



Lycored Stability Studies

Application areas we have tested our super stable colors include:

(select one of the following to view the study)



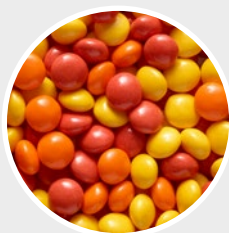
Fruit preparations



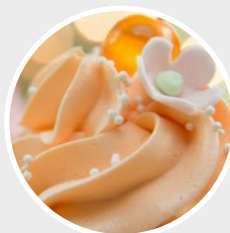
Beverages



UHT treated dairy drinks



Confectionery



GoldHold™ A Dry powder based applications



Cheese

Visit WWW.LYCORED.COM/COLORANTS for more information



Super-stable colors that pass the test

How Lycored's natural colors perform
in fruit preparations for yogurt layers



Background

We're in the middle of a sea change in attitudes to colors in food and beverages. It's no longer enough for products to look good — customers now demand that the colors that make them appealing are achieved safely and naturally. More than three in five consumers globally say they try to avoid artificial colors.

Manufacturers who make the switch from artificial to natural reap the rewards. When 506 health-conscious consumers were asked "Would you be willing to pay more for a product with natural flavorings and colors?", almost nine in ten said they would. On average they said they would pay up to 47% more.

However, going natural can also be technically challenging. Some non-artificial colors are sensitive to pH, UV light and extreme temperatures, and may not interact well with some recipe matrices, such as high fat systems.

Lycored therefore works closely with manufacturers to make it as easy as possible for them to get the benefits of the switch to natural without sacrificing stability.

This paper outlines the results of recent stability tests in fruit preparations for layered yogurts, highlighting color consistency and lack of migration in application across 3 phases of research.

Lycored's own grown natural color solutions

With consumer preference for natural growing, and manufacturers seeking product stability, Lycored's super stable colors are the perfect solution.

Using a range of proprietary techniques and our own plant sources, Lycored has created a wide range of versatile carotenoid based color solutions. At the source of our colorant family are the carotenoids Lycopene from tomato and Beta-Carotene from our own strain of *Blakeslea trispora* fungus.



Both Lycopene and Beta-Carotene offer several advantages over other natural colorants:

Lycopene

- Provides authentic, vegan pink to red shades
- Highly stable under a wide range of pH, light and high-temperature conditions
- Stable in products containing Vitamin C (ascorbic acid) – in fact the vibrancy of our red shades are amplified with its addition
- Shade variations and formulations suitable for high fat systems
- Greater versatility than other naturally sourced red options (beet is sensitive to heat, anthocyanins are sensitive to pH, and carmine is not consumer-friendly)
- Well known by consumers

Beta-Carotene

- Offers a spectrum of natural, vegan yellow to orange shades
- Shade variations and formulations for a wide range of food and beverage applications
- Highly stable under a wide range of pH, light and high-temperature conditions
- Stability is amplified with the addition of Vitamin C (ascorbic acid)

Both are certified kosher and halal, vegetarian-friendly, non-GMO, heat, light, and pH stable, safe and easy to use.

Avoiding bleed in fruit preparations for yogurts

A range of natural color sources are commonly used in fruit preparations in yogurts. These include **Lycopene and other carotenoids, foodstuff colorings such as carrot concentrate, paprika and carmine.**

Lycored set out to explore the comparative stability of its natural colors in this category. It aimed to understand:

- How adding color to fruit preparations creates lasting visual impact
- The authenticity of Lycored's fruit preparation color shades compared to real fruit varieties, and how this changes over time
- The stability over time of Lycored colors in a retail lighting environment, versus common alternatives
- How Lycored red colors withstand migration into white dairy mass in yogurt, and how their performance compares with that of carmine
- The stability of Lycored's colors through a process of industrial scale-up

Phase 1 – Shelf life tests

In Phase 1 we monitored and assessed the comparative appearance of yogurts containing fruit preparations over a shelf life of 31 days.

Twenty-four unique samples were tested. Each sample of 100g full fat Greek yogurt contained 40g of preparation from four common fruit varieties – lemon, apricot, peach and strawberry.

For each fruit variety, at least one sample contained an appropriate Lycored colorant and at least one contained an alternative natural colorant. For some of the samples we also assessed the performance of fruit preparations with no colors (comparing them to at least one each of the Lycored red, orange and yellow shade range).



Lemon: StellarYellow C Clear, Paprika



Strawberry: ConstantCrimson C, ResilientRed A, No Color



Apricot: OrangeOvation A, Carotene



Peach: Carrot concentrate, StellarYellow A, No Color

The samples were all tested in two different stability environments. In one, temperature was controlled at 4°C for 30 days. In the second, temperature was controlled at 4°C for 30 days under light of 2,200 Lux.

Results



In the yogurt containing **lemon** preparation, there was significant fade and migration in the sample colored with paprika, compared with the sample colored with StellarYellow C Clear.



In the **strawberry** samples, there was severe migration from the carmine based colorant, compared with the samples colored with ResilientRed A and ConstantCrimson C. This was the case even in the samples containing pectin. There was also significant fade and distortion from the sample containing fruit preparation with no color.



In the yogurt containing **apricot** preparation, OrangeOvation A delivered high vibrancy and lack of fade compared to the carotenes sample. This was the case even in light cabinet conditions (double the typical grocery chiller cabinet temperature of circa 750 to 1000 Lux).



In the **peach** yogurt, there was significant fade and migration in both the sample with no colorant, and the sample colored with carrot concentrate. By contrast StellarYellow A delivered far higher stability.

Comparative appearance of yogurts containing fruit preparations over a shelf life of 31 days:



= stored in light cabinet

Phase 1 conclusions

The trials from Phase 1 demonstrate that:

- Fruit bases or preparations in yogurts need added color to retain vibrancy and fresh appeal
- Lycored's natural colors are color-fast even under light conditions more extreme than retail lighting conditions
- Lycored's natural colors offer authentic true to fruit and vibrant fruit shades from lemon yellow to strawberry red
- Migration is a real issue for carmine based coloring in strawberry, even when paired with pectin

Phase 2 – Industrial scale up

In Phase 2 we assessed the stability of four of Lycored’s natural colorants under the stronger and longer heat process of scaled industrial production. We looked at:

- **Lemon:** StellarYellow C Clear
- **Apricot:** OrangeOvation A
- **Peach:** StellarYellow A
- **Strawberry:** ResilientRed A and ConstantCrimson C

We wanted to assess how stable they were when heated to 75°C, 85°C and 95°C. We commissioned external researchers to take Digieye pictures and lab measurements to give an objective set of results.

In each of the samples, the colors remained stable at 95°C when held at that temperature for over 30 minutes.

True to fruit: withstanding heat for fruit preparation:



PREPARATION	TEMPERATURE	75°C	85°C	95°C	Holding time over 30 minutes
	Lemon StellarYellow C Clear				
	Peach StellarYellow A				
	Apricot OrangeOvation A				
	Strawberry 1 ResilientRed A				
	Strawberry 2 ConstantCrimson C				

Phase 2 conclusions

The tests show that Lycored’s natural Beta-Carotene and Lycopene colorants are both process stable, even when subjected to high heat levels and holding temperatures over 30 minutes.

Beta-Carotene can be tailored to achieve multiple fruit shades for lemon, pineapple, apricot, peach, mango. Lycopene delivers red shades for authentic strawberry

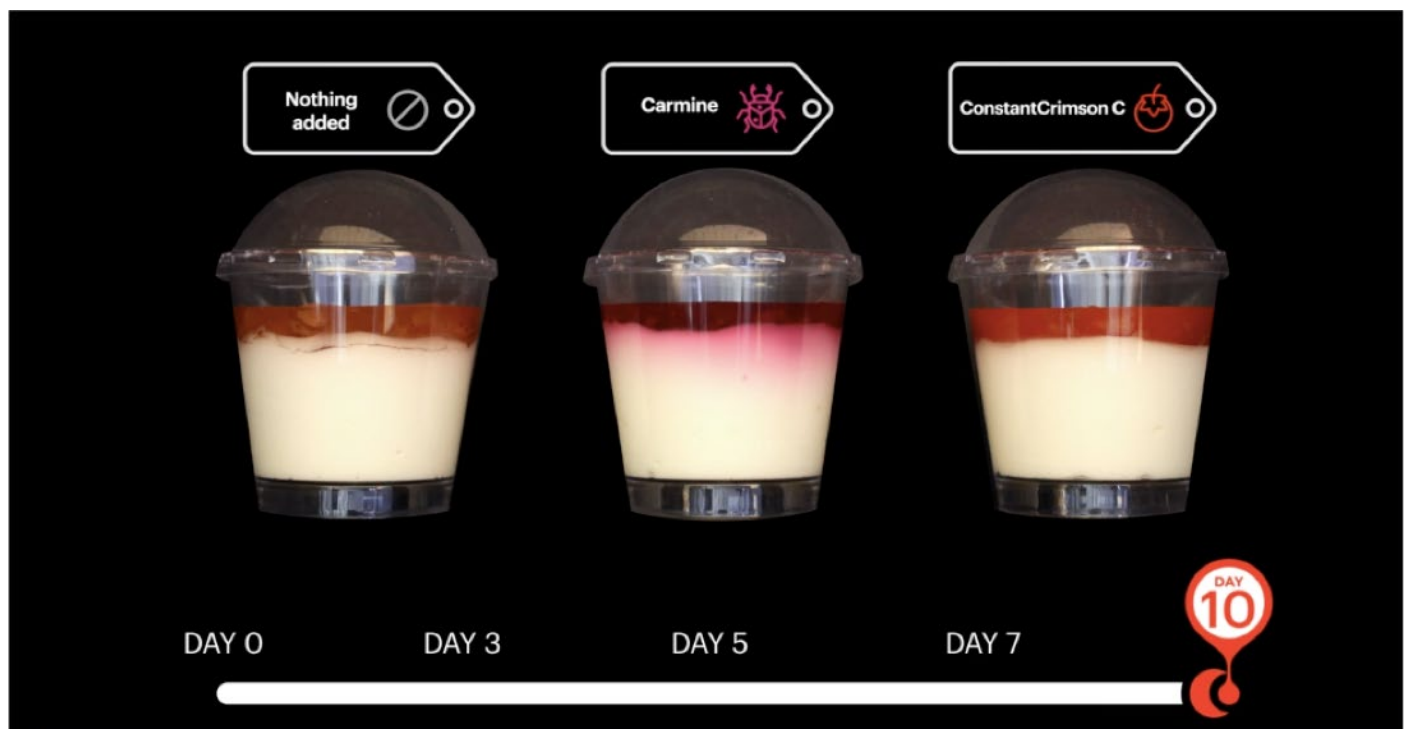
and raspberry fruits that maintain their vivid hue and do not fade to purple when blended into yogurt. Both are process stable and stable to UV light in a chiller cabinet.

Manufacturers who use Lycored’s true to fruit colors in fruit preparations in yogurts can achieve both vivid impact and high stability.

Phase 3 – 10 day observation

Observational study to monitor migration & deterioration level

Using video & time-lapse technology to demonstrate change over 10 days time at ambient temperature of:
Fruit prep with no color v carmine v ConstantCrimson C.



Phase 3 conclusions

Within only 10 days the fruit prep with no added color had deteriorated significantly, while the fruit prep with carmine had already shown significant migration.

The ConstantCrimson C maintained a stable clean line within the white mass.

Why Lycored colors are better for fruit preparation



Lemon
StellarYellow
C Clear



Apricot
OrangeOvation A



Peach
StellarYellow A



Strawberry
ConstantCrimson C
or ResilientRed A



Raspberry
ConstantCrimson A

Beta-Carotene

- Can be tailored to achieve multiple fruit shades for lemon, pineapple, apricot, peach, mango, and guava fruits
- Process stable (including high heat levels & holding temperatures over 30 minutes)
- Stability to UV light in chiller cabinet
- Vertically integrated super producing source of known origin

Lycopene

- Unique red shades for authentic strawberry, cherry, pomegranate and raspberry fruits
- Process stable (including high heat levels and holding temperatures over 30 minutes)
- Stability to UV light in chiller cabinet
- Vertically integrated super producing source of known origin
- Clean layer: no migration into the dairy base – migration is a real issue for carmine based coloring, even when paired with pectin

Conclusion

Manufacturers now have greater opportunities than ever to color products naturally without compromising on stability. In fact, rather than creating limitations these super stable colors offer new ways to position products as more natural and fresh, with longer shelf life. They can also potentially reduce the operational costs involved in packaging, transport and storage of final product.

Every day we are learning more about the possibilities offered by our natural colorants and showing that they demonstrate stability in a growing number of applications. Frequently we discover that they outperform not just other natural alternatives, but also artificial colorants.

There is a long-standing perception that natural colors are harder to work with than artificial alternatives. We are working towards a day when that is a thing of the past.

For more information, or to download a brochure, visit:
connect.lycoredfoodhub.com/super-stable-colors

¹Nielsen 'What's in our food and on our mind: Ingredient and dining-out trends around the world' August 2016 [http://www.nielsen.com/content/dam/niensenglobal/eu/docs/pdf/Global%20Ingredient%20and%20Out-of-Home%20Dining%20Trends%20Report%20FINAL%20\(1\).pdf](http://www.nielsen.com/content/dam/niensenglobal/eu/docs/pdf/Global%20Ingredient%20and%20Out-of-Home%20Dining%20Trends%20Report%20FINAL%20(1).pdf)

²Lycored 'True Colors: Consumer Preference for natural colors and what it means for dairy' <http://www.lycored.com/wp-content/themes/lycored/dist/images/true-colors-paper.pdf>



True colors shining through your beverages

How our super-stable shades deliver superb
performance in flavored waters and carbonates



How super stable pink, yellow, orange and red shades from Lycopene and Beta-Carotene deliver superb performance in flavored waters and carbonates.

The beverage market

The global non-alcoholic beverage market is evolving. Expected to grow to \$190 billion by 2020, it shows no sign of slowing. Whatever direction consumers take the market next, the use of effective beverage colorants remains central to developing appealing and innovative drinks that stand out across the segment. Currently, the non-alcoholic beverage industry's product development is driven by several key demographic and consumer choice trends.



Changing taste and consumption habits

Consumer tastes are changing. The non-alcoholic beverage category is expanding every day as consumers choose to drink fewer alcoholic beverages and select alternatives. The beverage industry is responding by introducing a broad, new range of drinks across several key categories including fruit, carbonated and non-carbonated waters, vegetable and vegetarian choices and more.



Clean label

Still high on the agenda, clean label has transcended trend status to become a standard consumer expectation. Around 80% of consumers want to know more about a product's ingredients before making purchase decisions¹ as part of their quest for healthier products and greater ingredient transparency. In response, manufacturers across the industry are producing and reformulating products with simpler, more natural ingredients. Between 2012 and 2016, clean label product launches in Europe grew by 19,974 products to 30,774.



Plant based flavors

Flavor remains a key differentiator for beverages and the increasing popularity of plant based diets and ingredients is introducing bolder flavor notes to the category with earthy flavors and botanical based beverages taking off. A product that exemplifies this trend is coconut water, which is set to have a market value of \$2.5bn by 2024.

A recent Mintel² report also shows that the appeal of fruit flavors is as strong as ever, with growing consumer interest in drinks with berry and other red or pink hued fruit flavors as well as citrus based flavors, highlighting an opportunity for ingredients that are naturally red, orange or yellow in color.



Health & wellness

Closely linked to clean label is the health and wellness drive that continues to impact the beverage industry. Greater focus on health and wellness leads to replacement of unhealthy products for healthier choices and opens up new opportunities for functional products. The market for energy and sports drinks continue to rise in line with this, as consumers seek out healthier beverages to consume on the go or rehydrate after physical activity. Many of these consumers are health-conscious and want their products to be part of their healthy lifestyle.

Bringing beverages to life with color

For consumers in the Instagram generation, visual appeal is everything. Adding color to a beverage product is a great way to increase its sensory appeal and ensure it looks true to flavor, particularly with fruit flavored products.

The fruit matching challenge

Among consumer choices, clean-label fruit and fruit-flavored beverages are gaining ground. Many of these drinks possess hues and tones in the red spectrum as well as yellow and deep orange; think cranberries, cherries, strawberries, watermelon, raspberries, pink grapefruit, blood orange and orange, papaya, lemons and more. Beverage industry processors and formulators' main challenge in fruit beverage coloring is ensuring a new, all-natural, fruit based product has an appealing color to match its flavor.



Keeping it real, red and natural with Lycopene based color solutions

Relying on artificial colors to achieve color vibrancy may not be an option or a sustainable business choice in the face of consumer tastes. A recent study of US adults found that just under half prefer to avoid artificial additives in the food and drink that they consume, and the level of 'naturalness' associated with a product is key to its acceptance in today's market.

All of Lycored's colors are extracted from mother nature using innovative methods that leverage a proprietary Lycopene-rich tomato breed, and Beta-Carotene from a unique super-producing strain of *Blakeslea trispora*. These naturally derived colors are pH independent, so work well even in challenging beverage and juice applications unlike several artificial red colors.

Fully backward-integrated, Lycored colors are actually synergistic with Vitamin C offering more options and fewer compromises for today's beverage innovators and entrepreneurs looking to capitalize on the health and wellness and clean label trends.



Putting Lycored's natural colors to the test in beverage applications

Lycored set out to test how well its cast of all-natural colors performed in flavored waters, one of the fastest-growing non-alcoholic beverage categories. Researchers conducted a study on a standard flavored water base not containing juices or fruit. The results were then evaluated on six key criteria - stability, ringing, sediment, clarity, fade and homogenization. As the flavored water recipe and process is similar to that of carbonates, this insight also applies to the carbonate category.

Lycored's cast of all-natural color shades were given a 'dress rehearsal' to demonstrate their talent and assess their performance and stability on the main stage—store shelves. Typical shelf-life for these types of beverages is six to nine months. Lycored checked for advanced talent to the 12-month mark. Those showing stability to 12 months are the star performers allowing extended shelf-life with high quality visual appeal even beyond the standard life-cycle.



The results

Stability

Researchers found six of the shades delivered good stability over 12 months, with only OrangeOvation B and ConstantCrimson A displaying slightly diminished hues, with eight and nine months of good stability respectively, well within the standard shelf-life range.

In contrast, synthetic Lycopene displayed poor stability over a similar period, demonstrating significant color loss even when stored in the dark.

Ringling

Ringling, the undesirable effect of color additives coalescing along container liquid interfaces over time, is another shelf-life issue. For most of Lycored's cast of colors, there was no ringling after 12 months in six of the samples. Although Lycored's study did note slight signs of ringling after nine months in test samples colored with ResilientRed A, and after seven months with StellarYellow C Clear, this wouldn't be a concern given the standard 6 to 9 month standard shelf life.

Sediment

Researchers found no sediment in six of the eight samples, although in samples colored with OrangeOvation B and ConstantCrimson B, they noted a slight amount of sediment gathering at the base of the bottle only at the end of the 12 months.

Clarity v Cloudiness

Researchers found no sediment in six of the eight samples. Only at the end of the 12 month study, did a slight amount of sedimentation at the bottom of the bottles develop in those waters colored with OrangeOvation B and ConstantCrimson B.

Fade

Fading is another issue central to shelf life. The only flavored water which faded was the one colored with OrangeOvation C Clear in which there was some fade after six months. The synthetic Lycopene displayed the worst fade of all with significant levels of fade of 12 months.

Homogenization

OrangeOvation C Clear, StellarYellow C Clear and StellarYellow A did not require homogenization for stability. It is recommended that the other shades are homogenized.

Overall, the red, orange and yellow shades from Lycored delivered excellent performance in flavored waters and displayed solid stability characteristics.

Standout shades

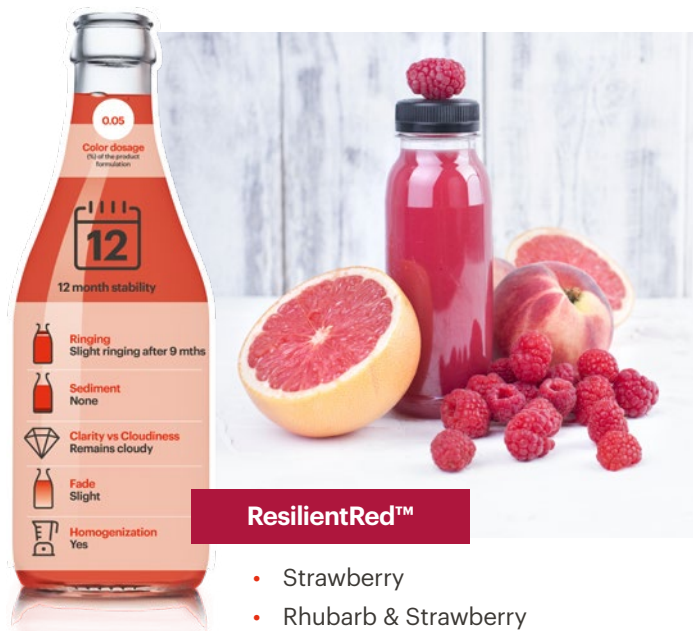
The results of the study highlighted four standout shades in the series that were truly top performers over the 12 months:



- Blood Orange; at lower dosage
- Pink Grapefruit
- Pink Lemonade
- Alternative to synthetic Lycopene



- Lemon
- Good Safflower alternative



- Strawberry
- Rhubarb & Strawberry
- Summer Fruits
- Alternative to synthetic Lycopene



- Energy Drinks
- Fruit Punch
- Peach
- Iced Tea
- Fantasy-type flavors

Replacing artificial colors

The increasing consumer preference for less artificial ingredients and the regulatory considerations that follow means that more manufacturers are compelled to rethink their current product recipes. For manufacturers facing reformulation challenges in an attempt to shed synthetic colorants in their beverage products, Lycored's cast of super stable, colors from natural sources can offer vibrant, stable alternatives to the leading artificial equivalents.

Lycored's team works closely with beverage processors and manufacturers and offers to facilitate the switch to natural colors without sacrificing stability or visual appeal. Colors derived from our Lycopene and Beta-Carotene formulation science offer colorations that present hues more naturally, avoiding neon effects or loud brightness that may be off-putting to consumers in particular applications.



Synthetic Lycopene can be replaced with all of the red shades offered including Steadfast Scarlet, ResilientRed And ConstantCrimson shades – even in dark conditions, synthetic Lycopene has a tendency to fade quickly. Our natural Lycopene colors perform much better than what can be made synthetically.

Tartrazine can be replaced with StellarYellow. Already prohibited in Europe following studies linking it to hyperactivity in children, tartrazine is still used in some yellow beverages in the US.

Conclusion

Using natural colors is a great way to enhance a product's consumer appeal in today's market where artificial ingredients are under increasing scrutiny. And the great news is that using natural colors in a beverage product does not mean sacrificing stability, shelf-life or visual appeal. In fact, with Lycored's super stable colors across red, orange, gold and yellow spectrum, shelf life can actually be extended while providing consistent visual quality over processing and shelf life cycle.

Lycored continues to deliver great science and even greater application experience to the beverage industry. From nature to consumer, our colors bring natural vibrancy and appeal to thousands of products that people enjoy every day.



¹FMI LI Transparency Imperative Report

²Mintel, Beverage Flavors to Watch

³Simmons National Consumer Study, Spring 2018.



Resolute reds that endure

Natural reds emerge as the best performers in UHT stability tests



Lycored tested the stability of two of its natural red Lycopene based colors versus the artificial colorant Red 3 (Erythrosine) during and after UHT (ultra high temperature) processing in a flavored milk drink matrix. Accelerated shelf life tests were carried out to evaluate the stability of the colors when exposed to light, dark and ambient conditions, simulating real-life storage, transportation and retail environments.

The natural colors outperformed the artificial color across all tests, demonstrating that there are considerable advantages to selecting Lycopene based red shades over other artificial or natural colors for UHT applications.

Consumers make the natural choice

Consumers everywhere are voicing a clear preference for natural rather than artificial colors.

According to Nielsen's August 2016 report on ingredient trends, 61% of consumers internationally say they try to avoid artificial colors, rising to 65% in the Asia-Pacific region. Savvy food and drink manufacturers are responding to this strong consumer sentiment by replacing artificial colors with natural colors in recipes. The number of new product introductions with natural colorants in Europe grew by 5.6% in 2015, compared to a decline of 5.2% for artificial colors.

This long term shift away from synthetic colors and towards natural ones is expected to continue for the foreseeable future, as more and more food and drink manufacturers convert to natural. Those who don't, risk alienating consumers and turning them on to alternative products that have embraced the natural trend.

However, natural colors can be more challenging to work with. In particular, they tend to be more sensitive to pH, UV light and extreme temperatures. In some food and drink applications, these technical barriers make it difficult to find a stable natural replacement.

Ultra challenging applications

One problem application is UHT treated dairy products, such as flavored milk drinks. Manufacturers of these products have historically been reluctant to switch to natural colors owing to concerns about their ability to withstand the UHT process and remain stable throughout the product's shelf life at ambient conditions.

Indeed it is true that natural colors can be prone to fading or degradation when subjected to heat processing, and that the higher the temperature, the more marked the color loss is likely to be.

In direct UHT heating or 'direct injection', steam is briefly injected into the product, and this is rapidly followed by flash cooling. The brevity of the treatment makes it possible to achieve very high product quality, but the exposure to temperatures of 143°C, albeit brief, can be at the expense of color degradation. With indirect heating, the product does not come into direct contact with the heat source, but is instead heated using heat exchangers. Whilst slightly less harsh than direct methods, indirect methods still subject the colors to temperatures of over 120°C and may therefore lead to color loss.

The last few years have seen the development of natural green, yellow, orange, and brown colors that are suitable for use in UHT applications. However, finding successful and robust red/pink natural alternatives has been more problematic, with the colors either being destroyed immediately after processing, changing shade under the neutral pH conditions or fading during storage.

Lycored has drawn on 20 years of Lycopene research to come up with a stable natural color solution that offers unrivaled technical performance in UHT applications. Our natural red to pink shades from Lycopene are derived from non-GM tomatoes grown on farms in Israel and California. Drawing on the power of carotenoid based pigmentation, they offer a more robust alternative to sensitive natural colors such as beetroot and anthocyanins, as well as carmine, which is not vegetarian-friendly.

What's more, a recent study conducted by Lycored found that Lycopene based red shades to be even more stable than artificial colors in a UHT flavored milk drink matrix.

In direct UHT heating or 'direct injection', steam is briefly injected into the product, and this is rapidly followed by flash cooling.

Reds put to the test

Lycored ran a trial to establish the stability of its Lycopene based red colors following UHT processing.

Three strawberry flavored milk drinks were prepared: one colored with ResoluteRuby A, one colored with ConstantCrimson A and one colored with Red 3.

UHT stability

Immediately after the UHT treatment, the researchers measured the samples for any changes in color using HunterLab's color measurement software and the DeltaE method of calculation. Under this system, a DeltaE score of 2 or below indicates that there has been no change that is visible to the naked eye.

ResoluteRuby A and ConstantCrimson A both performed exceptionally in this test, with the samples that had been subjected to the harshest direct injection treatment achieving DeltaE scores of 0.52 and 0.67 respectively. Red 3, by contrast, scored 10.55, showing that this artificial color had experienced a dramatic variation in color during the direct injection process.



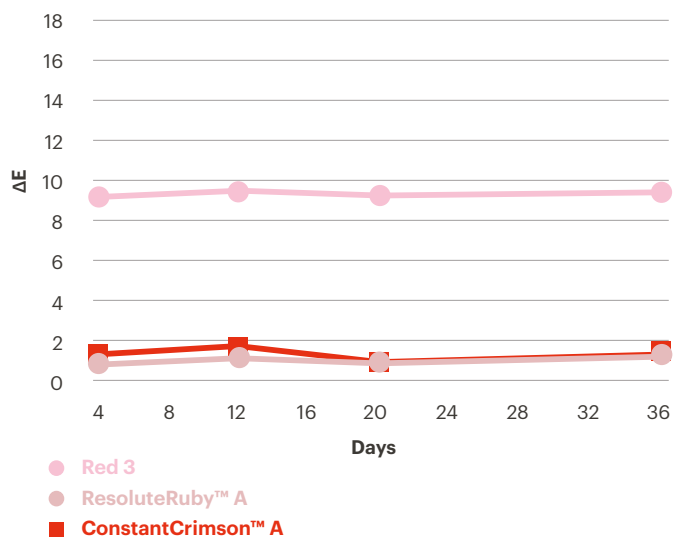
Accelerated shelf life tests

Lycored's scientists also evaluated the performance of the colors in accelerated shelf life tests. These simulated the harshest possible conditions during transportation and storage and whilst on sale in store.

In a test to determine the color stability of the UHT strawberry drinks in ambient conditions the Lycopene based colored drinks outperformed the drinks made with the artificial Red 3. After six months at ambient temperatures of between 25 and 40°C, there was no visible difference in the color of the Lycopene based drinks, with both registering DeltaE scores of 2 or under. However, there was a marked difference in the color of the Red 3 drink (DeltaE score of over 9). This demonstrates that drinks colored with Lycopene shades will retain their color over a long ambient shelf life.



Table 1: Ambient conditions: UHT Injection Downstream



The drinks were exposed for extended periods to 24/7 light (6000 lux) to test their light stability. This is a limiting factor with colors based on beetroot or turmeric, and precludes their use in UHT products that are designed for a chiller cabinet environment or packaged in a transparent or sleeveless bottles.

After 36 days, the Red 3 drink displayed a significant color variation (DeltaE score of 17), whereas there was no discernible change in the brightness of the Lycopene red colored drinks, confirming their suitability for the chiller aisle.

In a final test, the drinks were kept in an incubator in the dark at a temperature of 40°C, to establish their ability to remain stable during warehousing and transportation. The Lycored red colored samples were able to withstand 40°C heat in incubation conditions over 30 days without any discernible impact on color, but the color of the Red 3 sample underwent a considerable variation. This shows that drinks colored with Lycopene shades can be transported via ambient rather than cold chain distribution - particularly beneficial in hotter climates.



Table 2: Light Stability: UHT Injection Downstream

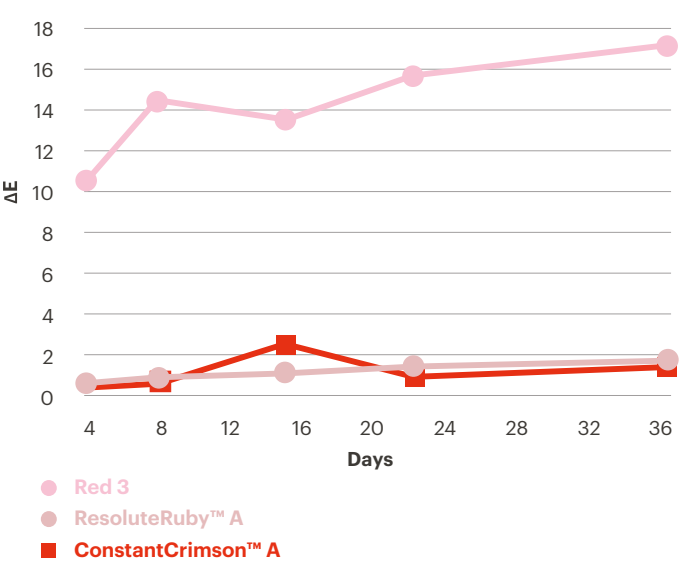
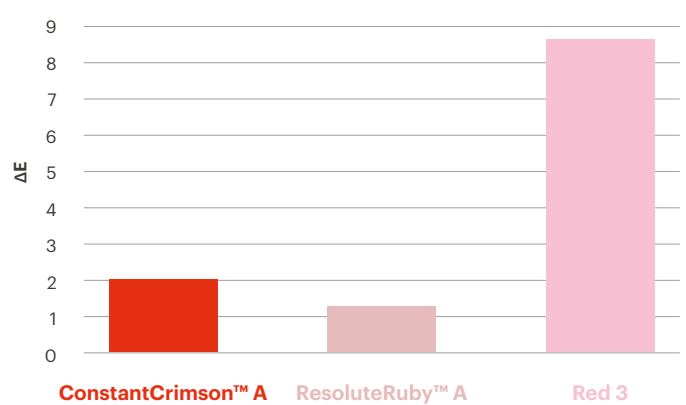


Table 3: 30-day Incubator Stability: UHT Injection Downstream



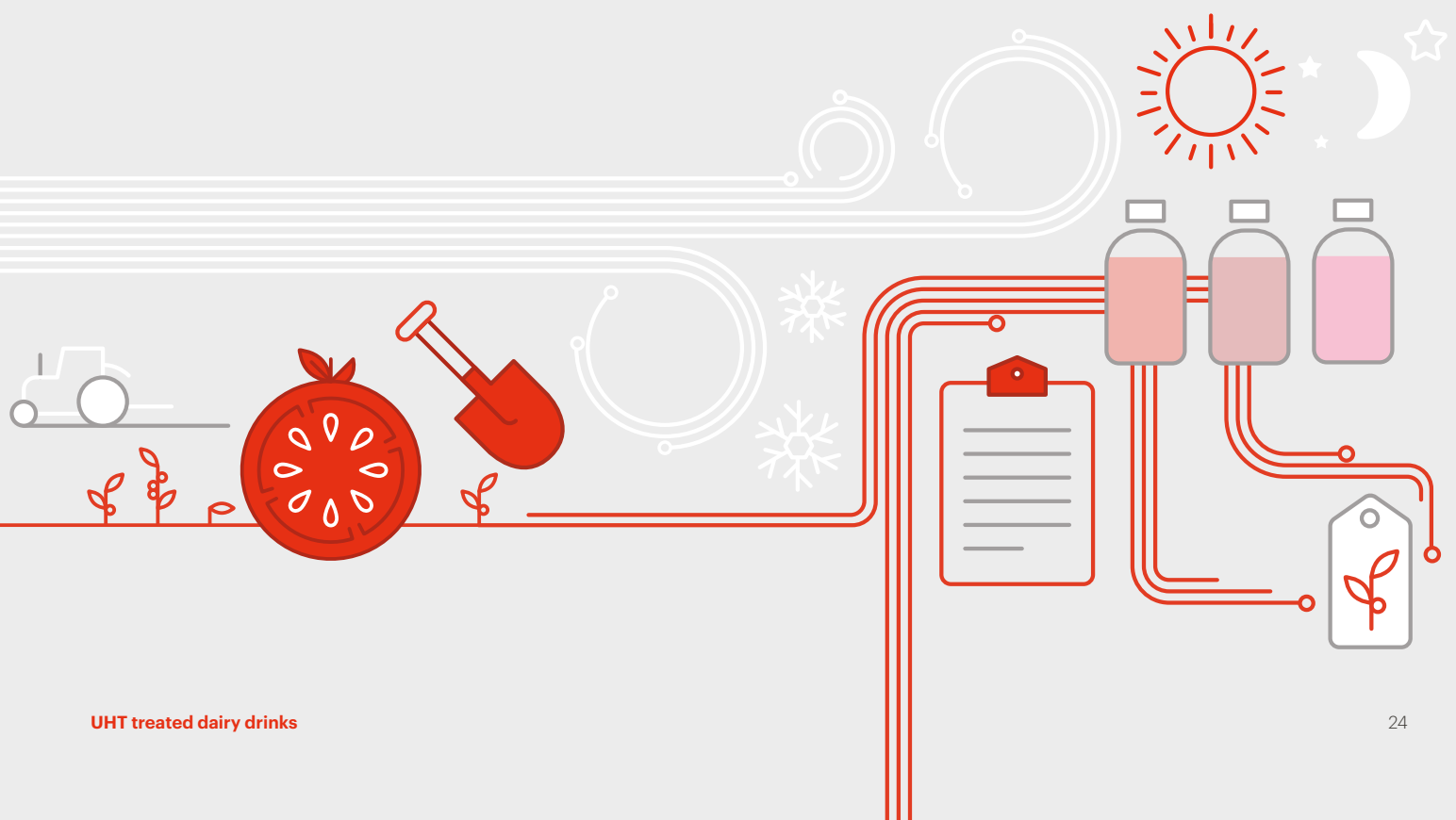
Color with confidence

In summary, the trial proved that Lycopene based natural red colors ResoluteRuby A and ConstantCrimson A can withstand even the most demanding processing and storage conditions. They are more robust, have a longer shelf life and offer more packaging, display and storage flexibility than their artificial counterparts. This has far-reaching and exciting implications for manufacturers of UHT milk products who may have been deterred from switching from artificial to natural colors due to quality and stability concerns.

From a marketing and positioning perspective, this opens up much-needed opportunities for developing milk beverages with a 'natural' or 'free from' sell, in a category that is currently lagging behind in this respect. Lycopene based red colors can simply be declared as 'Lycopene from red tomatoes' on the label, allowing companies to achieve much sought after clean label status that has thus far eluded this category. It also gives manufacturers of UHT milk products access to the chiller cabinet, and with it, the chance to give their products a fresher and more natural positioning.

Benefits of using Lycopene based natural red shades versus artificial colors

- Can withstand even the most demanding processing and storage conditions
- Longer shelf life and more packaging, display and storage flexibility than artificial colors
- Clean label status, can be declared as 'Lycopene from red tomatoes'
- Enhances the natural positioning of products





Starting bright and staying bright

Natural and healthy colors for gummies and hard-coated candies



CONTENTS:

- New consumer insights into Natural versus Artificial colors in candy
- Testing the performance of carotenoid-derived colors in gummies and hard-coated candies

Coloring confectionery naturally - the challenge for industry

In recent years, the most important story in the market for food colors has been the growth in demand for naturality. This has largely been driven by health concerns, particularly for children. Some artificial colors have been linked with health scares, resulting in negative scrutiny from regulators. In Europe, the “Southampton Six” study, which found a possible link between some artificial colors and increased hyperactivity, led to major European changes in food labeling¹.

Similarly, the ‘Seeing Red’ report from the Center for Science in the Public Interest has raised awareness of issues with artificial reds in the US². And while consumers may not be fully aware of the details of the scientific studies, they have certainly got the message that artificial colors are associated with health risks. In the confectionery segment, questions about colors are part of a broader set of health concerns. Rising childhood obesity means parents are wary of high sugar levels, while sweeteners such as high-fructose corn syrups are also negatively perceived.

Meanwhile, there is a historical perception that natural colors may be harder to work with. In many cases this is true: some naturally derived colorants are sensitive to pH, UV light and extreme temperatures. Here we set out the results of three important new pieces of research for the confectionery industry: a consumer study on the attitudes of children and their parents to colors in candy, and separate stability trials testing the performance of Lycored’s colorants in Vitamin-C enriched gummies, and in hard-coated candies.

Lycored’s carotenoid-derived colors for confectionery

Lycored offers a range of versatile carotenoid based color solutions for confectionery. Its range of pinks to reds is sourced from natural Lycopene from tomatoes and yellow to orange is extracted from the company’s own strain of *Blakeslea trispora* fungus.

Both have been shown to be super stable in a range of applications, standing up well to tough processing conditions such as extremes of heat and light, and high levels of ascorbic acid. Sourced naturally from plants, they are vegan, kosher and halal, non-GMO, and have global regulatory approval for use in confectionery. Lycored offers both a shade of red (ResilientRed C) and a shade of orange/gold (OrangeOvation D) that are specifically formulated on sugar syrup for optimum use-friendliness in hard-coated confectionery.

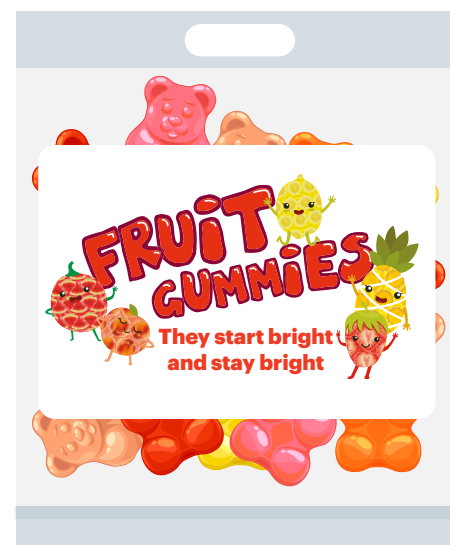
Natural v artificial colors in candy – what kids and their parents think

Lycored commissioned consumer research to gain new insights into the way children, and their parents, respond to colors in confectionery. The aim was to better understand the impact of natural versus artificial colors on liking and purchasing decisions.

Researchers conducted real-time, face-to-face, 30-minute interviews with ten children (aged between 5 and 13, with an even gender mix) and their parents.

All participants were regular purchasers and consumers of gummy candy and/or fortified vitamin gummies. Each parent-child pair was sent an unbranded bag of gummies colored naturally with Lycored colors and another bag of gummies made by the same manufacturer but colored artificially. The gummies with Lycored’s colors were fortified with Vitamin C, which subjected them to extra stress. The interview participants were asked to visually examine the two bags of candy and answer questions about them.

“In the confectionery segment, questions about colors are part of a broader set of health concerns.”

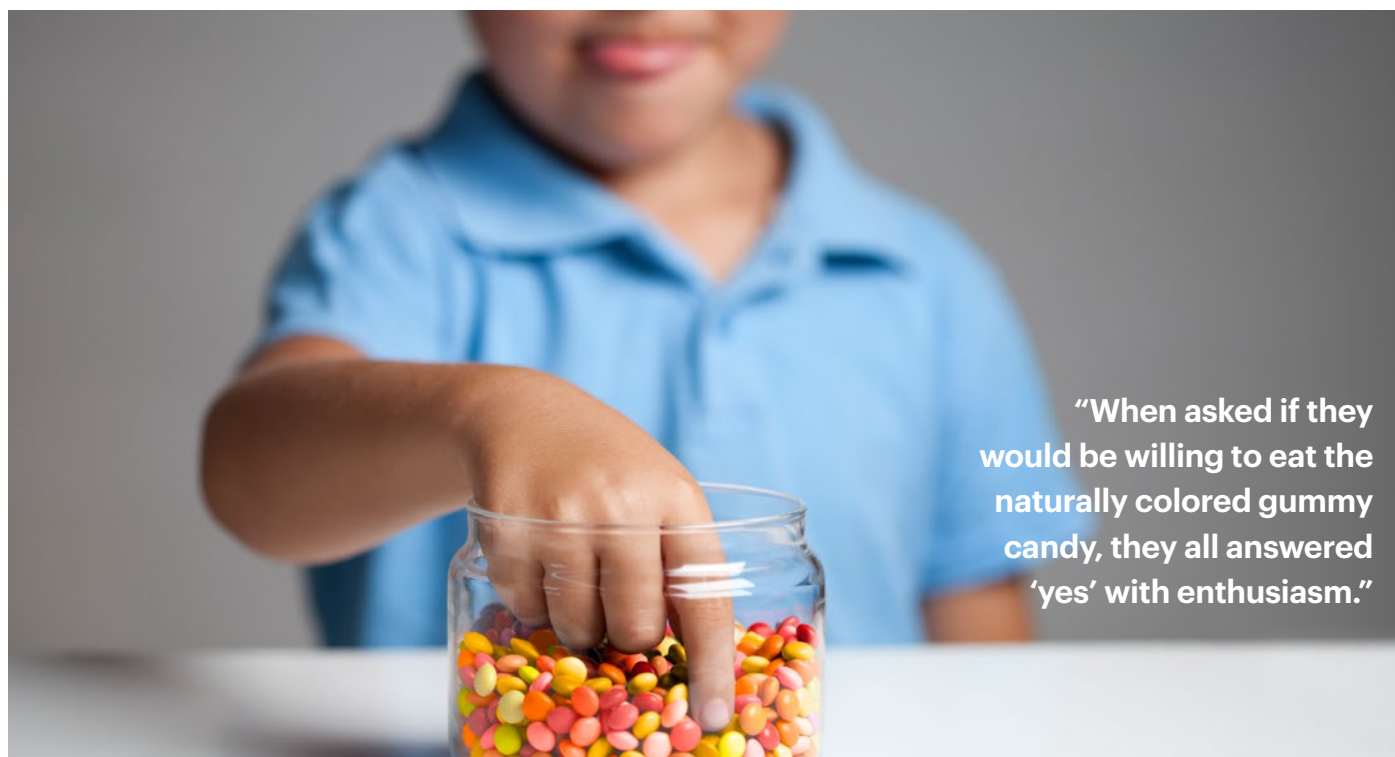


For kids, candy is candy

The children and their parents were all able to distinguish between the naturally colored candies and the artificial ones (although in some cases this required careful scrutiny).

The children tended to prefer the brighter, artificial colors to the more muted natural ones.

However, crucially, they were excited about all of them. When asked if they would be willing to eat the naturally colored gummy candy, they all answered yes with enthusiasm: One typical response was: “Of course, it’s candy! They are both candy - I would eat both of them!” In other words, for kids candy is candy, and natural colors definitely do not appear to be a “deal-breaker”.



“When asked if they would be willing to eat the naturally colored gummy candy, they all answered ‘yes’ with enthusiasm.”

Parents see the benefits of natural, clean label

Although the parents interviewed did not actively seek out candy with natural ingredients, most were aware that artificial coloring is not a healthy option for their children.

They said the Lycored-colored candy appeared to contain less sugar and assumed it would be lower in other unattractive ingredients, such as high-fructose corn syrup. Meanwhile, they expected the artificially colored candy to contain more additives, more chemicals, and more artificial sweeteners, as well as sugar. Even some of the children surmised that the brighter colored gummies would contain more artificial food coloring.

Most of the parents said they viewed candy as a treat and made allowances for sugar content and artificial features. However, most also said they read nutrition labels on confectionery products. Primary items of interest or concern were sugar content, serving size, artificial dyes,

high-fructose corn syrup (which was called out by many without prompting), artificial sweeteners, calories and carbohydrates. Some recounted negative effects of artificial colors on children’s health and one mother attributed childhood obesity to unnatural additives in candy.

As well as concerns about known “baddies”, there was a desire to avoid unrecognizable or unpronounceable ingredients. When asked what would deter them from buying a product, one said “whether there is tonnes of artificial coloring garbage”. Others mentioned “a long list of things I don’t recognize...” and “really long words that I don’t know what it is!”

There was a higher expectation that vitamin-enriched candy would be colored naturally. Participants said that if they were buying nutritional gummies, they would expect them to be healthier and would scrutinize the ingredients more carefully.

When all factors are equal, the preference is for natural

The research revealed that taste is king, with flavor expectations the most important driver of liking and re-purchase. There was also a strong association with the color of the product and perceptions about the strength of flavor.

However, it is worth noting that most participants did not understand that the coloring of the candies was not the source of their flavor. When all other factors were equal, and they knew they would not have to sacrifice taste, the parents voiced a clear preference for natural colors, saying they would prefer to feed their kids healthy options. One said: "I would prefer to go the natural ingredient way, my only concern would be how it would taste."

Once they understood that the taste would be the same – and their children would eat them – the parents said they would buy candy colored naturally. As one put it: "I would probably choose [the naturally colored candy] especially if the tastes are similar. I would rather have the natural than the artificial with the red dyes and different things like that." Even some of the children said they might opt for the natural options. "It looks like there's more dye in it", one said of the artificially colored product. "That might also not be a good thing, so I might choose (the naturally colored candy).

Furthermore, some of the parents said they would be willing to pay a little more for naturally colored products, as long as the taste was not compromised. Comments included: "If I can find a natural one that has less extra stuff in it that they'll still eat, then I'll buy that, even if it's extra (additional cost)."

Potential for consumer education

There is therefore significant opportunity in the gummy vitamin space for natural coloring, and clear benefits for manufacturers who use natural colorants. However, consumers need more assurance that natural coloring will not diminish flavor. Packaging cues could help bolster confidence in the flavor appeal of naturally colored products.

Furthermore, Lycopene can add value in the fortified gummy category. Initially, the parents interviewed were unaware of it, but when its benefits for the heart and skin were explained, it was highly appealing to them. More consumer education around Lycopene and its added benefits would be helpful, especially among the health-conscious demographic.

Stability tests in fortified gummies

Lycored also set out to test the performance of its carotenoid-derived colors, from both Lycopene and Beta-Carotene in Vitamin C-fortified gummies.

Researchers carried out accelerated and real time shelf life stability tests on gummies with six different colors representing various fruit types: red (strawberry), pink (watermelon), and orange (orange), peach (peach), yellow (lemon and pineapple). They were aligned with those fruit flavors and fortified with Vitamin C. These naturally colored samples were compared with gummies containing an artificial colorant but produced by the same manufacturer. With the exception of the Vitamin C, the ingredients were generally the same.

The accelerated test was carried out for ten weeks. All the samples were subjected to light conditions of 4000 Lux at 21°C. The real-time tests are ongoing at the time of writing and will continue for a total of six months.

The natural colors from Lycored showed great starting shades, with true to fruit character compared to the synthetic alternatives. Their stability was strong under the intense light conditions, and similar to that of the synthetic colors, even with the additional stress of the Vitamin C content.

Pineapple Color

Accelerated light & temperature effect: 1 vs. 9 weeks.



StellarYellow A 0.01%
5ppm Beta-Carotene

Lycored Natural Pineapple

Pantone: 142C
RHS: YELLOW-ORANGE, GROUP 16
Light Orange Yellow B



Synthetic Dark Yellow

Pantone: 1295CP
RHS: YELLOW, GROUP 7
Brilliant Yellow A

Peach Color

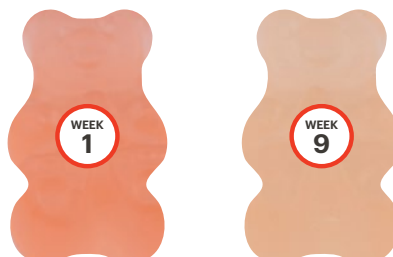
Accelerated light & temperature effect: 1 vs. 9 weeks.



OrangeOvation A 0.02%
4ppm Beta-Carotene

Lycored Natural Peach

Pantone: 163C
RHS: ORANGE, GROUP 29
Light Orange B



Synthetic Peach

Pantone: 1635CP
RHS: ORANGE-RED, GROUP 33
Moderate Yellowish Pink D

Orange Color

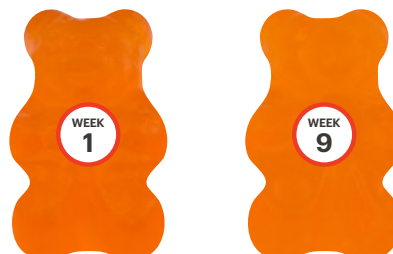
Accelerated light & temperature effect: 1 vs. 9 weeks.



OrangeOvation C Clear 0.1%
1ppm Lycopene

Lycored Natural Orange

Pantone: 144C
RHS: ORANGE GROUP 24
Strong Orange A



Synthetic Orange

Pantone: 158CP
RHS: ORANGE GROUP 28
Vivid Orange B

Watermelon Pink Color

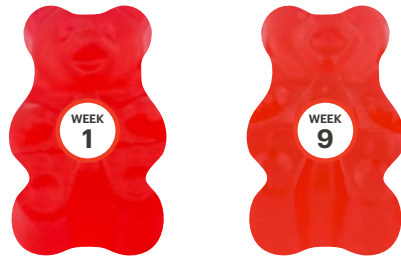
Accelerated light & temperature effect: 1 vs. 9 weeks.



ResilientRed A 0.03%
6ppm Lycopene

Lycored Natural Watermelon Pink

Pantone: 1635CP
RHS: ORANGE-RED GROUP 32
Strong Yellowish Pink D



Synthetic Light Red

Pantone: 7626CP
RHS: RED GROUP 41
Strong Red B

Strawberry Red Color

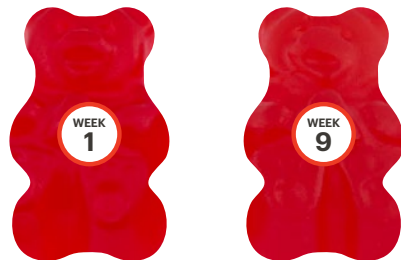
Accelerated light & temperature effect: 1 vs. 9 weeks.



ResilientRed A 0.08%
16ppm Lycopene

Lycored Natural Strawberry Red

Pantone: 2033CP
RHS: RED GROUP 42
Strong Reddish Orange B



Synthetic Dark Red

Pantone: 199C
RHS: RED GROUP 46
Vivid Red C

Lemon Color

Accelerated light & temperature effect: 1 vs. 9 weeks.



StellarYellow C Clear 0.01%
3ppm Beta-Carotene

Lycored Natural Lemon

Pantone: 141C
RHS: YELLOW-ORANGE, GROUP 16
Light Orange Yellow C



Synthetic Light Yellow

Pantone: 1205CP
RHS: YELLOW, GROUP 10
Pale Greenish Yellow D

Lycored's colors all remained true to fruit in their natural color hues but their performance differed slightly. For example, the yellows and oranges displayed bright starting shades, and retained them, while the reds were more muted.

Colorful coats for hard-coated candies

Testing the stability of colors in hard-coated confectionery

Lycored's ResilientRed C and OrangeOvation D variants are specifically formulated on sugar syrup for optimum user-friendliness in hard-coated confectionery. The company set out to find out how they stood up to the rigors of the hard-coating/panning process over shelf life.

A technical stability review was carried out by pan coating application and coating performance experts. They produced six batches of hard-coated chocolate lentils and six batches of chewy toffee centers. They were coated with opaque bases from two different materials – QUICK WHITE from Norevo (a fine white powder from a mixture of sugars and natural hydro-colloids) and Titanium Dioxide.

A range of Lycored's yellow, red and orange shades (ResilientRed C, OrangeOvation A, and StellarYellow A) were added into a total of 15 layers of coating. They were tested for four weeks at temperatures of 20°C, 25°C, 30°C, and 35°C in clear plastic bags and in humidity-controlled environment. Further accelerated shelf-life trials to stress-test capability in intense light conditions are ongoing.

Challenges, results and learnings

The experts who conducted the trial highlighted some potential concerns relating to the coloring of hard coatings. For example, working with water-soluble colors (such as fruit and vegetable concentrates or synthetic colors) can be challenging. When sugar crystals start to grow, the coatings can become white and dusty. Red colors can be particularly difficult to work with as they have a tendency to become dusty and mottled after crystallization while powder maltodextrin can also be problematic because it disturbs crystal formation.

Excellent performance at 4 weeks

3 colors on both chocolate, hard chocolate cores and chewy toffee soft cores: 15 layers of coating. Tested with Titanium Dioxide and Quick White at temperatures of 20, 25, 30 and 35° Celsius.



Slightly superior performance with Titanium Dioxide vs. Quick White

Colors with Titanium Dioxide v with Quick White



Lycored's carotenoid-derived colors are oil based pigments so do not suffer from any of these problems. They all performed very well in both coatings, but achieved a particularly vivid performance with the Titanium Dioxide.

Conclusion

Confectionery is different from many other categories. Parents view it as a treat and health concerns are rarely the most important driver of purchase choice. Nevertheless, as our consumer research shows, when factors such as flavor are removed from the equation, naturality and clean label become more important.

Meanwhile, our stability trials demonstrate the high performance of Lycopred's carotenoid derived colors in both Vitamin C enriched gummies and hard-coated candies, adding to their appeal as a natural choice for confectionery.



¹McCann D. et al (2007) 'Food additives and hyperactive behaviour in 3-year-old and 8/9-year-old children in the community: a randomised, double-blinded, placebo controlled trial' Lancet, 370, 1560-1567.

²Center for Science in the Public Interest, 'Seeing Red: Time for Action on Food Dyes (2016) <https://cspinet.org/resource/seeing-red-time-action-food-dyes>



Achieving the gold color standard

An overview of Lycored's GoldHold™ A Dry powder based applications



All that glitters...

All that glitters is not necessarily gold so the old saying warns; but just because something looks attractive on the surface, it doesn't mean it's value is only skin deep. Just ask the food and beverage industry which continually seeks effective ways to polish the sheen and enhance the appeal of its golden-hued drinks, snacks and deserts. Although many yellow and orange shaded colorants promise vibrant visual appeal to food and beverage products, they may fall short in production and on consumer shelves, presenting poor processing attributes and color stability issues.

How food presents itself visually has always influenced its appeal both before and during consumption. A recent study by Emerald Insights found that 90% of shoppers decide whether to buy a product solely based on color and perceived taste¹.

In this paper we examine these issues and outline how a new standout, all-natural gold color solution from Lyncore can address food processors' toughest coloring challenges and achieve cleaner labels for their best-selling orange, yellow and golden-hued products. GoldHold™ A Dry sets a new gold color standard across a multitude of applications in both food and beverage.

¹ <https://www.emeraldinsight.com/doi/abs/10.1108/00251740610673332>

"90% of shoppers decide whether to buy a product solely based on color and perceived taste."



Good as gold

Gold has always been the color of prosperity, health and wealth, and these hues have earned a permanent place appetizing people's palettes. From amber waves of grain, to apple pie, custard and lemonade, shades of gold, orange and yellow are found in a variety of consumer favorites.

According to one industry insider, consumers 'have come to associate shades of gold with savory, indulgent flavors thanks to beloved food products like macaroni and cheese, buttered popcorn and slices of pre-packaged cheddar. More vibrant varieties of yellow and orange can also hint at citrus flavors in beverages, candy, ice cream and yogurt categories.'²

Attaining the rich golden/orange/yellow hue that will appeal to consumers can be challenging. Even popular synthetic colorants in this color range are notorious for stability issues and blending and processing attributes that can have a real impact on shelf life, color matching accuracy and cost.

This challenge is being compounded further by the clean label movement. According to Nielsen's August 2016 report on ingredient trends, 61% of global consumers say they try to avoid artificial colors.

When asked directly "would you be willing to pay more for a product with natural flavorings and colors?", almost nine in ten respondents to a Lycored-sponsored study (88%) said they would. On average they said they would pay up to 47% more.

² <https://www.fooddive.com/news/natural-food-color-trends/435907/>

Shades of gold

It's true achieving a warm, golden shade of yellow or orange in your food or beverage product can add a new dimension of visual and sensory appeal. Where would French vanilla ice cream and eggnog be without it? But getting there with all-natural ingredients can still be challenging for dairy, confectionery and dry mix categories.

Chefs from ancient times sourced a number of colors direct from Mother Nature to make their recipes more visually appealing. Eschewing synthetic colorants, modern chefs and food engineers are returning to these methods on a more industrial scale.

Many food brands are now sourcing yellow and orange tones from sorghum, Thai starfruit, carrots and pumpkins. In addition, paprika and annatto extract are two of the more popular natural gold-color sources.

Currently, food processors have a limited amount of choices when it comes to all-natural colorants. Dairy product processors also face technical challenges. Natural colors are often less stable under neutral pH conditions and tend to oxidize when exposed to UV light and extreme temperatures.





SAFFLOWER (*Carthamus tinctorius*) is a herbaceous, thistle-like annual plant. It is commercially cultivated for vegetable oil extracted from the seeds. Restrictions and processing barriers include:

- Regulatory restrictions
- Not globally accepted
- Not allowed in US



TURMERIC (*Curcuma longa*) is a flowering plant of the ginger family, Zingiberaceae, the ground roots of which are used to add color and spice popular Asian cuisines. Restrictions and processing barriers include:

- Shade may offer gray tint
- Not a true yellow
- Sensitive to light
- Can get bitter at higher dosages



ANNATTO (*Bixa orellana*) is an orange-red condiment and food coloring derived from the seeds of the achiote tree native to tropical regions from Mexico to Brazil. Restrictions and processing barriers include:

- Perceived to cause allergic reactions
- Can cause pink crystals in cheese at pH above 4.5–5
- Not allowed to have traces existing in whey by-product from cheese manufacture, if used in infant formula

Lycored's all-natural, stable Beta-Carotene based colorants offer a more robust alternative to sensitive natural yellows derived from sources described above.



GoldHold™

GoldHold™ A Dry is the versatile gold star among Lycored's range of colorants. This fine, free flowing orange powder from natural Beta-Carotene pigment enables formulators to create pleasant golden shades across flavor types and applications.



Disperses well in both water and milk



Neutral taste



Non-GMO



Suitable for vegetarians & vegans



Allergen free



Gluten free



Palm oil free



Kosher and halal



Can be a 1:1 replacement for artificial Beta-Carotene in many applications

Application success

For food processors going for gold, GoldHold Dry A has a proven application track record that alternatives don't match. In the following product categories, GoldHold Dry A demonstrated successes thanks to its excellent range of pale to dark yellow/orange colors, adjustable dosage depending on the color target and easy dispersal when mixed with water or milk:

Dairy Based Beverages

- Milkshakes (e.g. banana)
- Whey protein type sport blends



Ready to Drink Beverages

- 0% juice sports drinks (mango, pineapple, lemon)
- RTD beverages - a great 1:1 alternative replacement for synthetic Beta-Carotene



Bakery & Confectionery

- Water icing
- Baked products such as croissants
- Bakery creams – vanilla or custard creams
- Cream fillings in confectionery and bakery (biscuits)
- Buttercream icings for bakery



Conclusion

Food engineers and processors are under tremendous pressure to meet the competing demands of 'Tastes Good', 'Looks Good', and 'Good for You' and this is no different for golden and yellow-hued food and beverages. GoldHold Dry A offers a new gold standard in this coloration area that means food processors no longer have to make any compromises on taste or visual appearance when they use a naturally sourced coloration ingredient.



Natural, healthy, stable

New insights into color
formulations for hard cheese

CONTENTS:

- Consumer research on the importance of color in cheese
- Testing the stability of Beta-Carotene
- Why Beta-Carotene is the preferred choice for color in cheese

Ever since humans began eating cheese, color has been an important indicator of quality, value, and taste.

As long ago as the sixteenth century it was known that the natural color in milk was carried through to the curd in higher levels in summer when the cows were eating fresh grass. Today, the color of cheese still exerts a powerful effect on consumers, significantly influencing flavor perception and liking.¹

In addition to such associations, other important factors affect the choice of cheese color and the methods used to achieve it. These include demand for naturality, concerns about health and regulatory requirements.

Lycored works closely with manufacturers to help them find the right shades for cheeses.

As part of that commitment we have gained new insights into the importance of color to today's consumers. We have also looked at the performance of two common cheese colorants, annatto and Beta-Carotene, in Cheddar-type cheese and alternative hard yellow cheese varieties.

OrangeOvation & GoldHold: a range of Beta-Carotene-derived colors for cheese

Beta-Carotene, an antioxidant and yellow pigment that occurs naturally in grass, might be seen as the original colorant for cheese. It dissolves when cows chew cud but becomes visible during the manufacturing process, lending a natural buttery yellow color to cheeses from grass-fed cows.

Lycored offers a range of Beta-Carotene-derived shades for cheese. Our OrangeOvation and GoldHold can provide unique shades from yellow to orange for hard cheeses.

Because we produce our OrangeOvation and GoldHold families of formulations from our own strain of *Blakeslea trispora* fungus and control every step of production, we can ensure maximum safety, potency and efficacy. The colorants in the range are also highly stable under a wide range of pH, light and high-temperature conditions.

“Lycored works closely with manufacturers to help them find the right shades for cheeses”

The importance of color in cheese – new consumer insights

We commissioned expert researchers to gain new insights into the role played by the color of cheese in today's market. They carried out an online survey of 1000 consumers, 500 each in the UK and the US (two of the world's biggest consumers of hard, colored, cheese). We screened for people who had bought hard cheese, such as cheddar, in the last three months.

Respondents were divided into two segments: in each country, there were 250 'cheese lovers' (who consumed hard cheese at least once a week) and 250 'cheese likers' (who consumed hard cheese at least once every few months).

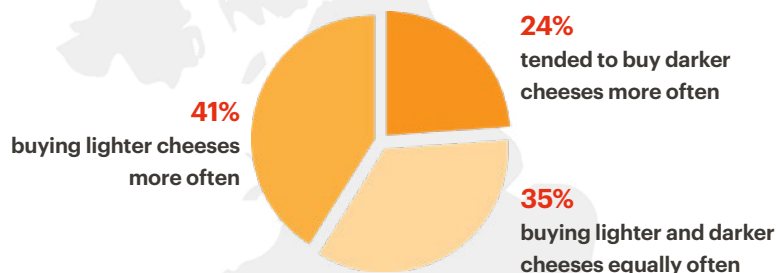
They were shown a series of images and asked questions to gauge the role color plays in their perceptions and decisions.

UK results

Color was rated as either very or extremely important by 40% of UK respondents, similar to the number who considered brand and producer very or extremely important.

Over half (57%) said that color usually affected how much they like the taste of cheese and that they expected cheese to have a certain level of color (59%). A small majority also said they used color as a guide to flavor (53%); that they thought more intensely colored cheeses tend to have more flavor (54%); and that they prefer more intensely colored cheeses (56%).

There was a wide spread of opinion as to which shade is ideal for Cheddar, although there was a tendency to prefer lighter shades.



Attributes associated with darker shades of Cheddar were:

mature, expensive, premium quality, sharp, bitter, nutty and **vintage**.

Those associated with lighter shades were:

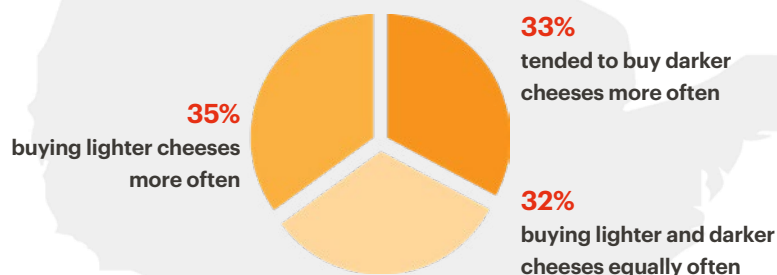
natural, healthy, sweet, mild, moist, good for snacking, good for sandwiches and **melts easily**.

US results

The color of cheese had even more significance in the US, with over half (52%) of consumers rating it as either very or extremely important. This was similar to the numbers who rated weight/size of piece, brand/producer, maturity level and packaging type as important.

Seven in ten (70%) of the American consumers agreed with the statement **"The stronger/deeper the color of the cheese, the stronger the flavor intensity."** A similar number (68%) said that color usually affected how much they like taste, with 65% agreeing with the statement **"I expect hard cheese to have a certain level of color."**

In contrast to the UK, US consumers tended to think darker shades were ideal for Cheddar cheese, although again there was a wide spread of opinion. However, darker and lighter cheeses had similar popularity when it came to purchase choice.



In other words, color has a major influence on decision making and perceptions of quality, taste and value for consumers, albeit in slightly different ways in the UK and the US.

Attributes associated with darker shades of Cheddar were:

mature, expensive, sharp, bitter, salty, nutty, vintage and **dry in texture**.

Those associated with lighter shades were:

natural, sweet, mild, moist and **melts easily**.



UK: Just about right: 30%



UK: Just about right: 24%



UK: Just about right: 19%



US: Just about right: 27%



US: Just about right: 20%



US: Just about right: 10%

Growing concerns about annatto

Annatto, a yellow-orange colorant from the seeds of the achiote tree, has been used to color cheese for hundreds of years. It is currently the most popular cheese colorant globally but is coming under increasing scrutiny from regulators and manufacturers due to concerns about safety.



EFSA research

Following a request from the European Commission, the EFSA Panel on Food Additives and Nutrient Sources added to Food (ANS) was asked to re-evaluate the safety of five annatto extracts processed in different ways.²

It concluded that the safety of the solvent-extracted bixin and norbixin (E160b(i)), alkali-extracted annatto (E 160b(ii)) and oil-extracted annatto (E 160b(iii)), could not be assessed due to the lack of data.

The Panel recommended that they be replaced with other annatto extracts, but the research has cast doubt on the safety of at least some annatto food colors.



Regulatory and technical burdens of using annatto

The presence of annatto has long been a concern for infant formula manufacturers using whey. At a minimum, they demand proof of zero trace of annatto in the whey that they purchase in order to comply with regulatory requirements such as EC Regulation No 1333/2008, which excludes infant formula from the “carry-over” principle.



Concerns about adverse reactions

Several studies have raised concerns about allergic reactions linked to annatto³⁴⁵⁶⁷.

Beta-Carotene: the preferred choice for cheese

Beta-Carotene is an ideal choice for cheese for four key reasons:



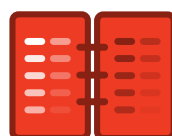
No maximum regulatory levels

In the US, Beta-Carotene is authorized as food additive CFR 73.95 and regulations state that it “may be safely used for coloring foods generally”. In cheese it can be used with no maximum limit (according to GMP) except in cheeses with colors that have been standardized. Any cheese that is enhanced with color can be colored with Beta-Carotene. In Europe, Beta-Carotene is listed in EU regulation 1129/2011 as food additive E160a and included in Group II of food colors authorized at quantum satis.



Infant formula-approved

Because whey from cheese made with annatto will often not be accepted by infant formula manufacturers there is a need for an acceptable, safe and comparable color source. Beta-Carotene is that alternative, optimizing your ability to sell whey in a variety of attractive industries.



Process and market-friendly

Beta-Carotene does not impact cheese composition at different acidity levels. Furthermore, Lycored’s trials with both OrangeOvation and GoldHold show that you can achieve the same, or better, stability as with other colorant alternatives. Our colorant portfolio offers you a selection of shades to choose from, ranging from market standards to unique product differentiators.



Healthy and naturally present in milk

Beta-Carotene is an important nutrient which supports the creation of Pro-vitamin A in the body. It occurs naturally in cow’s milk, particularly in grass fed cow’s milk, which comes from animals that largely graze in pasture year-round. Feeding with grass improves the quality of the milk and makes it richer in Omega-3 fats, Vitamin E and CLA (a beneficial fatty acid), as well as Beta-Carotene.

Testing the stability of our Beta-Carotene formulations

As part of our commitment to testing the performance of our products, we have investigated the stability of our Beta-Carotene colors.

Repeated trials were carried out to understand how formulations containing Beta-Carotene behaved and how they compared with annatto:

- in terms of stability and shelf life
- in varied packaging, storage and light conditions
- for color intensity and concentration efficiency in the final cheese in varied cheese production types (Cheddar v Hard yellow)

Phase 1 – Stability in Cheddar-type

We first carried out trials in Cheddar-type cheese, comparing the behavior of annatto to two different Beta-Carotene based formulations: OrangeOvation XL and GoldHold XL all gave different shades of orange:

- **OrangeOvation XL:** (Higher dosage) (Pantone 151 C) RHS Reference: Orange Group N25, Strong Orange B
- **OrangeOvation XL:** (Lower dosage) (Pantone 151CP), RHS Reference: Orange Group N25: Strong Orange B
- **GoldHold XL:** (Pantone 2010 CP) RHS Reference: Orange Group N25: Strong Orange Yellow D

We carried out accelerated shelf life tests on Cheddar type cheese containing these blends, and on blends containing annatto. They were compared both with and without vacuum packaging.

Three comparisons were made:

- Reference 4°C in the dark
- Dark Held at 8-9°C in the dark
- Intense light – Held at 8-9°C under 2400 lux light

The results are displayed below:

		Annatto (industry sample)		Beta-Carotene: OrangeOvation XL: (higher dosage)		Beta-Carotene: OrangeOvation XL: (lower dosage)		Beta-Carotene: GoldHold XL	
Condition	Metric	T=0	T=3	T=0	T=3	T=0	T=3	T=0	T=3
8-9°C, 24hr Light 2400 lux	Chroma	41.03	37.91	43.58	47.36	38.65	41.29	38.11	39.59
8-9°C, 24hr Light 2400 lux		-	4.42	-	6.66	-	5.85	-	4.29
8-9°C, 24hr Dark	Chroma	41.03	37.91	43.58	47.36	38.65	41.29	38.11	39.59
8-9°C, 24hr Dark		-	5.73	-	3.75	-	2.55	-	3.59
Condition	Metric	T=0	T=9	T=0	T=9	T=0	T=9	T=0	T=9
Ref. 4°C, Dark	Chroma	41.03	37.91	43.58	47.36	38.65	41.29	38.11	39.59
Ref. 4°C, Dark		-	3.72	-	4.48	-	5.98	-	6.57

Definition of Chroma: the quality of a color's purity, intensity or saturation

The Chroma color intensity of OrangeOvation XL and GoldHold XL increases over time compared to annatto.

The Delta E change highlights intensifying color.

Phase 2 – Stability in hard yellow cheese

We next explored how Beta-Carotene based formulations performed in a different variety of hard cheese.

We looked at two different dosages of GoldHold B which gave different shades of yellow orange (Pantone 7401C and Pantone 2005CP). We again carried out accelerated shelf life tests on the cheeses, both with and without vacuum packaging.

There were three comparisons:

- Reference - 4°C in the dark
- Dark - Held at 8-9°C in the dark
- Intense light - Held at 8-9°C under 2400 lux light

The Chroma color intensity of GoldHold B very slightly decreased over time. The results are displayed below:

		GoldHold B (lower dosage)		GoldHold B (higher dosage)	
Condition	Metric	T=0	T=11	T=0	T=11
8-9°C, 24hr Light 2400 lux	Chroma	22.83	19.29	26.37	24.5
8-9°C, 24hr Light 2400 lux		-	5.09	-	2.5
8-9°C, 24hr Dark	Chroma	22.83	19.29	26.37	24.5
8-9°C, 24hr Dark		-	5.09	-	2.5
Condition	Metric	T=0	T=9	T=0	T=9
Ref. 4°C, Dark	Chroma	23.52	22.42	26.56	25.89
Ref. 4°C, Dark		-	1.21	-	1.86

Definition of Chroma: the quality of a color's purity, intensity or saturation
The Chroma color intensity of GoldHold B slightly decreases over time.
The Delta E change highlights intensifying color.

Conclusion

The Beta-Carotene formulation opportunity going forward

With cheese processors wanting to avoid annatto in order to optimize their whey business, there may be a temptation to remove colors from cheese entirely. However, as our research shows, color is hugely important to consumers, who use it to build expectations of characteristics such as quality, taste, maturity and liking - all of which contribute to purchasing decisions.

Beta-Carotene (OrangeOvation and GoldHold shade families) is an excellent alternative source of color in cheese. As well as being acceptable in whey (both to regulators and industry) it is versatile, allowing any yellow to orange/red shade to be reached. It is free from the health concerns associated with annatto – indeed it is an important natural nutrient. Finally, as our new trials show, it offers excellent stability.

¹Wadwhani, R and McMahon DJ (2012) 'Color of low-fat cheese influences flavor perception and consumer liking' J. Dairy Sci. 95:2336-2346

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³Gultekin, F and Doguc DK (2013) 'Allergic and Immunologic Reactions to Food Additives' Clin Rev Allergy Immunol. Aug;45(1):6-29

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⁸Floch, MH, 2009 'Annatto, diet, and the irritable bowel syndrome', J Clin Gastroenterol.; 43 (10): 905-6

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