Citrus Flavor Stability: the Holy Grail

Ongoing research tackles citral stability and other factors in the quest for extended RTD and powdered beverage shelf life

Citrus flavors and ingredients, particularly orange and lemon, lead the beverage category, both in the ready to drink (RTD) and powdered soft drink categories.[a] The presence of acid in citrus beverages enhances its flavor impact and authenticity; paradoxically, its presence also presents the greatest threat to flavor stability of liquid products—and thus shelf life—in formulations.

These technical roadblocks to customer and consumer needs are the focus of several strands of research being conducted by researchers at IFF, including Lulu Henson, and the University of Massachusetts. Together, they have pursued the elimination of off flavors and odors, and worked to stabilize citrus products, develop encapsulation systems for beverages, and enhance citral stability. This, says Henson, requires extensive work with many applications and finished products.

"We consider other factors beyond ingredient effects," she says. "We have to make sure that the flavor system is stable in the product and will provide the desired functionality or release properties."

Formulation challenges: Generally speaking, current beverage flavor system technology affords citrus RTDs a lifespan of about 12 weeks. At that point, says Henson, customers begin to notice product changes, including the development of off flavors. This is a challenge, says Henson, because it provides a very narrow window for production, distribution and sale. Ideally, flavor companies and customers would be happier with a lifecycle of 24 weeks.

"We have that as our target," says Henson. As things stand, even an incremental improvement would have an immediate benefit. Henson refers to this extended stability and shelf life as the Holy Grail of citrus RTD beverages, particularly for perennial favorites orange, lemon and lime. She notes that stability is a larger problem in RTDs compared to powdered soft drinks due to the fact that the acid is readily available in liquid formulations to catalyze undesirable chemical reactions. As mentioned, the acidic quality is both a blessing and a curse.

Under such acidic conditions, several materials, but particularly citrus oil component citral (3,7-dimethylocta-2,6-dienal; FEMA# 2303), undergo decomposition reactions. As a result, says Henson, citral levels fall, which dulls flavor impact; meanwhile, decomposing citral forms compounds that have undesirable aroma/flavor.

"It's unfortunate to have a desirable flavor component disappear," she says. "The bigger problem, however, is when undesirable compounds are generated at the same time."

And so, Henson and her co-researchers have been working to better understand citral and whether its decomposition in formulations could somehow be minimized. This is the Holy Grail.

Potential solutions: The traditional route to limit oxidative changes has involved the addition of antioxidants in formulations. Henson notes that this system has limited effectiveness as it doesn't truly address both mechanisms of degradation—acid-catalyzed and oxidative reactions. In the case of citral, the degredation rate, she says, is primarily "based on the low pH, or very acidic conditions, which catalyzes the reaction, although temperature and availability of oxygen can also play a role."

Having seen the limited efficacy of antioxidants, the IFF and University of Massachusetts researchers chose a different route. Henson and her colleagues investigated two approaches: 1) create an environment wherein citral can be protected from the acid, and 2) create an encapsulation in which one could protect citral.

First, the team examined the stability of citral in an oil-in-water emulsion. Henson and her colleagues surmised that if they could influence the ability of citral to stay within the oil droplets that are suspended in the emulsion, citral would be protected from the acid in the water environment. These oil droplets are remarkably small and invisible to the naked eye. The team found that it was possible to enhance the tendency of citral to reside in the oil droplet by varying the composition of the oil droplet.[1] This study provided evidence for the improved retention of citral in the low pH emulsion based on this approach.

[a]Powdered soft drinks tend to be more popular in developing markets, as they are relatively stable and cost-effective.

Next, the researchers worked toward the creation of a system in which to protect citral.[2]

"We investigated the effect of two types of food grade surfactants with very different properties," says Henson. One [reverse micelles created in the oil phase] influenced the citral to stay inside the oil droplet and remain protected. The other was more water-soluble and would be present in the aqueous phase and at the interphase between the oil droplet and the aqueous phase.

"Intuitively," says Henson, "it might be expected that the surfactant would draw the citral into the aqueous phase and make it more unstable." And, while the second surfactant did in fact draw significant levels of citral into the aqueous phase of the emulsion, an interesting phenomenon occurred.

"Beyond a certain concentration," says Henson, "[the surfactant] creates these little pockets, or micelles, that draw the citral inside; so even though the citral resides in the aqueous environment, these pockets protect it from the acid in the water." Henson explains that the exterior of each pocket is a water-loving network through which citral can pass in and out. The interior, or core, of this network is oil-loving, which is ideal for citral storage. And so, she says, success required a process of varying doses of the surfactant to determine the optimum concentration for citral-friendly pocket formation.

Henson notes that even when these parameters for citral/citrus stability have been satisfied, there are further hurdles.

"There are practical limitations, of course," she says, "because the surfactants must posses certain qualities; they can't negatively affect the flavor of the finished product."

The next step, then, is to screen various food grade surfactants to ensure that they have the proper physical and chemical properties and will not contribute off flavors in the final product.

"In addition, cost in use is also important," she says. "We need to select that surfactant system that will meet the required stability, sensory, and cost parameters. The next step would be to evaluate performance in different product formulations because [every] beverage customer has a different recipe."

These applications include carbonated and non-carbonated soft drinks, flavored alcoholic beverages, and sports drinks, among others. Each application presents a fresh set of scenarios.

"Once we identify a system that we think is promising, then we can start doing the longer-term storage tests in products to see how well it's going to perform," says Henson.

All of this has to be done before anything is launched for a specific customer.

Vetting formulation technologies and solutions: Henson notes that any successful research requires the bridging of results with marketplace needs. To illustrate, she discusses the researchers' work related to powder/dry applications in which citrus flavors are vital, for example, lemon-flavored powder in a powdered soft drink or as granules in a tea bag. Whether lemon, orange or another citrus flavor, she says, the expected shelf life for such products is typically two years at the retail level.

"The consumers expect that," says Henson. "We obviously need to maintain the quality during that period by using systems that will be suitable for those products. IFF has recently launched the trademarked FreshTek system, which provides the shelf-life needed for powdered soft drink applications."

But in addition to adding citrus directly to a dry/powder product as a flavor, Henson and her colleagues have explored the use of packaging materials that can transfer aroma via the vapor phase or reduce off-odor in foods and other products.[3] Such activities are conducted using IFF's trademarked TransEssence technology, which according to Henson "provides aroma in the package in order to maintain the freshness and authenticity of the flavor during its shelf life, or allows off odors to be reduced."

"We have collaborations with customers to meet their specific needs in terms of keeping the freshness of the product throughout its shelf life," says Henson. To make this type of novel approach to flavor delivery work, she says, "We need to collaborate with the end user [customer] and the packaging converter." Coordination in such a scenario is far trickier than typical flavor system projects, particularly making sure that the packaging and food formulation elements work together and at the same time getting consumer validation.

"Of course, understanding the cost benefit of the technology relative to the consumer is critical," says Henson. Improved aroma performance for freshness and better flavor are desirable, she says, "but if these are provided to the consumer, will it drive repeat purchase? If the quality of the product delivers the benefit, will the consumer pay more for this added benefit?"

This is not always easy to measure. Additional, untraditional facets of packaging that can only be perceived post-purchase requires a more thorough explanation for success.

In the meantime, Henson and her colleagues continue to pursue The Holy Grail of citrus stability.

References[b]

1. SJ Choi, EA Decker, L Henson, LM Popplewell and DJ McClements, Stability of citral in oil-in-water emulsions prepared with medium-chain triglycerols and triacetin. *J Agric Food Chem*, 57(23) (2009) 11349–11353

2. SJ Choi, EA Decker, L Henson, LM Popplewell and DJ McClements, Inhibition of citral degradation in model beverage emulsions using micelles and reverse micelles. *Food Chem*, 122(1) (2010) 111–116

3. US Patent 20080317929, Packaging for Eliminating Off-Odors, issued to LM Popplewell, L Henson, F Meehan and MJM Brown (2008)

[b]References cited refer to key examples of relevant research; not all related studies are listed herein.

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