, but reasonable doses of caffeine have actually shown to be quite healthy, particularly for the brain."

There is nothing inherently unhealthy about caffeine, "but when you start putting excess amounts in shots and energy drinks, you may run into problems, especially if someone

consumes multiple energy products in a day," Davis says. "It's all a matter of moderation."

An 8-oz. cup of brewed coffee contains 95 to 200 mg of caffeine, according to Mayo Clinic, Rochester, MN. Caffeine levels in a 12-oz. serving of cola average 30 to 40 mg. By comparison, an 8-oz. energy drink typically contains around 80 mg caffeine, while 2-oz. energy shots can pack in anywhere from 100 to 200 mg of caffeine, or more.

"Different government agencies have been working through definitions of 400 mg per day consumption as being kind of a cut off," Paul says. "But the science literature, which is separate from government regulations, is comfortable with up to 1 gram in most individuals who are not sensitive, who are adults and who are not pregnant or nursing." While the amount of caffeine does matter from a health perspective, Davis notes that its source is less of a factor. "Caffeine as a molecule is going to be the same from any source," she says. "Like with guarana, it's often said it's a 'natural' source of caffeine, when in

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fact the molecule caffeine, the chemical, is going to do the same thing once it gets into the body, regardless of its source."

Caffeine derived from the seeds of guarana, *Paullinia cupana,* a South American plant, is increasingly common in energy products. The seeds contain 2.5% to 7.0% caffeine, compared to 1% to 2% in coffee beans, and 0.5% to 0.8% in yerba mate.

> The next generation of energy products might rely less heavily on stimulants.

Green tea also supplies caffeine, but offers an added benefit of epigallocatechin-3-gallate, a polyphenol linked to reduced stress, improved heart, mental and dental health, and weight management.

Glucuronolactone is an enzyme that is reported to help clear out toxins in the liver. "The liver can certainly make you feel fatigued if you have liver disease, but that's not the case for most individuals," Paul says. "And there's certainly no data that suggests adding glucuronolactone to any energy product stimulates liver function in any way to actually make people feel more energetic."

While glucuronolactone may be ineffective and even unnecessary in energy products, it does not appear to do harm. As Paul sees it, the ingredient that needs rethinking is taurine.

"The published studies that have looked at the effect of taurine alone, or taurine in combination with caffeine, on physiological systems and cognitive systems show no benefit from the taurine," Paul says. "When you look at where those receptors are for that ingredient, and what one would expect to happen based on inclusion of that ingredient, you really can't find a strong science basis for including it in an energy product." The receptors, he says, are located on the heart, so high consumption of taurine has been shown to disrupt heart rhythms and induce cardiac abnormalities. "There are some safety concerns," he notes. "There is a lack of clarity and no theoretical basis for inclusion of taurine, particularly at high doses."

Another ingredient some experts question as far as dosage is concerned are the B vitamins.

"We need a certain amount of B vitamins to convert food to energy," Davis says. "But going above and beyond the recommended daily requirement for these vitamins won't boost energy. I don't think anybody has ever shown that it will."

Looking ahead

The next generation of energy products might rely less heavily on stimulants.

"Stimulants are beneficial to a lot of people," says Vonderbrink. "The problem is they turn the thermostat up and let you work harder, but you typically end up paying the price after about 5 hours, when you end up with a crash. When you turn the thermostat up like that, you're burning more energy than your body can keep up with, so when you come down off of that, your energy levels are significantly below where you started. It's like pressing on your gas pedal a lot harder. You'll get there faster, but you're going to use a lot more gas getting

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there; that's what stimulants do. I believe if you can use a little bit less stimulant and use some things that help preserve some of those energy stores, you can end up with a much healthier energy product."

Ribose, a 5-carbon carbohydrate, can help slow down energy depletion. Vonderbrink calls it the "backbone" of the adenosine triphosphate molecule, or ATP, where our bodies store energy. "When we use energy, we burn off the bond between the last phosphate group of ATP, energy is released, and we form adenosine diphosphate (ADP)," he explains. "Through the intake of fuel and oxygen, that is cycled back up in the ATP. This happens thousands of times every day." Stimulants can cause what he calls a "demand versus supply mismatch," whereby our demand for energy outpaces our body's ability to supply it. When that happens, we build up extra ADP that is waiting to be re-formed into ATP; it eventually breaks down and washes out of the cell. "Now we have less batteries," he says. "But ribose acts as the rate-limiting step in how quickly we rebuild ATP after it's been depleted. With ribose on board, we can collect those breakdown products before they're pushed out into the circulatory system and drive them back upstream, and it slows down the rate at which are batteries are being drained."

Including ribose in an energy drink allows for the use of less stimulant, as it essentially slows down the inevitable crash and helps our bodies rebuild energy stores more quickly.

Any amount over 250 mg in an energy beverage will have an impact, Vonderbrink says, but 1.5 to 2.0 grams is ideal. It's about half as sweet as sugar and has a pleasant, brown-sugar like flavor. "Ribose will tend to cause mild hypoglycemia," he says. "It will lower blood sugar 5 to 6 points for about 30 minutes. The way to offset that is to mix it in with just a little bit of carbohydrate."

Buzz free

Or how about a new generation of energy products free of stimulants?

"There's really an interest among consumers, and especially with manufacturers, to try to move away from the stimulant-containing energy drink," Davis says. "We're thinking about the energy drink reinvented to provide a mental energy, focus and mood benefit."

Another option that enhances mental energy is citicoline. The ingredient, on which Paul's beverage line is based, supports mitochondrial function by increasing ATP, thereby enhancing and sustaining mental energy. "It's not a stimulant," he says, "but it provides the increase in performance people are looking for." It is self-affirmed GRAS for use at levels of 250 mg per serving.

Another option is an extract from the South African herb *Sceletium tortuosum*. This

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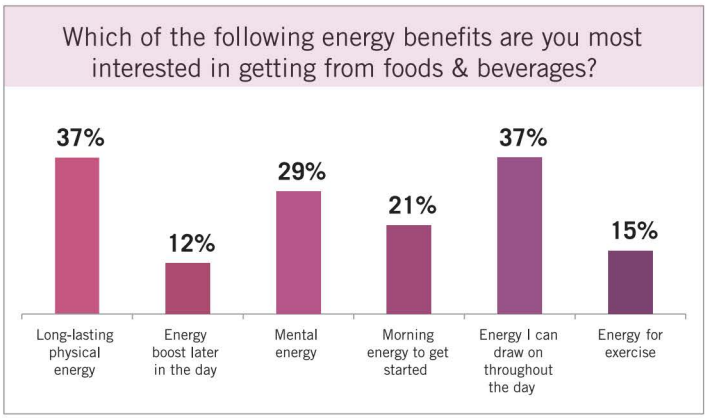

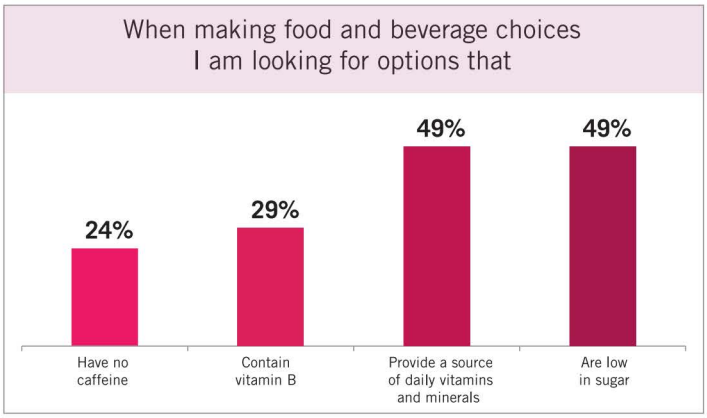

Source: 2013 HealthFocus Trend Report; National Study of Public Attitudes and Actions Toward Shopping and Eating

ingredient is a unique cultivar of *Sceletium* that has been developed into a proprietary, standardized extract by P.L. Thomas. In addition to clinical trials demonstrating reduced stress and improved mental energy and focus at approximately 25 mg per day, there are also "unsolicited reports of positive effects on stress, mood and coping, and enhanced quality of sleep," Davis says. "We think that's part of the energy benefit we're seeing: better sleep, less fatigue during the day. Two additional clinical trials have been submitted for publication showing statistically significant enhancement in cognitive ability and the ability to focus and become less fatigued when working on cognitive tasks in people who are taking our proprietary extract versus those who are on placebo."

Rhodiola Rosea is an adaptogen that also helps the body deal with stress. "It has a lot of benefits not only for energy, but also for physical performance and also mood," Davis says. "Anytime you're enhancing mood and enhancing physical ability, then energy is sort of a given as an end benefit of that." She says most studies use dosages of 300 to 350 mg twice per day.

A different approach

Maybe energy products of the future will be more about overall health and long-term maintenance.

"Our energy comes from the calories we consume every day," says Don Cox, Ph.D., senior vice president, research & development, Biothera Healthcare Group, Eagan, MN. "When you maintain your health, your body can use that energy to support other activities, like sports or work, instead of expending energy to support a run-down system. Then you won't have to take something that's going to give you a temporary boost and then put you right back where you started."

Biothera's yeast beta-glucan, produced from a proprietary strain of baker's yeast, helps support immune health and, therefore, Cox says, helps support energy. "What we've found consistently across a number of our

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published studies is that, generally, people taking yeast beta-glucan have higher feelings of energy, that is physical and mental energy, and lower feelings of fatigue," he says.

The studies not only tracked how overall health was maintained over a 90-day period, but also used a profile of mood states to measured how people felt when taking the product. In one study (*Agro Food Industry Hi-Tech*, 2010; 21:21-24), subjects supplementing with 250 mg per day of the yeast beta-glucan reported 42% increased vigor, 38% reduction in fatigue, 19% reduction in tension and 15% reduction in stress-induced confusion.

"Generally, if you don't feel well, you are lethargic, you don't feel like working, you'd rather be at home sleeping, etc.," Cox says. "If you're healthy, you're raring to go, not feeling run-down and in need of a quick boost of caffeine."

Cox sees the new age of energy products as being energy-maintenance products with ingredients that support immune health, as well as overall physical health, like vitamins, minerals and antioxidants that might be missing from the diet. The ingredient is currently on the retail market as part of an energy/immunity beverage shot.

Sweet effects

"Sugar is also part of the argument of healthy versus unhealthy energy ingredients," Davis says. "Sugar provides calories, and therefore energy, but excess amounts of sugar are going to be a negative because of the extra calories. Again, it's about moderation."

A quick scan of sugar content in energy drinks shows a range from 14 to 62 grams of sugar in 16 fl. ozs. While the ingredient provides part of the "rush" consumers are looking for from energy products, its caloric load can be mighty.

"The energy segment has seen significant growth because you have a different subset of people buying the products," says Schmelzer. "It's skewing younger, and as awareness of calories and sugar intake ramps up, consumers, especially the younger audience, are going to be more and more adept at understanding what they want to have delivered to them in an energy beverage or bar. So you're seeing a lot of pressure to go either low-calorie, reduced-calorie or no-calorie."

> From a beverage perspective, the biggest issue when you pull out the sugar is the texture and mouthfeel.

But removing sugar from a formulation isn't always easy, as it's important for mouthfeel and for offsetting some of the bitterness caffeine, guarana, vitamins and botanical extracts bring to the table.

"From a beverage perspective, the biggest issue when you pull out the sugar is the texture and mouthfeel," says Vince Cavallini, beverage applications manager, Cargill. "Sugar greatly enhances the mouthfeel and gives you a good overall flavor, as well. So, when you take that out and add back some sort of high-intensity sweetener, you may also need to add back some mouthfeel, and you may bring in some off flavors, such as bitterness or lingering sweetness, that need to be managed."

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There is a whole realm of low- or no-calorie, high-potency sweeteners to choose from, Cavallini says, including acesulfame-K and erythritol, and "natural" options, like stevia and honey.

"Honey is composed primarily of carbohydrates (natural sugars) and water, as well as trace enzymes, minerals, vitamins, and amino acids, which provide a natural energy boost without any added ingredients," Catherine Barry, director of marketing, National Honey Board, Firestone, CO. Honey provides 17 grams carbohydrates per tablespoon, she says, which are important for maintaining muscle glycogen, an important fuel source, particularly for athletes.

Replacing sweetness can be accomplished with high-intensity sweeteners like aspartame or stevia; what is not easy to replace is the texture, stability, gloss, stickiness and film-forming attributes.

Sucromalt is a full-calorie sweetener that still holds promise in healthier energy products. It is 70% as sweet as sugar but is low-glycemic, which provides extended energy. "With sucromalt, you're not just looking at whether there are sugars there, but how they are digested," Cavallini says. "How does the body handle them in terms of conversion to energy? With sucromalt, you get more of a sustained energy, not the kind of crash most people associate with sugar."

Reducing sugar in bars can be more challenging. "Sugar in general plays quite a key role, not only to give you sweetness, but also with flavor interactions and texture, and also helps control the water activity," Norris Sun, snacks and cereal principal scientist, Cargill. "High-fructose corn syrup is also effective in controlling the water activity and the moisture."

When those ingredients are removed or reduced in a formulation, Sun says, glycerin can help control water activity. He has also had success with inulin in a fiber system for maintaining texture and flavor profile in bars with 20% to 25% reduced sugar.

Sugar and high-fructose corn syrup also provide "structure for binding, hold and shape in granola bars," says Harold Nicoll, marketing manager, TIC Gums, Belcamp, MD. "Replacing sweetness can be accomplished with high-intensity sweeteners like aspartame or stevia; what is not easy to replace is the texture, stability, gloss, stickiness and film-forming attributes that construct and hold separate ingredients together." A binding syrup composed of a blend of hydrocolloids mimics the texture sweeteners provide at usage levels of 5% to 20%, he says.

"As we continue to look forward in the energy space, we need to ask: Are calories most important; is sugar is most important; is natural most important; or is a clean label most important?" says Schmelzer. "Energy products tend to have longer labels because they have vitamins and minerals, etc., but there is a proliferation of products of all kinds out in the market with small ingredient decks. If those products with limited ingredients start doing significantly better, that changes the market. It changes the game."

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EDITORS' REVIEW

- Why hot and RTE cereal is historically a popular functional food and its current market direction.
- The interwoven role of nutrition and breakfast-cereal processing, with a focus on extrusion.
- Making a heathier base by reducing sugar and increasing whole grains and other whole ingredients.
- Technical considerations for fortifying breakfast cereal with vitamins, minerals, protein, fiber, omega-3s and more.

The Cereal Nutrition Re-Evolution

BY LYNN A. KUNTZ
Executive Editor

In the beginning days of breakfast cereal creation, originators of products such as Granula, Muesli, Corn Flakes and Quaker Oats developed and marketed them as health foods, making them one of the first functional foods. Breakfast foods took a turn off the healthy path in 1939, when a dad designed the first presweetened cereal, Ranger Joe Popped Wheat Honnies, because—ironically—his children put too much sugar on their cereal. This heralded the era of sugary cereals that, while "now fortified with eight essential vitamins!" eventually became one of several categories criticized by public-health watchdogs.

So, given the public outcry, the current roadmap goes back to formulating cereals that put nutrition first, albeit often with a great deal more technical sophistication than those early entries to the market. This can take a number of formulation-based strategies, including reducing less-nutritious ingredients or swapping them out for healthier versions, and supplementation with any number of desirable fortificants.

A word about processing

Because you're not just stuffing nutrients in a capsule, the nutritional content of a finished breakfast cereal is intertwined with the process, particularly for ready-to-eat (RTE) versions. Therefore, product developers need to take the method of manufacture into consideration. Hot cereals are basically mixtures including processed grains for the base; granola style cereals are typically mixtures of grains and other ingredients mixed with binders and dried. But manufacturing RTE cereals encompasses a number of processes that have a greater effect on finished-product nutrients, including flaking, oven and gun puffing, baking, shredding, and expansion through extrusion cooking.

Of these, extrusion, which works with a combination of heat, pressure and shear, is likely to have the greatest overall effect on

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the nutritional profile and finished-product characteristics, like texture. A number of chemical and/or physical changes can occur during extrusion cooking, such as alterations in molecular or physical structure, volatilization, and thermal degradation of heat-sensitive nutrients. Formulation of the base with ingredients like grains, fiber, protein, etc., affect expansion and structure, and therefore texture, palatability and bowl life (the time it takes for the cereal to become soggy after it's drenched in milk). Modifying the extrusion parameters, type of extruder (single-screw or twin-screw) or configuration of the extruder can be just as important as working with the ingredients.

Altering the formula, and therefore the nutritional profile, of breakfast cereal takes no little amount of expertise and experimentation.

For basic formulations, most extruders' operating temperatures range "from about 100 to 110 or 120°C, depending on the formula," says Mian Riaz, Ph.D., head, extrusion technology program, Food Protein Research & Development Center, Texas A&M University, College Station, TX. "Most of the starches will gelatinize at 70 to 80°C, but with lower moisture you need to increase the temperature. As you add other ingredients to your starch base—fiber, protein, etc.—the temperature can go much higher." However, in a short-barrel extruder, the residence time

Breakfast cereal had the highest percentage of all food products with at least one health and nutrition related claim in 2010.

Source: UDSA/ERS

is 15 to 20 seconds. "That is enough time to gelatinize starch and denature the protein," he says. So, while it's not as harsh as a long, high-temperature cook, the final nutritional content, especially of heat-sensitive nutrients, can be degraded.

"I tell my students that cooking at 100°C in an extruder is not the same as cooking at 100°C in a kitchen," says Riaz. The combination of heat, pressure and shear makes it a "continuous pressure cooker," he says.

But it's not just extruded products that are affected. Altering the formula, and therefore the nutritional profile, of breakfast cereal takes no little amount of expertise and experimentation, especially when macro ingredients like protein, fiber and carbohydrates are involved.

Sugar, ah honey, honey

The introduction of sugar-sweetened cereals to please the kiddies' palate created

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a bit of a nutritional monster. After The Environmental Working Group (EWG) released a report on sugars in kids' breakfast cereals, Marion Nestle called them "cookies in disguise," noting they typically consisted of 40% to 50% sugar.

A 2011 article in *The Wall Street Journal* (*WSJ*) noted that General Mills, Inc., has been reformulating its breakfast cereals since 2005 to make them healthier. One aspect is sugar reduction, with a company target of dropping the sugar content in cereals marketed to children to 10 grams or less per serving from levels that reached as high as 15 grams. But there's a reason for the popularity of highly sweetened cereals in the first place. In the *WSJ* article, Susan Crockett, Ph.D., R.D, FADA, vice president and senior technology officer for health and nutrition at General Mills' Bell Institute of Health and Nutrition, was quoted as saying: "We know that right around nine grams of sugar per serving, you're at the breaking point where the sugar level is so low that the sweetness is not enough for a kid to eat it on day two after trying it on day one. We're close to the sweetness threshold in cereal."

That leads to one of two strategies: Lowering the sugar level gradually over time, and relying on stealth health to acclimate sugary-cereal consumers to a lower sugar level. Or, formulators can look at other healthier sweeteners that provide sweet taste and functionality.

A natural sweetener like honey might be better than sucrose, but only marginally, nutritionally speaking. It's still mainly sugar, although approximately 3% to 4% of honey consists of oligosaccharides. Honey has vitamins and minerals not found in standard sugars. However, it's extremely hygroscopic, so unless the goal is a chewy cereal, it may create more problems than it solves.

One sweetener might reduce sugar calories while adding desirable functionality—the sugar alcohol isomalt. BENEO-Palatinit GmbH, Mannheim, Germany, formulated a production-scale run of RTE breakfast-cereal rings with sugar replaced completely or

Breakfast Cereal, a Healthy Habit for Kids

Out of 625 children

- **95%** Who ate cereal four out of nine days tended to be in the 95th percentile for BMI (overweight)
- **65%** Who ate cereal all nine days; had measurements in the 65th percentile (healthy weight range)
- **32%** Did not eat any breakfast at all
- **25%** Had something other than cereal and about 43% had cereal

Children who ate more cereal consumed more

vitamin D, B_3, B_{12}, riboflavin, calcium, iron, zinc and potassium than kids who ate less cereal or none at all. They also got slightly more calories, fat, fiber and sugar.

Source: Journal of the Academy of Nutrition and Dietetics, *2013; 113(4): 511-519.*

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partially by isomalt. The reformulated cereal stayed crispier for a longer time than those made entirely or in part with sugar. The isomalt-sweetened cereal also had a longer bowl life when milk was added to the cereal, and had a longer shelf life during storage, due to isomalt's low hygroscopicity. Isomalt substitutes for sugar in a 1:1 ratio. It has approximately 45% to 65% of the sweetness of sugar and, for labeling in the United States, it is considered to contribute only 2 kcal per gram.

Merely reducing sugar doesn't automatically transform breakfast cereal into a health food.

Another sugar-reduction strategy is using oligofructose, which is approximately 30% as sweet as sucrose. Adding approximately 15% oligofructose to RTE extruded cereal improves bowl life and crunchiness, although it decreases expansion somewhat. Oligofructose can work in RTE cereal coatings at levels of 10% to 15%, and at similar levels as a binder in granola and cereal clusters.

Speaking of coatings, research (*Journal of Food Science,* 2012; 77(8): C901-C906) shows that a coating with debranched-amylose-containing corn starches versus sugar could extend the bowl life of RTE cereals. This type of corn starch also increased the dietary-fiber content of the cereal flakes.

Take your vitamins (and minerals)

But merely reducing sugar doesn't automatically transform breakfast cereal into a health food. A feature found in many cereals is nutrient fortification. These are typically vitamins and minerals, but can run the gamut of good-for you ingredients. But again, we're just not compounding a vitamin pill here.

"Many cereal products are extruded or processed with steam, which can involve high heat, humidity and pressure," warns Russ Hazen, raw materials and innovations specialist, Fortitech, Inc., Schenectady, NY. "The product pH and moisture content also should be considered as these too vary from product to product." This can wreak havoc on the quality of many nutrients, particularly vitamins.

Some of the most-sensitive ingredients are certain B vitamins, like thiamine, or vitamin C. "Even the fat-soluble vitamins, like vitamins A, D and E, are susceptible to oxidation during processing," says Hazen. "This does not mean that these more-sensitive nutrients cannot be

Photo: ADM

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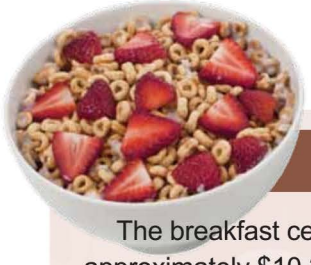
added, just that the conditions of processing need to be considered when selecting the level of the nutrients to add."

Breakfast-cereal manufacturers generally use an "overage," a higher level of nutrients that accounts for "expected losses due to processing and time to ensure the declared level of the nutrient is in the finished product," says Hazen. "These overages are different for each nutrient, and for the specific manufacturing processes used. By conducting stability tests in the finished product, these overages can be optimized to account for the specific losses seen in the manufacturing of a specific product."

Other techniques can preserve the vitamin content of the finished product without watching expensive vitamin mixtures dwindle in the presence of heat.



Minerals typically remain unaffected by heat. Therefore, adding the heat-stable vitamins and the minerals at the start of the mix gives the best dispersion.

According to Riaz, vitamin losses during extrusion can be as low as 10% and as high as 80% or 90%. "In some extruders, they can inject the vitamins in the very last zone, so they don't encounter much heat," he says. "But in most cases, manufacturers know how much they are going to lose, and add maybe 20% to 30% extra." The percent lost depends on factors such as "residence time in the barrel, temperature and moisture, and the amount varies from formulation to formulation," he says.

"One option for protecting the more-delicate fat-soluble nutrients may be to separate nutrients into premixes that will each be added at an appropriate time," says Hazen. "For example, separating the oil-soluble

It's Crunch Time for Cereal

The breakfast cereal category generated approximately $10.2 billion in total U.S. sales for 2011, according to Mintel, Chicago. However, it has been struggling to grow significantly in recent years.

According to a Rabobank report, "Cereal Killers–Five Trends Revolutionizing American Breakfast," a number of factors are causing consumers to turn away from the cereal bowl in favor of other breakfast options.

1) Breakfast has become the new eating-out occasion.
2) The increase in snacking is turning breakfast into "snackfast" as consumers seek convenience and portability.
3) As illustrated by the boom in Greek yogurt, protein is the latest superfood for addressing satiety and weight management.
4) The nutritional profile of food is increasingly important to consumers, and RTE cereal suffers from two issues: added sugars and marketing to children.
5) Declining birth rates mean the slowing of an important cereal-eating demographic—children.

Rabobank suggests companies "think beyond the bowl to remain relevant" by:

- Putting a renewed focus on innovation to generate new brand platforms.
- Recognizeing that cereal doesn't need to be a least-cost formulation. Spend more on ingredients relative to advertising budgets.
- Better communicating to consumers that cereals remain a highly relevant product to deliver many health-and-wellness benefits.

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and water-soluble vitamins can help with dispersion by allowing them to be mixed with compatible ingredients in the formulation."

An appropriate premix allows a manufacturer to dissolve or disperse the vitamins and minerals in an aqueous or fat-based spray at the end of the process to keep the nutrients from being exposed to the harmful effects. "This could be the sweetener solution, or a flavor being applied as a spray at the end of the processing," Hazen says. "This minimizes the exposure of the nutrients and can decrease the needed overages in the premix formulations, since this ensures the sensitive vitamins avoid the high temperatures and pressures encountered during cooking, extrusion and drying. This method only exposes them to a relatively short, mild finished-drying process."

Keep in mind that while minerals may be relatively stable to the process, they can adversely impact the organoleptic properties of the finished product. "Minerals like iron can react with the cereal matrix, leading to color changes which could produce undesirable shades of gray, green or yellow in the product," says Hazen. "These interactions can be minimized with selection of appropriate market forms or encapsulated materials, and changes to processing procedures may also be beneficial."

Don't forget when calculating the nutrient level—and this applies to any nutrient—"The FDA defines serving size as the Reference Amount Customarily Consumed, or RACC, for each food," says Michael McBurney, head of scientific affairs, DSM Nutritional Products North America, Parsippany, NJ. "In

Photo: Almond Board of California

the ready-to-eat cereal category, serving sizes are based on density and volume. So, in short, there are multiple serving sizes. Secondly, the FDA defines 'good' (10% Dietary Value) and 'excellent' (20% DV) as the amount of nutrient that must be present per serving to make these claims. Thus, the amount of nutrient x which must be added through fortification may differ for cold versus hot cereals because of differences in serving size."

Beyond vitamins and minerals

Of course you don't have to stick to the basic fortificants for cereal. Big Life Living, Inc., Toronto, introduced a granola-style brand called SexCereal, which has separate products for men and women with a tagline of "Fuel Your Fire," i.e., your love life. "His" formula contains bee pollen, black sesame, wheat germ, camu camu, maca, pumpkin seeds, chia seeds, goji berries and cacao nibs mixed

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with oats. "Hers" mixes maca, cranberries, cacao nibs, sunflower, chia seeds, almonds, flax seeds, oat bran and ginger with oats.

Plant-based ingredients like chia seeds and flax can provide omega-3 fatty acids to provide a whole range of functional benefits beyond "fueling your fire." But they only add the short-chain form, alpha-linolenic acid (ALA), which the body needs to convert to long-chain omega-3 polyunsaturates (lc omega-3 PUFAs) eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) to achieve the full range of benefits. For a more-detailed discussion on the health benefits of these compounds, see "Omega-3: A World of Possibilities" in this issue.

But adding DHA and EPA to breakfast cereals isn't as easy as mixing a little flax with your granola. "The nature of DHA/EPA long-chain polyunsaturated fatty acids from algal or marine sources makes them highly susceptible to oxidation, producing off flavors and odors," says Sherry Siteman, senior technical marketing manager, food and beverage, DSM Nutritional Products. "Processing conditions, packaging materials and post-production storage conditions of breakfast cereals present a significant challenge."

Adding DHA and EPA to breakfast cereals isn't as easy as mixing a little flax with your granola.

A number of steps can minimize the potential for omega-3 oxidation. "Reduce exposure to oxygen, heat and light where possible during processing," explains Michelle Harlow, senior technical marketing manager, DSM Nutritional Products. "Remove transition metals (iron, zinc, copper, etc.) from your application to avoid further oxidation, and use low-oxygen-transmission-rate packaging with nitrogen flush to help maintain flavor integrity of your product and extend shelf life."

Siteman suggests that, if transition metals are added, "they are in a robust encapsulated or low-reactivity form."

Direct addition to an RTE cooked/puffed, extruded cereal is generally not recommended, says Siteman. "Addition of encapsulated DHA/EPA through a syrup, compound coating or filling is a more viable option. Encapsulation of the DHA/EPA ingredients can offer protection from other ingredients and processing conditions, depending on the nature of the encapsulation and the application."

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Siteman also recommends encapsulated forms for hot, instant and cook-up cereals where transition metals can contribute to oxidation over time. In these products, too, the oxidation can be accelerated by increased temperature, humidity and exposure to atmospheric conditions.

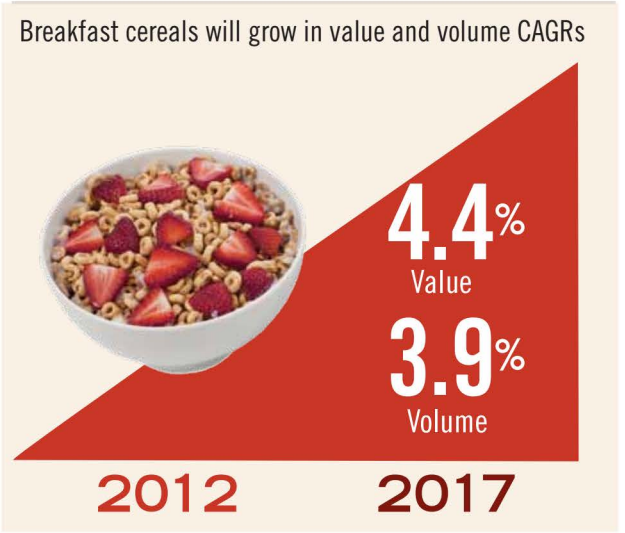
For hot instant cereals, such as oatmeal, manufacturers could add the sugar/flavor mixture that is deposited into the pouches. However, according to Harlow, this dilution can damage the powder due to the sugar granules, reduce shelf life and cause off-flavor development. Ideally, she says, the DHA powder "could be dropped into the individual packets without blending." The company's DHA powders cannot be added directly to the oatmeal "because it will fall out, as the flakes are too large to suspend the powder evenly," she says, but it can be packed into small-flake infant cereal packed into foil-lined canisters with a nitrogen flush."

"Whole" ingredients that deliver any number of nutrients seem to be a natural fit with breakfast cereal. For example, researchers found that a combination of maize (corn) bran and oat flour in an extruded breakfast cereal provided an antioxidant and complex polysaccharides (*Food Chemistry*, 2008; 111(3): 654–657). An extruded breakfast cereal containing 30% maize bran was the most accepted by consumers; it delivers 0.2 grams of ferulic acid, and 8 grams of complex polysaccharides, which includes 1.2 grams of β-glucans and 6.8 grams of arabinoxylans, per 100 grams.

And of course product designers can always take advantage of other naturally occurring nutrients in ingredients that also increase organoleptic appeal. The fiber and antioxidants in fruit ingredients, the vitamin E in almonds, or the omega-3 fatty acids in walnuts.

Better yet, formulators can add a nutrient that performs double-duty, like beta-carotene. "Typically, less than 1 mg pure beta-carotene per lb. of a baked or toasted cereal could provide a yellowish-orange color," says Diane-Louise Hnat, senior technical marketing manager, human nutrition and health, DSM Nutritional Products. "However, the beta-carotene may need additional stabilization to maintain the color stability. It is more common to use specialized forms of beta-carotene as a source of vitamin A in darker-colored cereals. This application has been patented or is proprietary."

Cereal Business Growing in Japan



Growth will occur as the category begins to replace the traditional breakfast foods to which Japanese consumers are accustomed.

Source: Canadean

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Whole-grain goodness

Probably one of the most popular ingredients to increase a breakfast cereal's nutrition quotient is whole grains. According to an FDA guidance document, the agency considers "whole grain" to include "cereal grains that consist of the intact, ground, cracked or flaked fruit of the grains whose principal components—the starchy endosperm, germ and bran—are present in the same relative proportions as they exist in the intact grain. Such grains may include barley, buckwheat, bulgur, corn, millet, rice, rye, oats, sorghum, wheat and wild rice."

While nongrains like legumes (soybeans), oilseeds (sunflower seeds) and roots (arrowroot) are not allowed to be labeled as whole grain, the Whole Grains Council notes that "pseudo-grains," such as amaranth, quinoa and buckwheat, are normally included with true cereal grains.

Whole grains can add a nutritional lift beyond fiber. "Quinoa is the most well-known for the nutritional quality of its protein, but amaranth and buckwheat also have high-quality protein," says Beth Arndt, director of research and development, ConAgra Mills, Omaha, NE. "Depending on the grain, the protein ranges from 12% to 15%." She also notes that ancient grains can have a higher mineral content and that, in addition to protein, quinoa and amaranth provide significant levels of folic acid.

Studies have found that including whole grains in a healthy diet reduced stroke risk 30% to 36%, type 2 diabetes risk 21% to 30%, and heart disease risk 25% to 28%, and assisted in weight maintenance. (A summary of the research can be found at *wholegrainscouncil.org/files/WGResearchSummary_WGCJan09.pdf.)* This makes whole grains a natural for functional breakfast cereal.

As far as using whole grains in cereal, "ready-to-eat cereals really run the gamut, from 100% whole grain to quite a bit less," says Arndt. "It depends on the other ingredients included in the cereal. Granola, for instance can have sugar coatings, nuts, fruit and other ingredients. But 95% or more of the ingredients in a simple whole-grain brown rice crisp or a whole-wheat flake can be whole grain."

> Probably one of the most popular ingredients to increase a breakfast cereal's nutrition quotient is whole grains.

In addition to using rice and whole wheat, Arndt has used flour from ancient grain blends to make extruded crisps and other shapes in gluten-free and not-gluten free versions. Some of the ingredients categorized as ancient-grains are naturally gluten-free, such as amaranth, sorghum, quinoa, millet, teff and buckwheat. But others, such as spelt, einkorn and Kamut®, are heirloom varieties of wheat that, like common wheat, contain gluten. She's used amaranth, quinoa, millet, sorghum and teff in blends with wheat for nongluten-free formulas and with rice or corn for gluten-free. Multigrain blends in breakfast cereals can provide advantages in cost, flavor, nutrition and functionality.

When extruding whole grains, in addition to the fiber, the high level of fats in the germ can affect the end product. "The fat acts as a lubricant," says Riaz. "About 1% fat will decrease

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the expansion. When extruding formulas with fat levels of 2% to 3%, you need a twin-screw extruder which can help you to overcome the issues. You can still make a very nice product; you just have to set up your extruders and processing parameters differently, and maybe work with certain additives," because you have to work against the nature of the composition.

Luckily, consumers have a broader acceptance of differing textures in whole-grain cereals than in times past. Currently, some popular extruded whole-grain cereals "may have a denser texture and a different kind of crunch," says Arndt. "They are very much an extruded cereal, but they have a much different texture than crisped rice." That denser texture "can work to your advantage," she continues. "Sometimes you don't want a low bulk density in a crisp or other shape, or you may want a little more 'bite' to it." All of that can play into the perception of a hearty, healthy cereal.

Of course, whole grains are historically the basis of hot cereals as the "everything old is new again" success of hot oatmeal illustrates. Other grains can be incorporated to modify nutrition, texture and flavor. Arndt recommends blending rye with barley and oats, for example.

And about that hot oatmeal? For those interested in foods for weight maintenance, research sponsored by PepisCo and presented at the Experimental Biology 2013 conference says that having oatmeal for breakfast enhances satiety more than RTE oat cereal.

Fortifying with fiber

While one of the reasons to add whole grains is the fiber content, sometimes formulators might want to add a purified source, especially if they

are seeking label claims. FDA allows cereal to be labeled a "good source" at 2.5 grams per serving and an "excellent" source at 5 grams per serving.

Depending on the formulation, whole grains alone might allow a fiber claim on a cereal. "Using hot oatmeal cereal as an example, absolutely you'll have enough fiber (in whole-grain oats)," says Arndt. "One ounce of cereal made of wheat, oats, barley or rye will have enough fiber for a 'good source of fiber' claim." She goes on to say that ConAgra Mill's high-fiber barley (containing at least 30% fiber) would supply more than 8 grams of fiber per 1-oz. serving, allowing "excellent source of fiber" on the label. "Using oats as the standard for hot cereals, they only contain about one-third of the fiber" as high-fiber barley, she says.

Unfortunately for makers of extruded RTE cereals, products with high levels of dietary fiber—either from whole grains or from added fiber ingredients—are difficult to expand. Riaz says that fiber "provides no expansion, no texturization—it's just a filler," but you can

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generally add up to 5% fiber. "What happens is, basically, the fiber prevents the bubble growth, due to its sharp edges," he explains. "We've done a lot of work with fibers and found that in some products you can add up to 20% fiber if you can grind—or pulverize—the fiber very fine. Then it has much less effect." He recommends a twin-screw extruder for these higher levels of fiber.

One fiber ingredient that doesn't fit into the difficult-to-add category is resistant starch. A study (*Cereal Chemistry*, 2011; 88(6):584-588) found that replacing 5% to 20% of the whole corn flour in an extruded ring-shaped RTE cereal with a phosphorylated cross-linked type-4 resistant wheat starch (RS4) containing 85.5% total dietary fiber increased cereal density, but the resistant starch did not affect internal air-cell wall thickness, air-cell size, or porosity. Levels of 5% or 10% RS4 did not affect expansion, physical appearance, initial crispness or bowl life of the cereal rings, however. Testing at Henry H. Ottens Manufacturing Co, Inc., Philadelphia, also found that resistant starch added to puffed or flaked cereal at a level of 3 to 15 grams per 30-gram serving had no negative effect on either flavor or bowl life.

Power by protein

Another popular ingredient to increase nutrition in breakfast cereal is protein. "When looking at the heightened consumer awareness of protein and its benefits, cereal and protein are a natural fit," says Courtney B. Kingery, marketing and customer development manager, ADM Foods & Wellness Division, Decatur, IL. "First, the variety of cereal makes it an excellent matrix into which to add protein.

"Each cereal formulation, and the process to make it, lends itself to the addition of protein in different ways," continues Kingery. "For example, proteins can be added with other dry ingredients in extruded cereals and processed through existing equipment, such as single-screw short-barrel extruders. Manufacturers should work with suppliers to select the right protein, one that doesn't over-expand and one that doesn't impair expansion."

In an extruder, the starch will undergo expansion, "but if you add a protein, it will texturize it; it won't let it expand," says Riaz. "The protein is going to give you a chewy, harder texture." Using functional proteins like soy isolate or concentrate will minimize the effect on the taste or texture, he says. Other proteins, such as pea protein concentrate, also work well in cereal.

Photo: Almond Board of California

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According to Kingery, another characteristic of cereals that makes them a good delivery method for protein is the natural association of breakfast and protein in consumers' minds. "Consumers understand that consuming protein in the morning can help contribute to a longer sustained feeling of fullness and increased energy," she says.

Whey protein's "excellent amino-acid profile can complement foods that are less well-balanced in protein," notes Gwen Bargetzi, director of marketing, Hilmar Ingredients, Hilmar, CA. "Oats, for example. Plus, whey protein helps with satiety. Research suggests whey protein can play an important role in helping people control their weight. We generally feel more full when consuming protein than when consuming the same calories of carbohydrates, in part because we digest carbs so quickly. Addition of whey protein helps prolong the feeling of fullness and hunger satisfaction."

Consumers understand that consuming protein in the morning can help contribute to a longer sustained feeling of fullness and increased energy.

While the high-heat processes for making RTU breakfast cereals isn't a good match for most dairy proteins, instantized whey protein isolate (90% protein) or whey protein concentrate (80% protein) can be used in instant oatmeal, says Bargetzi. "Both are heat stable and, being instantized, can be stirred easily into water along with the oats," she says. But for RTE cereals, product designers might consider using a whey-protein crisp.

This identifies another way to add protein—adding high-protein inclusions. These are made with everything from whey protein, bean powders, soy proteins and peanut flours to wheat flours and gluten-free sorghum flours and are suitable for hot or cold cereals.

Keep in mind, no matter what nutritional ingredient is added to a breakfast cereal, whether protein or micronutrients: "Identifying detrimental effects on the nutrients in the processing, market positioning and label claims, and finished product organoleptic requirements are all important factors when deciding the type and level of nutrients for a product," says Hazen. "The last one is likely the most important, since it doesn't seem to matter how well you do on the other items, if it doesn't taste good consumers don't continue to buy it."

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EDITORS' REVIEW

- A review of the wide range health benefits attributed to omega-3 consumption.
- How omega-3s can help manufacturers meet skyrocketing consumer demand for functional foods.
- Ingredient technologies, from encapsulation to spray-drying, that help manufacturers create a range of omega-3 products.

Omega-3: A World of Possibilities

BY CASSANDRA WELLS
Associate Editor

Omega-3 fatty acids, also known as n-3 fats, are polyunsaturated fatty acids (PUFAs) that are essential nutrients for health.

Of the three main omega-3s, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are long-chain n-3 fats, the major source of which is oily fish. DHA can be derived from algal and fungal sources, as well. The third, alpha-linolenic acid (ALA) is a shorter-chain n-3 fatty acid that mainly comes from plant-based sources like soybeans, chia, flaxseed, some vegetable oils and walnuts. ALA is considered an essential fatty acid as both EPA and DHA can be synthesized from ALA. "Although ALA is considered the essential omega-3 fatty acid because it cannot be synthesized by humans, evidence that human conversion of EPA and, particularly, DHA is relatively inefficient suggests that EPA and DHA, may also be essential under some conditions," according to "Essential Fatty Acids" by the Linus Pauling Institute, micronutrients research for optimal health, Oregon State University, Corvallis, OR. Omega-3 fatty acids offer consumers a wide range of health benefits that provide manufacturers with a world of functional-food formulation possibilities.

Emerging evidence

Omega-3 fatty acids are associated with many health benefits, from cardiovascular benefits to controlling blood clotting and building cell membranes in the brain.

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Emerging evidence has also identified potential benefits for a range of conditions, such as cancer, inflammatory bowel disease, and autoimmune diseases like lupus and rheumatoid arthritis, according to Frank Sacks, professor of cardiovascular disease prevention, Department of Nutrition, Harvard School of Public Health, Boston, in "Ask the Expert: Omega-3 Fatty Acids."

The market value of EPA/DHA omega-3 packaged products is projected to reach $34.7 billion in 2016.

A number of studies show long-chain n-3 fats to be exceptionally beneficial to heart health. A combination of omega-3 fatty-acid ethyl esters (FAEEs) and weight loss in obese individuals can correct dyslipidemia, insulin resistance and hypertension, as well as artery elasticity, according to a 2013 study published in the *Journal of Nutrition* (143(4):437-441).

Similarly, individuals with higher blood levels of ALA had a 34% lower risk of heart failure compared to people with lower levels, according to data collected from over 20,000 people (*American Journal of Clinical Nutrition*, 2012; 96(4):882-888).

Research also shows long-chain n-3 fats to be beneficial for brain health and cognitive function. A 2006 study published in *Dementia and Geriatric Cognitive Disorders* (21(2):88-96) found omega-3 fatty acids were associated with reduced risk of dementia. Likewise, DHA was found to play a role in eye and brain maturation of developing fetus' during pregnancy, according to the 2008 study published in the journal *Current Opinion in Clinical Nutrition and Metabolic Care* (11(3):297-302).

Studies also suggest ALA provides some benefits associated with longer-chain derivatives due to the body's ability to elongate this shorter-chain omega-3 into EPA and DHA, but at an inefficient rate. Over 10 times the quantity of shorter-chain n-3 fatty acids must be consumed to emulate the beneficial effects seen in long-chain n-3s EPA and DHA, according to a 2003 study published in *The American Journal of Clinical Nutrition* (77(5): 1140-1145). In other words, 100 grams of salmon supplies about 1.8 grams of EPA/DHA compared to a plant-based source of omega-3, like chia or flax, where only 0.2 to 0.3 grams of EPA/DHA would result from 100 grams, says Dilip Nakhasi, director of innovation, Bunge Oils North America, St. Louis. One hundred grams of salmon contains about 5.93 grams of total fat, 100 grams of dried chia seeds has 30.75 grams total fat, and in 100 grams of flax seeds there are 42.16 grams total fat.

A booming market

As more consumers become aware of the benefits of omega-3 fatty acids in the diet, the demand for easy and convenient ways to consume n-3 fats is increasing. The market value of EPA/DHA omega-3 packaged products is projected to reach $34.7 billion in 2016, according to a report, "The Global Market for EPA/DHA Omega-3 Products," by Packaged Facts. The report states that this represents a compound annual growth rate

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(CAGR) of 6.4% over 2011. It says that, "expanding public awareness of EPA/DHA omega-3 health benefits through positive media coverage of scientific research findings, as well as developments in regulatory markets, will contribute significantly to continued growth in the global market for EPA/DHA omega-3 products."

Additionally, in the Packaged Facts press release, "EPA/DHA Omega-3 Products Market to Jump to $35 billion by 2016," the creation of a positive growth environment for EPA/DHA omega-3 products is partly attributed to "continued popularity of EPA/DHA omega-3 nutritional supplement products, including krill oil and vegetarian algae-based supplements," says David Sprinkle, research director and publisher, Packaged Facts.

Products with healthy, omega-3 fatty acids appear to have a bright future, says Carol Cheow, general manager, Cactus Botanics, London, who references research from the International Food Information Council (IFIC) showing that, in 2008, 38% of American consumers often bought omega-3 fatty acid foods and from 2006 to 2008, omega-3 food consumption increased more than 35% per year.

The functional-foods industry has seen an increase in the demand for omega-3 ingredients. "More consumers are becoming conscious of the foods they eat as they strive to use nutrition as an option to combat health issues such as heart disease," says Doreen VandenTillaart, vice president of operations, Natunola Health, Inc., Winchester, Ontario, Canada. This demand is expected to increase, and food manufacturers are taking note of the formulation opportunities.

Creating omega-3 products

Food and beverage manufacturers are adding EPA and DHA into a range of products, including baked goods, bars, smoothies, a variety of beverages, yogurts, dressings, mixes and more. These functional foods provide an alternative for people who have a difficult time taking regular fish-oil supplements so that they can consume adequate levels of EPA and DHA on a daily basis using everyday foods.

A number of methods are used by food technologists in formulating foods with omega-3 fatty acids, as well as many challenges. Some involve encapsulation technologies, some involve process technologies and others involve the omega-3 oil itself, according to Steve Dillingham, regional director, North America, GC Rieber Oils, Inc., Montclair, NJ, and Philip Bromley, CEO, Virun, Inc., Walnut, CA.

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The difference in methods is how various ingredient technologies protect the lipids from oxidation and how they will further prevent oxidation when incorporated in the food or beverage matrix, says Dan Wiley, vice president of nutrition and health, Organic Technologies, Coshocton, OH.

The issue of oxidative stability is the most frequently cited challenge by food technologists, according to "Novel Omega-3 Emulsion Technologies" (*Nutrafoods,* 2011; 10(4):17-21), an article detailing the process Croda Europe Ltd., East Yorkshire, England, uses to encapsulate its high-purity omega-3s. Oxidative stability is especially challenging when formulating with long-chain n-3 fats.

"The presence of additional double bonds can lead to more opportunity for oxidation and generation of peroxides and 'fishy' flavors in the case of the PUFAs, EPA and DHA," says Wiley.

As stated in the Croda report, there are processes that can be used to reduce oxidative potential like, "like steam deodorization to remove polar impurities and the addition of antioxidants to reduce the levels and potential of free radicals." A natural mixed tocopherol (vitamin E) antioxidant can be used as a preventative measure to help provide protection for the oils should they come in contact with oxygen, he says. "However, it's not possible to obtain 100% protection from an antioxidant package for the highly unsaturated EPA and DHA PUFAs," he adds. The best method is to exclude oxygen throughout the manufacturing process through utilizing vacuum, inert gases and a lot of care during every step.

Another method for protecting against oxidation is to create a structured lipid that has the fatty acids hooked to the backbone so that it becomes more stable, says Nakhasi. If the fatty acid is in the middle of the triglyceride, it will be protected and provide an extended shelf life.

"One of the most-popular methods to date for incorporating EPA and DHA into foods is through the use of spray-drying. This can either be in the form of a powder in its native state or combined with other materials to give a microencapsulated powder," according to the report by Croda. It goes on to explain that, there still are challenges when food manufacturers formulate powders into foods including, "gritty mouth feel and the high temperatures and access to air necessary for the spray-drying process that can accelerate the oxidation of oil resulting in 'fishy' off flavors and reduced shelf life." For foods that might require a powdered product, omega-3 oils can be spray-dried onto a carrier, like silica, starch or corn syrup solids, and the powder would then be coated or encapsulated with an oxygen-barrier such as gelatin or wax. Powders are often used in baked goods or in beverages with heavy suspension.

Encapsulation by freeze-drying has been used as a potential delivery method for fish oil, according to the Croda report. This technique uses low

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Omega-3 Health Claim

The market for omega-3 functional foods is booming in response to the wide range of health benefits they offer and increasing consumer demand for healthier food products. This is appealing to manufacturers wanting to use health claims, nutrient-content claims and structure/function claims to give their products an edge, however such claims are regulated. Ensuring the validity of these rests with FDA, or, in the case of advertising, with the Federal Trade Commission.

In 2004, FDA approved a qualified health claim for reduced risk of coronary heart disease (CHD) on conventional foods that contain EPA and DHA omega-3 fatty acids. It reads: "one serving of (name of the food) provides (x) gram of EPA and DHA omega-3 fatty acids."

The FDA guidelines also note additional qualifying guidelines of the health claim, such as total fat, saturated fat, cholesterol and more. Individual foods' total fat, for example, cannot exceed 13.0 grams per RACC (reference amounts customarily consumed) and per 50 grams if the RACC is less than or equal to 30 grams or less than or equal to two tablespoons. "The total fat disqualifying level is 26.0 grams per label serving size for meal products and 19.5 grams per label serving size for main dish products," states FDA.

Saturated fat is also a factor in the health claim. Conventional foods other than fish must be low in saturated fat at, "less than or equal to 1 gram per RACC and no greater than 15% of calories from saturated fat for individual foods, less than or equal to 1 gram per 100 grams and less than 10% calories from saturated fat for meal products and main dish products," as stated by FDA. Cholesterol content is also taken into consideration as follows: "Conventional foods other than fish must meet the low-cholesterol criterion (21 *CFR* 101.62(d)(2))."

Further, "all conventional foods and dietary supplements must meet the sodium disqualifying level, less or equal to 480 mg per RACC and per 50 grams if RACC is less than or equal to 30 grams or less than or equal to two tablespoons for individual foods, less than or equal to 960 mg per label serving size for meal products, less than or equal to 720 mg per label serving size for main dish products," state FDA guidelines. A conventional food has to meet the 10% minimum nutrient requirement of 500 IU of vitamin A, 6 mg of vitamin C, 1.8 mg iron, 100 mg calcium, 5 grams of protein and 2.5 grams of fiber per RACC, before any additional nutrients are added to the food.

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temperatures under vacuum, producing a highly stable, encapsulated fish-oil product. "However, matrices produced by this method are porous, sponge-like structures that may make the fish oil vulnerable to oxygen and rancidity," according to the Croda report.

Alternative technologies use encapsulation of the omega-3 fatty acid within an emulsion, protecting them against contact with oxygen, trace metal and other substances that can lead to oxidation, as stated in the Croda report. Emulsions are also more potent than powders. While spray-dried powders require many other constituents like carbohydrates, to ensure stable encapsulation, fish oils based on liquid emulsions require very little carbohydrate to obtain adequate stability. The result has little effect on the label claims when added to food, whereas the addition of spray-dried fish oils to foods can require changes in label claims, including increased total calories, carbohydrate and saturated fats.

Materials used to encapsulate oils can range from other lipids to polysaccharides and proteins. For example, using vitamin E to encapsulate high-DHA omega-3 concentrate, including a patent-pending process to assure stability of the omega-3 in finished applications, allows the omega-3 to not react with oxygen to avoid interactions with iron, acid and other catalytic constitutes that promote oxidation, according to Dillingham and Bromley.

However, these microcapsules can form sediments and settle out in low-viscosity products due to their large size, making them unsuitable for beverages. They are also susceptible to off-flavors, so Nakhasi suggests using plant sources of omega-3 fatty acids in beverages.

Shelled flax is stable, as the flax oil inside the flax kernel is undisturbed and therefore avoids the problem of off-flavors.

Omega-3 Options

Flaxseed is a common source of ALA n-3 fatty acids. Shelling flax, a patented technology allowing the separation of the outer shell from the inner kernel says VandenTillaart. This offers various fractions of the flaxseed components, such as products with a higher kernel-to-hull ratio and vice versa," she adds. "The higher the ratio of kernel, the higher the omega-3 content; therefore, due to the higher concentration of omega-3, manufacturers can incorporate a smaller amount of flaxseed into their formulations for optimum omega-3 content."

Shelled flax is stable, "as the flax oil inside the flax kernel is undisturbed and therefore avoids the problem of off-flavors," says VandenTillaart. The shelled-flaxseed

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technique offers manufacturers a variety of options for fortifying their formulations with a vegetable source of omega-3, she says. "The flax kernel can be added in as you would add other seeds or nuts." Shelled flax powder can also act as a binding agent, it can be added in place of 10% to 25% of the flour to offer omega-3s and improved stability, she adds.

As the popularity of plant-based diets increases, there is a need in the marketplace for more vegetarian sources of omega-3 in functional foods. DSM Nutritional Products North America, Parsippany, NJ, recently partnered with Monsanto Company, St. Louis, to deliver stearidonic acid (SDA) omega-3 soybean oil for foods in North America. Unlike ALA, SDA is a long-chain omega-3 fatty acid and has been shown to efficiently convert to EPA in the body at a rate of 6:1.

Food product designers are adding omega-3 fatty acids to a range of foods, including already healthy foods like bars, juices, cereal and dairy products.

SDA soybean oil can be used in a range of applications at levels that provide 375 mg of SDA soybean oil per serving. Such applications include baked goods, baking mixes, dairy product analogs, cheeses, fats and oils, desserts, soups, sauces, soft candy and more. "SDA soybean oil has similar flavor, shelf life and stability as conventional soybean oil, giving food companies the opportunity to create products using it and consumers the opportunity to increase their omega-3 consumption by eating many of the same foods they currently incorporate into their diet," says Cassie France-Kelly, director of consumer communications, DSM.

A bright future

Proven health benefits of omega-3 fatty acids, along with continually emerging evidence, has led consumer demand for food products fortified with n-3 fatty acids to skyrocket. Food product designers are adding omega-3 fatty acids to a range of foods, including already healthy foods like bars, juices, cereal and dairy products. This new segment of functional foods offers benefits to a wide demographic of consumers, from those who need heart-health benefits, cognitive benefits and immune benefits, to pregnant women, older adults, vegetarians and those individuals who are simply health conscious. Omega-3 foods are booming, and with continued technological advancements and a growing range of food applications—the future of omega-3 functional foods looks bright.

"Krill oil is distinct from vegetable oils, such a flaxseed oil, due to the fact that it is rich in long-chain polyunsaturated fatty acids, i.e. the omega-3 fatty acids, EPA and DHA," says Wael Massrieh, Ph.D., vice president of scientific affairs, Neptune Technologies & Bioressources Inc., Quebec. "Furthermore, EPA and DHA in krill oil are attached to and carried by phospholipids. Phospholipids are a major component of all biological membranes and contribute to the membrane's permeability and fluidity. Due to their amphipathic nature, both lipid-soluble and water-soluble, phospholipids act as superior delivery systems."

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