

Color Me—and My Food—Beautiful

By Heather Granato, Group Editorial Director

Mother Nature equipped herself with quite the palette to color the world, and carotenoids are some of the richest options. These fat-soluble plant pigments deliver intense shadings of red, orange and yellow to plant foods, offering antioxidant protection during photosynthesis. In general, the more intense the color, the higher the carotenoid level. And while there are more than 600 known carotenoids in nature, the ones taken up by humans number only in the single digits.

Whether it's the beta-carotene seen in carrots and winter squash, lycopene in tomatoes and watermelon, or the xanthophylls in corn and dark leafy greens, the human body has developed preferences for certain bioavailable antioxidant carotenoids and uses them for support of systems such as immune function, eye health and cardiovascular wellness. In addition, certain carotenoids serve as vitamin A precursors, which the body can convert as needed for the fat-soluble vitamin.

While carotenoids may be one of the key categories of nutritional antioxidants, consumer awareness of these compounds remains middling. "Consumer interest in carotenoids is growing rapidly, but still has a long way to go," said Bob Capelli, vice president sales and marketing, Cyanotech. "The carotenoid market in the 1980s was all about beta-carotene; in the 1990s, lutein and lycopene came on strong. Now, astaxanthin is really carrying the torch. With all the new research being done on carotenoids and the publicity this generates, the public is becoming more aware of just how beneficial these products are. But even with this publicity, if you ask 100 consumers to name a carotenoid or explain what they do, you'll get mostly blank stares."

Scott Steinfeld, president, ZMC-USA, agreed that there is still a gap in consumer knowledge. "Carotenoids, as a category, have further to go in terms of consumer awareness than some of the individual ingredients inside the category," he noted. "Consumers have a higher awareness of the individual ingredients—lutein and beta-carotene, for example—than they do the category of carotenoids as a whole."

Some suppliers are using that as an opportunity to raise the profile of the category, while others are marching in step with the consumer, speaking directly to their understanding of specific ingredients and their health benefits. Cyvex Nutrition, for example, has developed consumer and industry marketing based on different ingredient "color benefits" to help further knowledge about the entire category. "There's much continued work to ensure the mass market consumer understands 'carotenoids' in the way they understand the parent group, 'antioxidants,'" said Matt Phillips, president, Cyvex. "This provides an opportunity to position to the general consumer concerned about diet and health. One message that can work is to tie carotenoids into color-benefit values. It is simple, compelling and potentially highly effective in cementing the message and, thus, increasing carotenoid consumption."

Because consumers generally associate carotenoids with good health, and understand some of the specific effects, the groundwork has been laid for marketing and education, said Hiren Doshi, business development director, OmniActive Health Technologies. "Lutein has been associated with eye health, lycopene with prostate health and beta-carotene with good vision and immunity," he said.

“However, this means that the potential of carotenoids has been only partially tapped, leaving tremendous opportunity for companies willing to invest in consumer education about the various health issues carotenoids can address.”

Industry marketing efforts are having some effect already. “Consumer interest remains very high in carotenoids and awareness of beta-carotene, lutein, lycopene and astaxanthin are higher than ever thanks to significant investments in advertising and promotion by the basic manufacturers,” said Sam Wright, president, The Wright Group. “Baby Boomers, in particular, are keenly interested in the condition-specific health benefits of lutein in eye health, lycopene in prostate and breast health, and astaxanthin in anti-inflammatory applications. There is also growing interest in the sunscreen effects present in lycopene and astaxanthin when taken internally.”

Tapping into the Supply

As with consumer understanding, the supply chain is also interestingly segmented, with some ingredient suppliers narrowing the focus to a single carotenoid ingredient, and others offer broad spectrum mixed carotenoids or a full portfolio of options. BASF, for example, provides beta-carotene, lycopene, lutein and apocarotenol. DSM is also a supplier of a range of carotenoid ingredients, several of which are branded. Gus Castro, senior technical marketing manager – beverages, DSM, noted the company’s portfolio includes beta-carotene, canthaxanthin, apocarotenol, FloraGLO lutein (from Kemin), OPTISHARP zeaxanthin and redivivo lycopene.

Cognis offers some individual carotenoid products, such as Xangold® lutein esters, but has placed increasing emphasis on its Betatene® natural mixed carotenoids. Extracted from *Dunaliella salina* algae, Betatene contains several carotenoids, including beta-carotene, alpha-carotene, lutein, zeaxanthin and cryptoxanthin. At the 2009 IFT Food Expo, Cognis announced Betatene was not only GRAS (generally recognized as safe) for a wide range of food applications, but also is approved as a natural colorant. Laura Troha, marketing manager, Cognis Nutrition & Health, noted, “We are pleased to offer functional food companies a dual bonus with this natural blend of five key dietary carotenoids that deliver health benefits and can naturally enhance the color of a broad range of foods and beverages.”

Another company delivering a mixed carotene complex is Carotech; W.H. Leong, vice president, explained the company’s Caromin® product is a mixed composition of carotenoids—33 percent alpha-carotene, 60 percent beta-carotene, 2 percent lycopene and 5 percent other carotenoids—extracted from virgin crude palm oil through a patented process. “We believe that no specific carotenoid is the best,” he said. “All the carotenoids must be present in significant levels in cells and tissues in natural proportions to function synergistically and confer their health benefits.”

While it is important for the body to have all the carotenoids to confer their benefits, the aging Baby Boomer population, and a rapidly expanding basis of scientific research, is focusing consumer interest on certain carotenoids with anti-aging effects. For example, lutein remains in the spotlight for its ability to support eye health and lycopene for benefits to the cardiovascular system.

However, the highest profile carotenoid of late appears to be astaxanthin. Found in *Haematococcus pluvialis* microalgae, natural astaxanthin is extracted from the algae. Companies, including Fuji Health Science, Cyanotech and Valensa offer astaxanthin ingredients, and have been exploring the health

benefits. Charlie DePrince, President, Fuji Health Science, noted the company's AstaReal® natural astaxanthin has been shown to have benefits for eye fatigue, muscle endurance, skin health, gastric health and even fat metabolism. The company produces its natural astaxanthin using internal cultivation bio systems in Hawaii and Sweden.

Cyanotech also promotes the extensive health benefits of astaxanthin—including effects on joint health, antioxidant levels and skin health, in marketing for its BioAstin® natural astaxanthin. Capelli noted the company produces its astaxanthin out of a growing location on the Kona Coast of Hawaii.

Formulating Effective Products

As consumer interest and scientific research intersect, it is the job of the marketers and formulators to develop products that will not only attract shoppers, but also deliver carotenoids in efficacious amounts and in a stable matrix. The functional beverage arena has been a particular area of attention, according to suppliers.

Capelli noted, "The most interesting product I've seen recently is a blueberry juice with astaxanthin, being marketed by a Cyanotech customer in Japan. They've taken an excellent fruit juice and supercharged it with astaxanthin to make a functional beverage for joint, skin and eye health."

Todd Sitkowski, senior marketing manager, DSM, agreed that the beverage market has been ripe for new product launches. "The vast majority of new applications involve functional waters and beverage powders," he said. "Beta-carotene, for instance, is not only used as a stable color in the yellow to orange range, but also as an antioxidant and safe form of pro-vitamin A, supporting the benefit of immunity in beverages. In addition, beta-carotene and lutein have also recently been added to beverages to support skin health, particularly as it pertains to hydration and anti-aging."

Wright agreed the area of skin health, via beauty foods and beverages, is an attractive one for formulators exploring carotenoids. "There are also some carotenoids such as phytoene and phytofluene which are nearly colorless while possessing much of the antioxidant power present in other carotenoid products," he said. "Another interesting new category is functional 'shots' for various specific health conditions such as high blood pressure and cholesterol management. We can see additional condition-specific products for energy, mood, stress, visual acuity, prostate health, etc., with carotenoids in the future."

While there are great opportunities, carotenoids also pose challenges in formulation, and product development teams have many issues to address. "Among the primary considerations are the color that carotenoids impart to a product and the approval status of the carotenoid in target countries," said Dr. Ute Obermuller-Jevic, head of communication, BASF Nutrition Ingredients. "In addition, a formulator has to decide whether adding a carotenoid oil, emulsion or powder is appropriate, depending on the matrix. Next, product characteristics like vegetarian, kosher, halal, protein-free, gluten-free and more, play a role. Last, but not least, a formulator should consider a product's quality, performance and stability, particularly in terms of reproducibility in the final application."

As carotenoids are, in fact, plant pigments, their color impact is a key consideration. However, the growing focus on "natural" among consumers should prove beneficial for companies looking to exploit the multi-functional effects of carotenoids. "It used to be that color mainly affected the perception of a

food's appeal, but now consumers are increasingly concerned about the health risks of certain synthetic colorants, prompting food manufacturers to find alternative sources for natural colors," Troha said. "Market research suggests that color is a leading factor influencing how a food or beverage appeals to consumers. And the source of that color, whether natural or synthetic, is expected to impact food safety in the coming years. Consumer interest in natural colors is being driven by the overall demand for natural, eco-friendly products, and scientific reports that suggest certain synthetic colors may adversely impact a child's behavior."

Leong cited a 2007 study published in *The Lancet*, which found combinations of artificial colors and preservatives could adversely affect children with hyperactivity or attention deficit hyperactivity disorder (ADHD) (DOI:10.1016/S0140-6736(07)61306-3). "Based on this study, the U.K. Food Safety Authority (FSA) called for a voluntary ban of the six cited synthetic colorants," he added. "The European food industry is currently under growing pressure from all sides to remove synthetic colorants, replacing them with natural alternatives. It is inevitable that the tide is turning away from synthetic colorants and the same trend will soon be seen around the world."

Another consideration when selecting and working with carotenoids is ensuring stability. "Carotenoids by their very nature are unstable and are particularly susceptible to oxidation," Capelli said. "Careful review of the product stability, production parameters for heat, light and especially, oxygen, and the packaging of the final product to ensure stability are essential."

Wright agreed the reactive nature of these antioxidant compounds means stability and nutrient interaction must be considered, along with an examination of the production parameters to maintain stability of the carotenoids. He noted, "In a food product, heat is often used in cooking or extrusion processes. The carotenoids must be stabilized to survive these challenging conditions and also guarantee an appropriate shelf life. Overage levels are important in this regard. In beverage products, where carotenoids also have a secondary role as colorants, the protective matrix must be able to go into a dispersion and achieve the desired color characteristics without leaving a ring around the top of the beverage either in the bottle or in the glass when it is poured."

The issue of solubility is complementary to stability, particularly in areas such as beverage formulation. "Our carotenoids perform very well in beverage applications due to their solubility," Phillips said. "For example, in beverages, Euro Black Currant turns from a dark purple to a cabernet red with a mild, barely fruity tea taste. It can be highly suitable for smoothies/enhanced yogurts, refrigerated beverages, such as enhanced waters or pops, or even sorbets."

Doshi explained OmniActive has spent a great deal of time addressing the issue of solubility and stability and developed a patent-pending technology, the UltraSOL Nutrient System, designed to enhance the aqueous solubility of nutrients. "This technology has an outstanding ability to effectively 'solubilize' carotenoids with poor-to-nil aqueous solubility in virtually any aqueous medium, without employing harsh chemical surfactants or emulsifiers," he said. "This technology works on the principle of creating molecular dispersions of active ingredients in safe and food-grade media, reducing the particle size of these active ingredients to several thousand-fold smaller levels than those seen in conventional liquid or dry delivery forms. Such molecular dispersions are then converted into liquid or dry delivery forms, using appropriate carriers that are completely food grade. The UltraSol range of products demonstrates rapid solubilization or micro-emulsification in aqueous medium with a clean taste profile."

Many suppliers have also spent time developing different forms of their carotenoid ingredients—oils, emulsions and powders, for example—that are designed to allow formulators easy incorporation of the compounds into different delivery systems. “In order to fulfill the different finished product uses and coloring needs, multiple carotenoid product ‘forms’ have been developed, making carotenoids useable in all types of applications—e.g., beverages, margarines, instant powders,” Castro said. “A formulator would need to understand not only his product’s matrix and process, but understand the effects of the added carotenoid form to his product.”

Formulators and suppliers working in concert can ensure the finished product will deliver the taste and health benefit to interested consumers, helping them color their own worlds with wellness.