PreScouter

Extending Shelf Life: Next Generation Additives

Research Support Service

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PRESCOUTER

Intelligence Brief Question

What are some next generation plant- or food-based additives currently in development for extending the shelf life of food and beverages throughout the industry?

We are primarily interested in developments that are derived from food-safe sources (food, plants, etc) and can potentially replace chemical additives commonly used for extending the shelf life of foods and beverages. Solutions should range from early-stage developments to near-term solutions.

Executive Summary

PreScouter Approach:

In the previous report, the PreScouter team focused on novel packaging changes utilized to extend the shelf life of various foods. In this report, the team focused instead on modifications and novel additives to the food itself. In this way, the shelf life of food products can be extended without additional development costs for the packaging processes- there is just an additional component with the food.

Overall, the team focused on developments within the far- and mid-term of development, as this is where much of the research is currently. Additionally, focus was placed on food safe or likely-to-be food safe components.

Discussion:

An interesting push in this area is not only the use of plant- and food-based additives, but also of utilizing components previously thought of as waste. In recovering food waste for use as additives, not only can food shelf life be extended, but the industry also sees a reduction in waste.

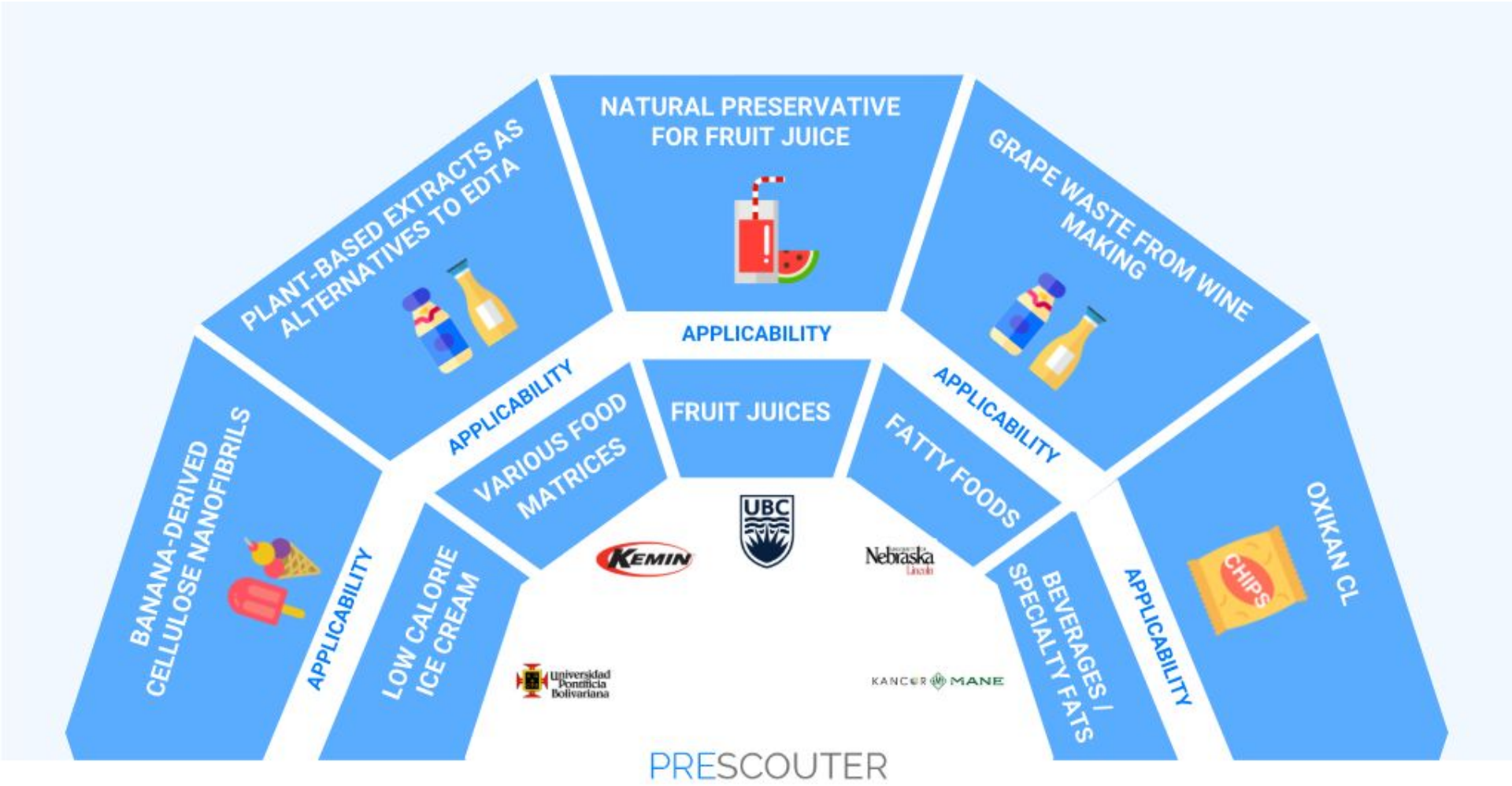
Long-used components like essential oils from herbs and fruit-based acids also continue to be a focus with their known preservation power. They are being used on their own and in combination with new substances for new efficacy.

Executive Summary

In development of naturally-derived preservatives, researchers are primarily focused on two major areas:

- Essential oils:
  - Oxikan (p. 26) is utilizing antioxidants from rosemary and has compared them to known antioxidants for their efficacy
  - A UBC research group (p. 8) has combined essential oils with fruit acids to mask the taste of the oils and increase the shelf life of fruit juice
- Foods:
  - University research has proved (p. 17) that banana-derived cellulose nanofibrils make ice cream less sensitive to temperature changes and slowed melting
  - Kemin (p. 12) has been seeking plant-based extracts to replace EDTA and has found success with rosemary, spearmint, and green tea extracts
  - A group at the University of Nebraska-Lincoln (p. 22) has devised a way to utilize wine-making waste (pomace) for food preservation additives

Technologies Included in Report



The Major Features of Each Technology

Technology	Company / Organization	Phase	Food Use Approval[1]	Type	Year	Page
Banana-Derived Cellulose Nanofibrils	Universidad Pontificia Bolivariana	Research	✓	Stabilizer	**2018**	**8**
Plant-Based Alternative for EDTA	KEMIN	Prototype	✓	Chelating agent	**2018**	**13**
Fruit Juice / Essential Oil Blend	UBC	Research	✓	Natural preservative	**2018**	**18**
Grape Waste Additive	University of Nebraska Lincoln	Research	✓	Antioxidant	**2018**	**22**
OxiKan CL	Kancor Mane	Product	✓	Antioxidant	**2016**	**26**

[1] *Approved for food use based on the plant-based or food-based nature of solution*

Replacements for Additives

Banana-Derived Cellulose Nanofibrils

Universidad Pontificia Bolivariana

Background

For several years, scientists struggled to overcome the challenges to increase the shelf-life of ice cream. Most importantly, it can melt easily at room temperatures. Research shows that adding agricultural waste to ice cream may have some benefit. Scientists at Pontifical Bolivarian University have found that cellulose nanofibrils (CNFs) derived from banana waste could slow melting, and increase the shelf-life of ice cream.

At a glance

Type: Banana waste-based additives

Key Feature: Banana derived cellulose nanofibrils (CNF), low-fat ice-cream

Year: 2018

Current Application: Ice-cream

Applicability: Long lasting, low calorie ice-creams

Main Limitation: Tests performed in closed chambers, effects of wind not determined, labor intensive

Banana-Derived Cellulose Nanofibrils

Universidad Pontificia Bolivariana

Technology

Researches isolated cellulose from banana stalks and used a specific machine to extract tiny bits of cellulose (nanofibrils) from ground-up banana stalks. These nanofibrils are tiny- 1000 times smaller than the width of a human hair. The team found that adding CNFs at a concentration of 0 - 0.3g per 100g of ice cream at 20°C caused a delay in the melting-rate.

Figure: CNFs extracted from the stalks (red) of Banana trees

Banana-Derived Cellulose Nanofibrils

Universidad Pontificia Bolivariana

Technology (cont'd)

The fibers could lead to the development of a thicker and tastier ice cream. The addition of CNFs to ice cream could even replace fats used for making it.

During tests, the scientists evaluated the effects of CNFs on ice cream using a rheometer, which measures the amount of force to move fluid and a texturometer to measure the hardness of the ice cream. The results showed that the addition of CNFs to ice cream made it **less sensitive to temperature changes** and **slowed melting**.

The CNF-enriched low-fat ice cream showed a higher viscosity, improved creaminess, and texture than its regular counterpart, which could be due to CNFs stabilizing of the structure of fats in the ice-cream.

Banana-Derived Cellulose Nanofibrils

Universidad Pontificia Bolivariana

Benefits

- Melt-resistant ice creams with lower calorie counts and improved texture
- Even in hot weather, CNF-enriched ice creams can be enjoyed for longer periods of time

Drawbacks

- The researchers performed the experiments in a closed air chamber with no air movement. Air currents or wind can affect the melting behavior differently.
- Currently, the process of extracting large amounts of cellulose from banana wastes is labor intensive.

Banana-Derived Cellulose Nanofibrils

Universidad Pontificia Bolivariana

Conclusion

This innovation could mean huge gains for the ice cream industry. The researchers plan to finish some more experiments before the technology goes to market. Currently, the plan is to investigate how different types of fat including coconut oil and milk fat, could affect the properties of CNFs in other frozen treats. The team is also working to make the cellulose extraction from banana waste process more efficient. Many ice cream makers add hydrocolloids to ice cream for the shape retention and prevention from dripping. The scientists are interested in testing if CNFs are superior to standard hydrocolloids.

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3. https://www.deccanchronicle.com/lifestyle/food-and-recipes/220318/this-plant-extract-will-keep-ice-cream-from-melting.html
4. https://www.sciencenewsforstudents.org/article/banana-plant-extract-can-slow-ice-cream-melt
5. https://www.studyfinds.org/melt-resistant-ice-cream-banana-extract/

Plant-Based Extracts as Alternatives to EDTA

Background

Kemin Industries has recently introduced a plant-based solution, NaturFORT™ RSGT, as a shelf-life extension solution for salad dressings and sauces. It is a blend of rosemary, spearmint, and green tea plant extracts and is a replacement of the chelating agent EDTA, traditionally used as a food preservative, additive, color enhancer, and stabilizer. Chelating agents react with metal ions to form a water-soluble complexes and are used to prolong the shelf-life of food items. NaturFORT retains its chelating abilities much like EDTA and is not affected by changes in pH, which helps to extend shelf-life.

At a glance

Type: Natural plant-based additive

Key Feature: Alternative to EDTA

Year: 2018

Current Application: Mayonnaise, salad dressings and sauces

Applicability: Replace EDTA as chelating agent in other food matrices

Main Limitation: Higher doses of the blend required to match EDTA performance, ranch dressing not receptive to the blend

Plant-Based Extracts as Alternatives to EDTA

Technology

The company screened many plant-extracts to determine the effects on delaying lipid oxidation in emulsions, with mayonnaise as a model. Mayonnaise was treated individually with known chelating agents and candidate plant-based ingredients. The peroxide value which correlates with the oxidative deterioration was monitored over a 4-week storage period at 22-24°C with daylight exposure mimicking a general retail setting. Among all the extracts tested, the spearmint solution was most effective.

A total of 15 different combinations of the plant ingredients with the various amounts were analyzed for oxidation with mayonnaise as a model over a 4-week time. The results led to an optimized ratio of each ingredient for the final blend formulation.

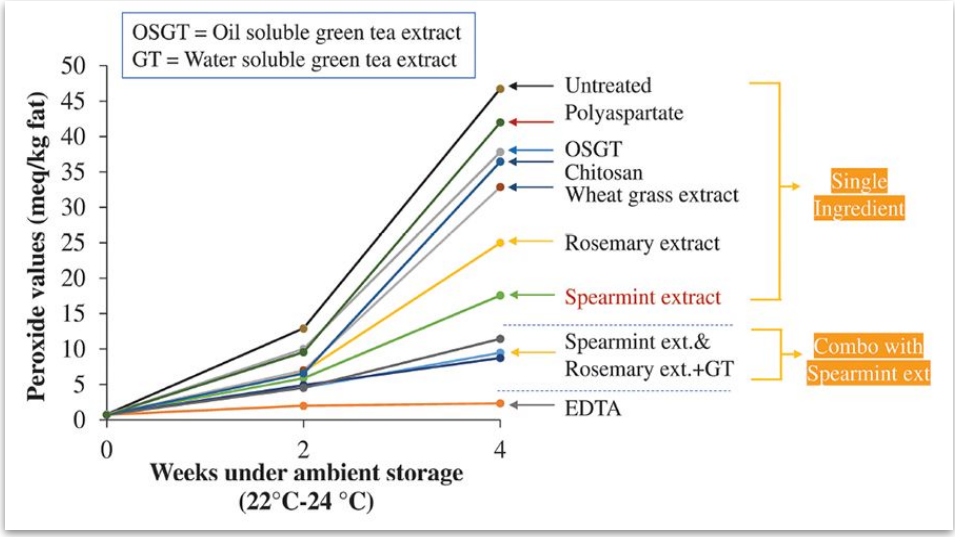

Figure: Screening of various ingredients and ingredient combinations with mayonnaise

Plant-Based Extracts as Alternatives to EDTA

Technology (cont'd)

The solution with rosemary, spearmint, and green tea extracts showed optimal performance and effectiveness in studies. Rich phenolic compounds produced by these plant varieties as selected by natural breeding contributes to the efficacy of this solution.

Rosemary targets the oil phase when added to an emulsion, and spearmint and green tea target the aqueous phase. The blend slows down lipid oxidation, reduces the byproducts of oxidation and therefore enhances shelf-life. The solution is used to extend the shelf-life of sauces and dressings.

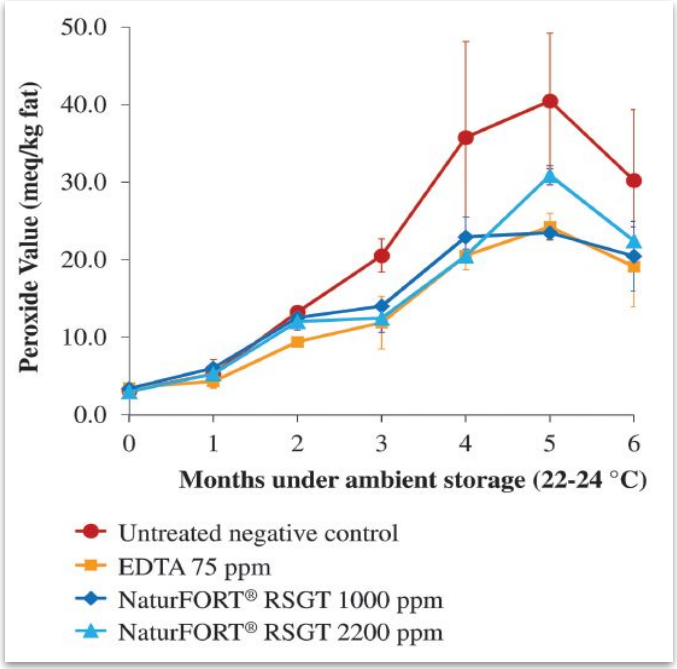

Figure: A comparison of peroxide values in mayonnaise treated with EDTA and NaturFORT blend.

Plant-Based Extracts as Alternatives to EDTA

Benefits

- The company provides manufacturers a consumer-friendly alternative for the shelf-life extension of foods.
- The studies show a shelf-life evaluation of up to 6 months with the solution.

Drawbacks

- Higher doses of the solution are required to match the performance of EDTA.
- The blend needs further optimization and is dependent on the type of food emulsions.
- Dose-response results were not found in the ranch dressing study.
- Oxidative stability tests of various other food matrices need to be performed to determine the efficacy of the solution.

Plant-Based Extracts as Alternatives to EDTA

Conclusion

Kemin's innovation is a promising start for manufacturers looking for an alternative to EDTA in their list of ingredients. Currently, the company is in the process of optimizing the blend to enhance the performance of shelf-life extension past six months.

References

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Natural Preservatives for Fruit Juice

Background

Fruit juices are a popular way for people to consume more fruits on the go, and they contain vitamins, minerals, and fibers that help sustain a healthy lifestyle. However, some of the nutrients contained in fruits (carotenoids, phenolic compounds) are heat-sensitive so thermal treatments of fruit juices may lower the nutritional value and alter the taste of the juice. Chemical preservatives, such as citric or tartaric acid, can affect taste and are also not popular with consumers. Essential oils derived from plants have antimicrobial properties, but too much of these also changes the flavor of the end product. To solve these issues, researchers at the University of British Columbia are investigating the use of natural acids from other fruits combined with essential oils as a natural preservative.

At a glance

Type: Natural preservative

Current Application: Watermelon juice

Key Feature: Natural, non-thermal, antimicrobial

Applicability: Fruit juices

Year: 2018

Main Limitation: Altered appearance

Natural Preservatives for Fruit Juice

Technology

Essential oils from cloves and cinnamon were extracted and added to watermelon juice, Researchers used this as a test case. A blend of apple and lemon juice was added to this mix to mask the taste of the essential oils with the tartness of the apple/lemon blend.

It was found that a 60:40 ratio of watermelon and apple/lemon juices with 0.02% essential oils has the most palatable taste by a panel of 50 judges while extending the shelf life of the juice to almost **14 days** due to the combined effects of acidity from the apple/lemon blend and antimicrobial activity of the essential oils.

Natural Preservatives for Fruit Juice

Benefits

- Ingredients are all-natural, derived from fruits or other plants
- No thermal process is required so there is no loss of nutrients from the final product
- Using apple/lemon juice blend masks the unpleasant taste of essential oils

Drawbacks

- Appearance of final product is altered due to the additives
- Adding a higher percentage of essential oils makes the final product unpalatable to consumers
- Approach still needs to be investigated for products other than watermelon juice

Natural Preservatives for Fruit Juice

Conclusion

The combination of natural acids from low-pH fruits and essential oil constituents could be a potentially effective way to extend the shelf life of fruit juices, non-thermally and organically. Further research needs to be done for other types of fruit juice.

References

1. https://doi.org/10.1111/1750-3841.14277

Grape Waste from Wine-Making

Background

Following wine processing, the wine industry produces about 14 million tons of pomace, a pulpy grape waste. Large amounts of pomace cause surface and groundwater pollution as the pesticides and fertilizers applied to the grapes can leach into the environment. Leftover pomace in landfills also turns the soil acidic and poses a risk to human health, as it attracts disease-ridden flies and pests. Researchers from the University of Nebraska-Lincoln have identified a way to extract the nutrients from pomace and convert it into beneficial food ingredients. The ingredients would not only increase the nutritional value of products but would also enhance the shelf-life of fatty foods.

At a glance

Type: Agricultural waste

Current Application: Mayonnaise and ranch dressing

Key Feature: Natural antioxidants; Antimicrobial agents; Prevents lipid oxidation

Applicability: Fatty foods

Year: 2018

Main Limitation: Optimizing technology to extract, separate and identify the nutrients from grape pomace

Grape Waste from Wine-Making

Technology

Dr. Xu's team has found that pomace can act as an **antioxidant**. Grape pomace is rich in antioxidants, such as proanthocyanidins, anthocyanins, and ellagic acid. These antioxidants can bind to free radicals and protect the cells from damage. In a trial, the group separated the antioxidant compounds in grape pomace from pesticides and other compounds. Then, they added the formulation to high-fat foods including mayonnaise and ranch dressing.

The results showed that the antioxidant formulation prevented the lipid oxidation of these products even at warm temperatures. Encouraged by these results, the group intends to substitute artificial antioxidants with natural antioxidants in grapes for the shelf-life extension of high-lipid human and even animal food products.

Currently, the researchers are optimizing technologies to remove pesticides on the surface of the grapes, extract, separate and identify nutrients from grape pomace.

Grape Waste from Wine-Making

Benefits

- Polyphenols in grape pomace can act as natural antioxidants and potential antimicrobial agents.
- They could protect food from foodborne pathogens such as *E.coli* and *Salmonella*.
- Recycling grape pomace can help wine companies to reduce environmental damage and make economic profits as well.

Drawbacks

- The team requires optimal technologies to extract, separate and identify the nutrients from grape pomace before widespread commercial applications.

Grape Waste from Wine-Making

Conclusion

This technology would not only increase the economic value of the grape and wine industry but will also reduce environmental pollution. The antioxidants in pomace could also potentially replace EDTA in many food products. The team is currently working to enhance the efficiency of the solution and ability to inhibit lipid oxidation.

References

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2. https://www.sciencedaily.com/releases/2018/03/180319090734.htm
3. https://food.news/2018-04-22-repurposing-wine-leftovers-waste-from-grapes-found-to-have-many-uses.html

Kancor: OxiKan CL

KANCOR MANE

Background

Lipid-oxidation is one of the main reasons for the deterioration of food products. It lowers the nutritional value & visual appeal, and results in unusual odors & flavors. Antioxidants prolong shelf life of food items by delaying the process of lipid oxidation thus preventing degradation and lipid-rancidity. Kancor has identified three kinds of antioxidant molecules in rosemary (Carnosic acid, Carnosol, and Rosmarinic acid) that can prevent the oxidation of other molecules by being oxidized themselves.

At a glance

Type: Antioxidant

Key Feature: Natural, clean-label, delays lipid oxidation

Year: 2016

Current Application: Potato chips, foods processed at high temperatures

Applicability: Beverages, specialty fats, Omega-3 fortified products

Main Limitation: Not suitable for infant food products

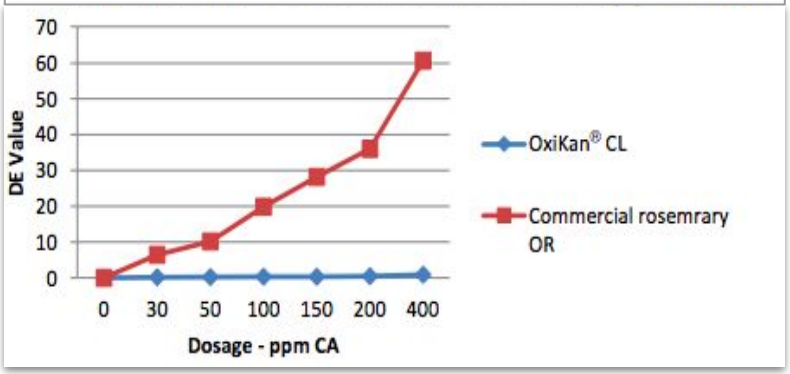
Kancor: OxiKan CL

KANCOR MANE

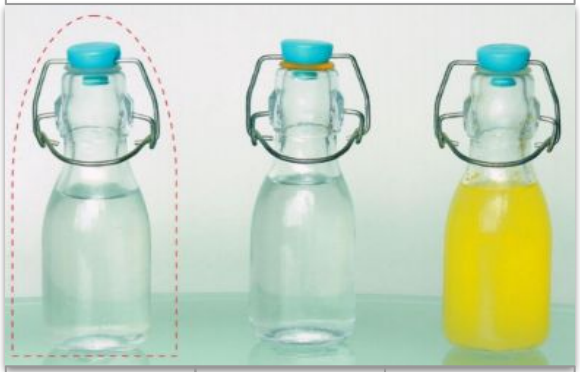
Technology

Kancor has developed a natural antioxidant solution derived from rosemary called OxiKan CL. OxiKan CL is a fully colorless, odorless and flavorless liquid extract that does not alter the organoleptic profile of the food matrix. It extends the shelf-life of the food products by fighting lipid rancidity without imparting any aroma or color.

How OxiKan CL compares to rosemary oil:
Color impact study of OxiKan CL versus rosemary oil at various dosages was measured using Xrite colorimeter and expressed as delta E (difference in lab value). The results show that OxiKan CL does not contribute to any color, flavor or odor of the food products even at 400ppm dosage.



Color-impact comparison of OxiKan CLS, the water-soluble version of OxiKan CL, to rosemary extract in citrus beverages:



Citrus beverage with OxiKan CLS @ 200 ppm Carnosic Acid	Citrus beverage without any antioxidants	Citrus beverage with rosemary extract @ 200 ppm Carnosic Acid

Kancor: OxiKan CL

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Technology (cont'd)

As for comparing with other antioxidants, OxiKan CL outperformed tocopherol, another natural antioxidant, and TBHQ, demonstrating its effectiveness in prolonging the oxidative stability of popcorn.

Sample	Induction Time (in hours)	Indicative shelf life in days under Accelerated conditions
Control	2.21	47
Mixed Tocopherol (Equivalent to 200 ppm of oil)	3.33	71
OxiKan CL (Equivalent to 80 ppm CA of oil)	3.48	74
TBHQ (Equivalent to 200 ppm of oil)	3.73	80
OxiKan CL (Equivalent to 200 ppm CA of oil)	3.82	81

OxiKan CL has a superior application efficacy, when incorporated into the packaging. The company claims that it is an ideal natural antioxidant solution for various sensitive food products that include popcorn, beverages, spreads, and dressings.

While OxiKan CL is oil soluble, OxiKan CLS is a water-soluble variant of OxiKan CL. Both antioxidant solutions possess excellent oil and heat stability. OxiKan CL is currently being used to extend the shelf life of potato chips or foods processed in high-temperature conditions.

Kancor: OxiKan CL

KANCOR MANE

Benefits

- The absence of unwanted molecules such as chlorophyll, carotenoids, and xanthophylls makes OxiKan CL superior to other natural antioxidants.
- It is most suitable for applications that are sensitive to the aroma, flavor, Omega 3 fortified products, and beverages
- Free from irradiation, non-GMO, halal and kosher certified.

Drawbacks

- Although OxiKan Cl is free of allergens, it is not allowed for use in infant food at the moment.

Kancor: OxiKan CL

KANCOR MANE

Conclusion

Kancor is in the process of improving variants of OxiKan CL. It recently won the IFT 2018 Food Expo Innovation Award for their comparative study on prolonging the shelf-life of popcorn. Extensive application studies are underway to study the efficacy of OxiKan on various food products including snacks, meat patties, chips, fats, and oil-beverages. If successful, some synthetic antioxidants can potentially be replaced with this natural, clean-label ingredient.

References

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6. https://www.globalmeatnews.com/Product-Innovations/OxiKan-CL-A-breakthrough-in-natural-anti-oxidants
7. https://www.ingredientsnetwork.com/Kancor%20Mane%20OxiKan%20R%20Plus-file079814.pdf

Next Steps

Topic	Question	Report
Extending Shelf Life of Foods and Beverages	What are novel technologies currently in development for extending shelf life?	*Extending Shelf Life- Novel Packaging*
		Extending Shelf Life- Next Generation Additives
		Extending Shelf Life- Food Treatment Methods
Food and Beverage Packaging Market	Who are main players in the industry and what are major technological trends in the coming years?	Overview of Startups in Packaging
		Discussion of Market Trends
		IP Landscape of Market Players
		Analysis and Discussion of Market
Trends in Allied Industries	What can we learn from packaging technologies in other industries?	Identification of Industries and General Packaging Ideas
		Deep Dive into Highlighted Packaging Technologies

About the Authors

Paula Hock, PhD

PreScouter

Professional Summary:

Paula is one of PreScouter's Project Architects and is one of the Primaries in the Transportation Segment. She has worked on a wide variety of projects in her tenure, including topics like coatings and materials research, process optimization in many industries, comparative intelligence, and more. Paula earned her B.S. from DePaul University in Chemistry before continuing on to her Ph.D. in Physical Chemistry at the University of Pittsburgh. There, her research focused on characterization of organic semiconducting thin films for use in electronic devices. That is also where she started with the PreScouter Global Scholars program in August of 2014. After working as a scholar for a few months, she became a Team Leader before eventually taking a full-time role with PreScouter.

About the Authors

Navneeta Kaul, PhD

University of Denver, USA

Professional Summary: Navneeta Kaul recently completed her PhD in Biology at the University of Denver in Colorado. After earning an engineering degree in Biotechnology, her passion for cutting-edge biological research motivated her to pursue her Master's at the University of Arizona in Tucson. At the University of Denver, she studied the biological mechanism behind Fragile X syndrome, an autism spectrum disorder affecting nearly 1.3 million adults in the United States.

Research Background: Navneeta graduated with a PhD in Biology from the University of Denver in August 2018. The focus of her research was to understand the mechanism of local protein synthesis at the synapse which is important for memory formation in vertebrates. She has experience in using biochemical and molecular biology techniques like cloning, PCR, real-time PCR, western blotting, immunoprecipitation, live cell and fixed cell imaging.

Scientific Interests: Scientific communication, Scientific consulting, Life sciences.

About the Authors

Natasha Jane Chrisandina

Georgia Institute of Technology, USA

Professional Summary: Natasha recently completed her Master's of Science in Chemical Engineering at the Georgia Institute of Technology. While completing her degree, she worked on possible industrial extraction methods and applications for lignin. She has also written science articles for the PreScouter Journal, Massive Science Consortium, and Lateral Magazine.

Research Background: Natasha's research work focused on designing a process for more efficient solvent and water recovery during lignocellulosic biomass pretreatment for pulp mills and determining its economic and engineering feasibility. She also worked on investigating the mechanism of biomass depolymerization through mechanocatalysis.

Scientific Interests: Chemical process design, techno-economic analysis, lignocellulosic biomass, science communication

About PreScouter

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