



**PACKAGED FOODS
SHOULD BE KEPT
IN THE DARK.**

**CONSUMERS
SHOULDN'T BE.**

Light has the power to degrade food and packaged goods, but new research proves protective packaging can protect against damage from all light sources.



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SUMMARY

Scientific studies have shown that light of any kind – whether in the grocery store, home, refrigerator or through a window – can cause food, beverages, pharmaceuticals and cosmetic products to degrade faster – often before they meet the expiration date. With milk and other dairy products, exposure to light affects the taste, freshness, and nutritional value of the food. As more consumers understand the impact of light on milk and other products they consume, they will seek packaging that protects these products from light degradation.

[Noluma](#) is the first company to develop technology to assess, measure, and certify light protection in packaging. A Noluma™ certification means that a product or food's freshness, nutrition, stability and sensory qualities are protected from light exposure as best as scientifically possible throughout the full shelf life of the product.



BACKGROUND

“Exposure to light can degrade milk’s quality and freshness before its expiration date, in some cases up-to twenty times faster than if it were in light protected, Noluma™-certified packaging”¹

Just as clothing fades in the sun, or skin can burn, packaged goods of any kind can be negatively affected by light. It is fairly well known that the quality and taste of olive oil and nut oils degrade if they are not kept away from light.² Many consumers are also familiar with perfume whose aroma profile changes and cosmetics that change color when exposed to light, or lotions that lose their freshness and effectiveness under similar conditions. Much research also exists in the *Journal of Pharmaceutical Health Care and Sciences* on the photodegradation of pharmaceuticals.

What is less known is that exposure to light can affect the nutrients, taste and smell of dairy products – degrading their quality sooner than expected. Scientific studies have shown that exposure to light can cause milk’s nutritional value to decline, giving consumers fewer important vitamins and proteins than they expect when they buy the products.³ But the right modifications in packaging can protect the flavor and nutritional quality of milk from light’s negative effects.⁴ Noluma has developed a unique patented technology to measure and assess the light protection capacity of packaging, providing expert advice to businesses that want to make packaging improvements, and certifying only packaging that meets the Noluma standard.

¹Jernakoff, P., Niedenzu, P. M., Stancik, C. H., Milone, M. P. (2012). USPTO S9638679B2. Wilmington, Delaware, USA: United States Patent and Trademark Office. Retrieved from <https://patents.google.com/patent/US9638679B2/en>

²Ayton, J.; Mailer, R. J.; Graham, K. [The Effect of Storage Conditions on Extra Virgin Olive Oil Quality](#). Australian Government RIRDC. 2012

³Min, D. B.; Boff, J. M. Chemistry and Reaction of Singlet Oxygen in Foods. *Compr. Rev. Food Sci. Food Saf.* 2002, 1 (2), 58–72.

⁴Johnson, D.S.; Duncan, S.E.; Bianchi, L.M. et al. [Packaging Modifications for Protecting Flavor Extended-shelf-life Milk from Light](#). *J. Dairy Sci.* 98:1-10

MILK AND THE DEGRADING EFFECTS OF LIGHT



MILK AND THE DEGRADING EFFECTS OF LIGHT

“After just 15 minutes of light exposure, sensory experts were able to detect taste changes in milk”

Consumers trust that the milk they buy will be fresh and contain the nutritional qualities promised on the label. But studies show that exposure to fluorescent, LED, or other lighting – from the dairy to the grocery to the fridge – can significantly erode the nutritional content of milk. Milk contains components that are sensitive to light, including riboflavin, known as “vitamin B2,” one of eight B vitamins that are essential to human health. Riboflavin is crucial for breaking down food components, absorbing other nutrients and helping to maintain body tissues that make up organs such as skin and eyes. When exposed to light, riboflavin and other components produce “singlet oxygen” – a less stable, chemically excitable oxygen, which reacts with proteins and other vitamins in the milk, leading to peculiar flavors, a staler smell and loss of nutrients.



FLAVOR

Food scientists studying light’s impact on milk have used expert tasting panels to assess changes in flavor:

- When exposed to light, milk proteins break down and flavor changes.⁵
- After just 15 minutes of light exposure, a panel of sensory experts were able to detect taste changes in milk.⁶
- After eight hours of retail light exposure in packaging that was not light protected, consumers in a taste test deemed the milk’s flavor as less acceptable. Their judgment of its acceptability continued to decline with further light exposure.⁷
- In one study, consumers detected aromas of old oil and plastic, as well as a cardboard aftertaste, after milk was exposed to either LED or fluorescent light for 48 hours – tastes they did not experience in milk that was kept in the dark.⁸

⁵ Jung MY, Lee HO, Min DB. 1998. Singlet oxygen and ascorbic acid effects on dimethyl disulfide and off-flavor in skim milk exposed to light. *J Food Sci* 63:408-412.

⁶ Chapman, K. W.; Whited, L. J.; Boor, K. J. Sensory Threshold of Light-Oxidized Flavor Defects in Milk. *J. Food Sci.* 2002, 67 (7), 2770-2773.

⁷ Walsh, A. M.; Duncan, S. E.; Potts, H.; Gallagher, D. L. Comparing Quality and Emotional Responses as Related to Acceptability of Light-Induced Oxidation Flavor in Milk. *Food Res. Int.* 2015.

⁸ Johnson, D.S., *Ibid.*



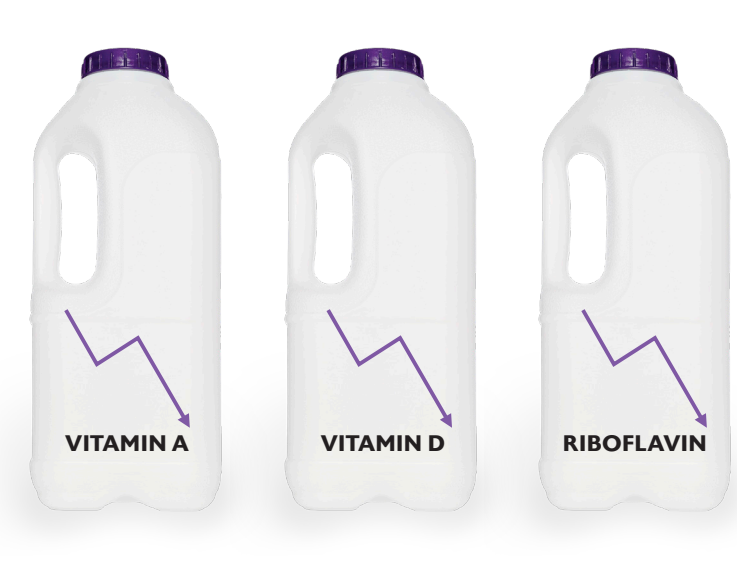
NUTRITION

“After 24 hours of sunlight, riboflavin levels in pasteurized whole milk dropped 28%”

For many people, milk is the cornerstone of a healthy diet. Consumers expect milk to provide many of their main nutritional needs. Aside from protein, the most important nutrients include calcium, thiamin, riboflavin, and vitamin B12. Milk also contains small amounts of niacin, pantothenic acid, vitamin B6, vitamin C, and folate, as well as the fat soluble vitamins A, D, E, and K.

People rely on food to provide their bodies the necessary nutrients to lead healthy lives. Drinking milk is one means of replenishing the body with valuable nutrients. **So when consumers drink milk that has been exposed to light, they are getting even fewer of these important nutrients than expected.**

Nutritional degradation caused by light varies, depending on the type of milk (full fat, skim, ultra-high temperature, etc.) and the type of containers – whether opaque, translucent plastic, cardboard, PET, or other types of cartons. Containers must be tested to determine how much light is reaching and changing the quality of the product.



Here are key findings of food scientists who have studied light’s impact on milk’s nutritional value:

- After only two hours of exposure to lights typically found in retail dairy cases, milk begins to lose Vitamin A.⁹
- After 16 hours of dairy-case light exposure, less than half of the Vitamin A (49%) remained in nonfat milk in a typical plastic bottle.¹⁰
- After one hour of sunlight exposure, riboflavin nutrients in pasteurized whole milk dropped by 28%.¹¹
- After 14 days of retail light exposure in a PET bottle, there was a significant decline in nutrients in fortified, reduced-fat UHT milk:¹²
 - 45% Riboflavin loss
 - 60% Vitamin A loss
 - 80% Vitamin D loss
- After 12 weeks of light exposure in a retail setting UHT milk’s nutritional value declined dramatically:¹³
 - 93% Vitamin A loss
 - 100% Vitamin B2 loss
 - 66% Vitamin D loss

For people who drink milk, protecting it from light exposure will replenish the body with higher amounts of vitamin A, D and riboflavin to support overall better health.

As consumers become increasingly aware of the effects of light on the nutritional quality of the milk they drink, they are likely to choose products that they know are light protected.

⁹Whited, L. J.; Hammond, B. H.; Chapman, K. W.; Boor, K. J. Vitamin A Degradation and Light-Oxidized Flavor Defects in Milk. *J. Dairy Sci.* 2002, 85 (2), 351–354.

¹⁰Whited, L. J.; Hammond, B. H.; Chapman, K. W.; Boor, K. J. Vitamin A Degradation and Light-Oxidized Flavor Defects in Milk. *J. Dairy Sci.* 2002, 85 (2), 351–354.

¹¹Herreid, E.O.; Ruskin, R.; Clark, G.L.; Parks, T.B. (1952). Ascorbic Acid and Riboflavin Destruction and Flavor Development in Milk Exposed to the Sun in Amber, Clear, Paper and Ruby Bottles. *Journal of Dairy Science*, 35(9), 772-778.

¹²Saffert A, Pieper G, Jetten *Journal of Packaging Technology and Science.* 2009;22(1):31-37. <https://doi.org/10.1002/pts.824>. “Effect of package light transmittance on the vitamin content of milk, Part 3: Fortified UHT low-fat milk.”

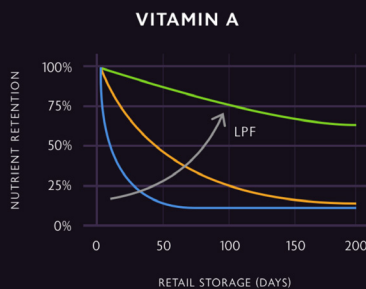
¹³Saffert A, Pieper G, Jetten, *Journal of Packaging Technology and Science* 2008;21(1):47-55. <https://doi.org/10.1002/pts.779>. “Effect of package light transmittance on the vitamin content of milk, Part 2: UHT whole milk.”



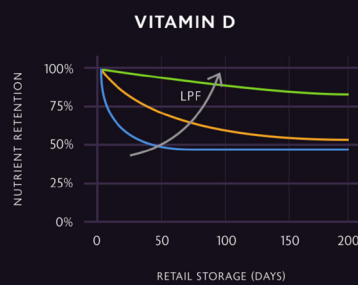
PROTECTIVE PACKAGING

When milk and other products are shielded from light, they maintain their quality, taste and nutrients much longer. Researchers at Cornell University found that when fresh milk is protected from light, it holds its flavor and nutritional quality for two weeks. Consumers who tested two-week-old, light-protected milk, preferred it over “fresh” milk that had been stored in a typical container and exposed to light for as little as four hours. The effects of light exposure were so strong, that in every case, testers preferred the “near code/near expiration date” sample of shielded milk to the “fresh” sample that had been exposed to light for only a few hours.¹⁴ The cited research highlights the role of light protection as an essential consideration to maintaining product freshness for longer timeframes.

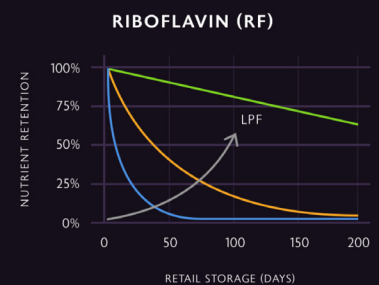
Light-protected packaging protects the nutrients in milk. These charts compares how low, medium, and high light protection can affect the vitamins in milk over time.



■ DESIGN A Low LPF ■ DESIGN B Medium LPF ■ DESIGN C High LPF



■ DESIGN A Low LPF ■ DESIGN B Medium LPF ■ DESIGN C High LPF



■ DESIGN A Low LPF ■ DESIGN B Medium LPF ■ DESIGN C High LPF

LPF Designs also protect other light sensitive milk nutrients including Vitamins A and D.

Model uses known relationship between RF and vitamin decay (Saffert et al. 2009)

The data presented in our graphs here represent predicted results based on the technology used by Noluma International, LLC in correlation with the literature listed in our bibliography.

¹⁴Carey, N.; Murphy, S.; Kent, D.; Bang, J.; Stubbs, T. [Exposure of fluid milk to LED light negatively affects consumer perception and alters underlying sensory properties.](#) Cornell Dep. Of Food Science, 2016

NOLUMA: MEASURING LIGHT PROTECTION

Noluma is the light authority: Protecting the goodness in the products and brands consumers love.

[Noluma International LLC](#), founded in 2018, is the only company to have developed patented, state-of-the-art technology that measures the light protection capacity of packaging. The technology is unique because the light protection determination is a function of the changes to the content inside the packaging. The company doesn't make or sell packaging materials, but advises clients on optimal design to achieve the highest level of light protection.

Using the highest level of light protection in product packaging can preserve nutrients, freshness, stability, color, efficacy, performance, sensory and quality characteristics, and lead to an extended sensory shelf life for many products that reduces food waste. Noluma uses patented technology to guide the design of the best protective packaging for a variety of products, to preserve the quality and performance that consumers expect.

Many products can be negatively affected by sun or artificial lights, whether LED, retail lights or fluorescent sources. Almost all packaging can be improved to enhance its light protection capacity, whether glass, cartons, plastic, or other materials. Noluma can measure, assess, guide, and certify the packaging design for all types of packaged goods, regardless of the material, shape or contents.

JERSEY GIRLS DAIRY: LIKE SUNGLASSES FOR YOUR MILK

Jersey Girls Dairy, LLC, a dairy farm in Chester, Vermont, partnered with Noluma to upgrade its packaging to protect its farm-fresh pasteurized milk against light exposure. Working with Noluma to launch a new bottle design, the two companies joined forces to educate the local community on light's negative impacts on milk, and the power of light-protected packaging to prevent nutrient degradation. Through educational campaigns at local farmers' markets during the summer of 2018 Jersey Girls demonstrated the benefits of light-protected dairy packaging, showing how it improves the overall quality of milk and maintains its fresh, wholesome taste through its full shelf life.

Community locals could clearly see, smell and taste the difference of light-protected milk. The campaign resulted in Jersey Girls' sales tripling in just two weeks, measurable quality improvements noted by consumers and an invitation for Jersey Girls to exhibit at the Vermont Farm Show in Burlington.





THE TECHNOLOGY

Noluma's research team has developed unique, patented technology that measures the light protection capacity of packaging as a function of its effects on the product contents

First, Noluma's research team uses a known marker ingredient in a solution inside a test package and exposes the package to intense light. The researchers and scientists on the Noluma team then measure the degree to which the marker is damaged after light exposure. The extent to which those markers are damaged or absent reveals the extent to which the freshness and or quality has also been degraded. The changes to the marker are measured to determine the Light Protection Factor (LP) that's needed for the packaging to reach optimal light protection capacity (total light block).

In the case of dairy, the marker is riboflavin (vitamin B2), the nutrient that becomes unstable when exposed to light, affecting the quality of the milk. The Noluma team measures how much riboflavin diminishes or disappears when measured through the Noluma testing process, which replicates two weeks of light exposure in just two hours. The team can then assess the effectiveness of the packaging, and offer guidance on how to redesign packaging to adequately protect from light damage.

Noluma's technology is fast, enabling companies to quickly innovate their package design. Noluma's experts can measure nutrient changes caused by light exposure 99% more efficiently and accurately than conducting a standard evaluation with a panel of expert taste testers. And because Noluma doesn't sell packaging, the company can objectively collaborate with clients to find the most effective ways to enhance the light protection of packaging while meeting other goals, such as environmental sustainability.

There are a variety of solutions to creating better light protection in packaging, with options to add appealing aesthetics to improve opacity and light shielding.

EFFICIENCY & ACCURACY OF TESTING NUTRIENT CHANGES CAUSED BY LIGHT EXPOSURE

NOLUMA TESTING



99%

STANDARD TESTING

1%



CERTIFICATION

Packaging certified for
light protection by:



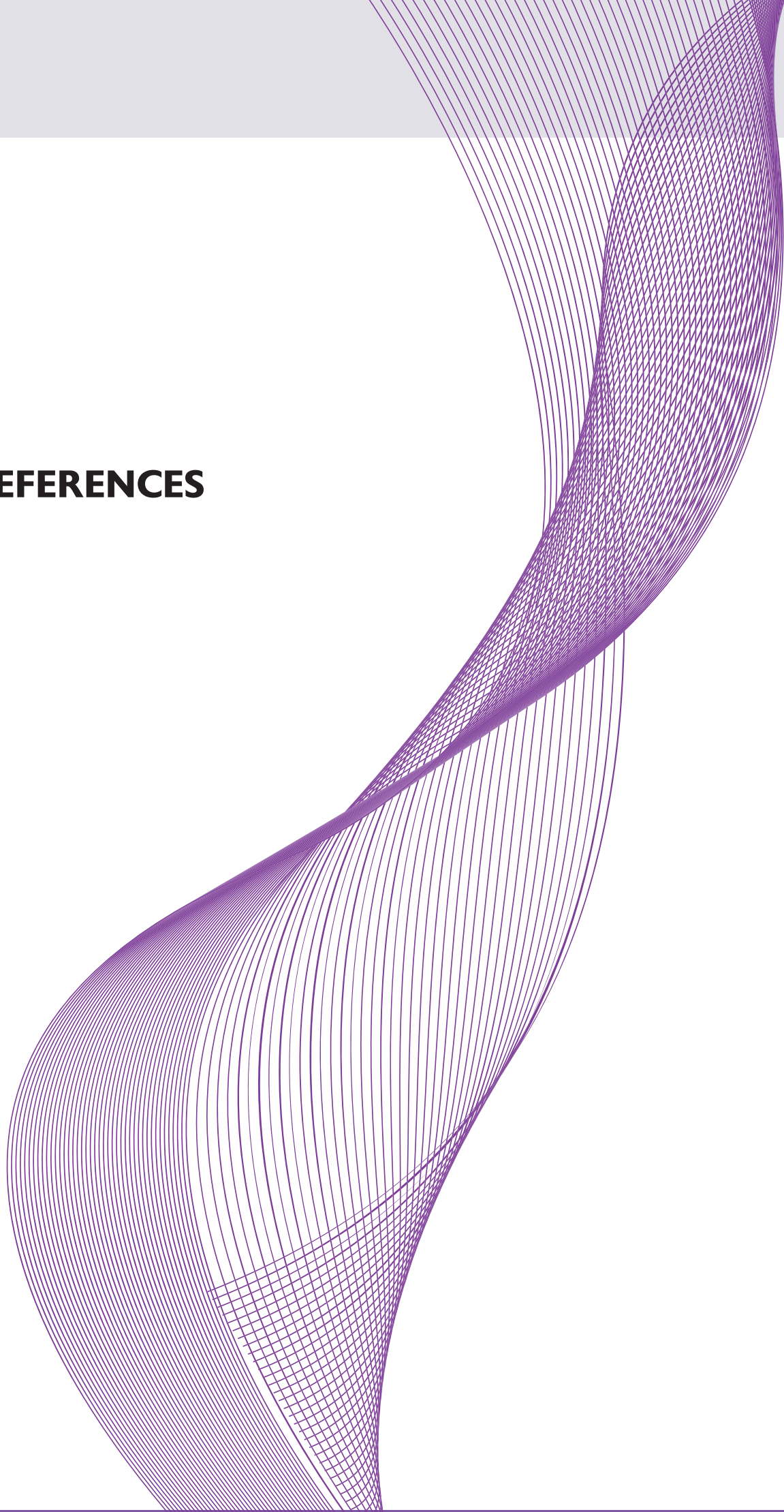
Noluma offers unique solutions and abilities to certify packaging to meet the highest standards of light protection. A Noluma™ certification means that a product's freshness, nutrition, efficacy and sensory qualities will be fully maintained against the impact of light exposure as best as scientifically possible throughout the shelf life of the product. Noluma guarantees the quality of the scientific testing process and the measurement of a package's light protection capacity.

When consumers see the Noluma™ logo, they'll know that the product will not be degraded by light, and will maintain freshness and overall quality through the product's full shelf life – whether edible oils, cosmetics, dairy or other degradable products. They can be assured that the milk they buy will have the same taste and nutrients as it did when it left the dairy.

As more consumers become aware of how light can degrade the quality and nutrition of the products they buy, they'll begin to look for light protected packaging solutions that preserve the goodness in the products and brands they love.

For more information or to speak with a Noluma representative, email info@noluma.com

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