




The science of antioxidant selection

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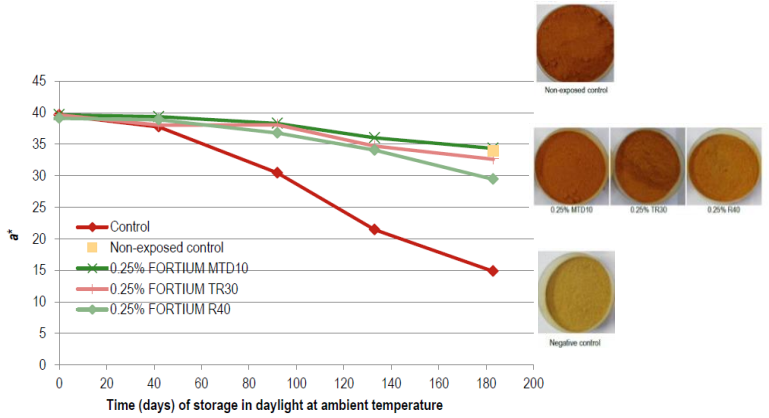
Food Technologies EMEA

KEMIN INSPIRED MOLECULAR SOLUTIONS™

Topics

- The oxidation process at molecular level
- Measuring shelf life in food matrices
- Prevention of oxidation - selection of the antioxidants.
- Natural plant materials as a sustainable alternative for synthetic solutions.



History of Kemin




- Founded in 1961 by RW & Mary Nelson
  - Independently owned by Nelson family
- 1,800+ employees worldwide
- Business operations in over 90 countries
  - Manufacturing facilities located in 8 countries
- Over $600M annual revenue
- Over 200 patents






The oxidation process at a molecular level

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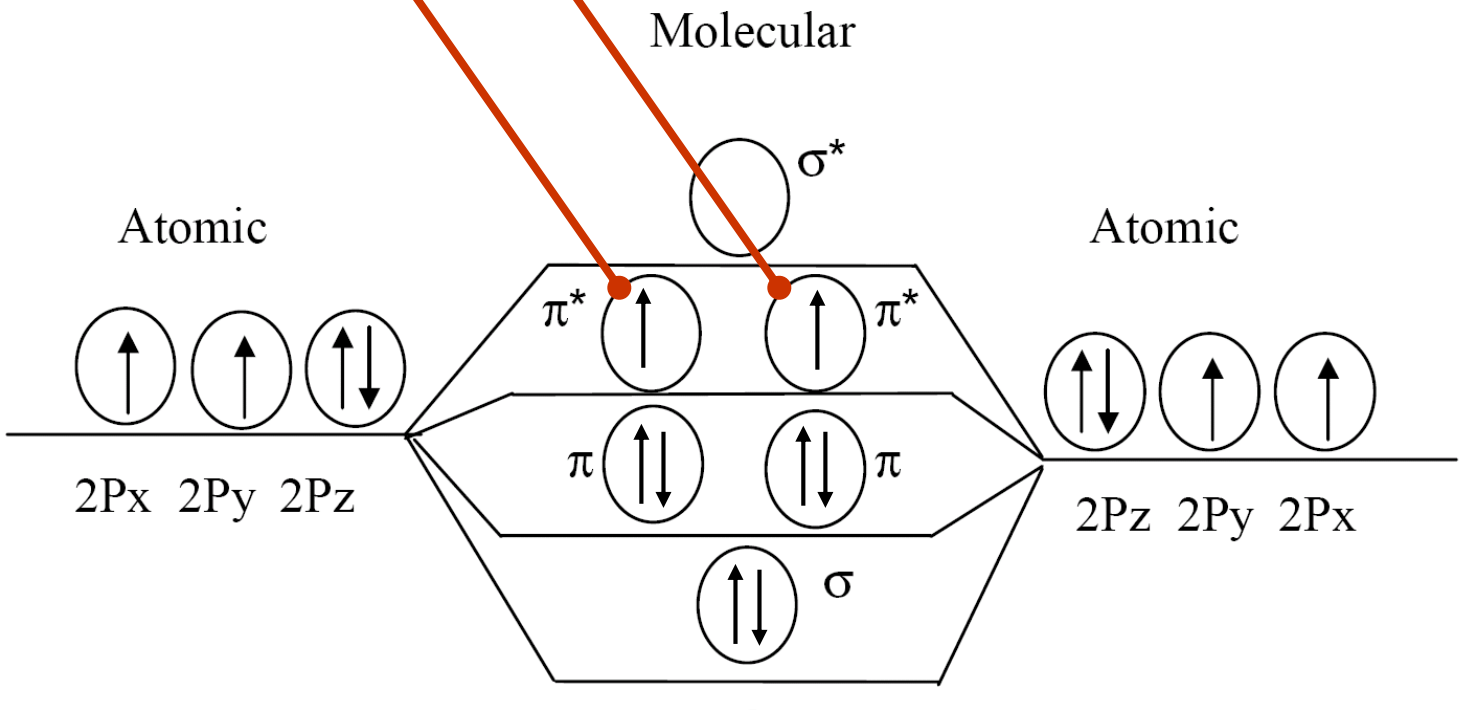
Triplet and singlet oxygen

- Why are there 2 types of oxygen and why do they behave so different?

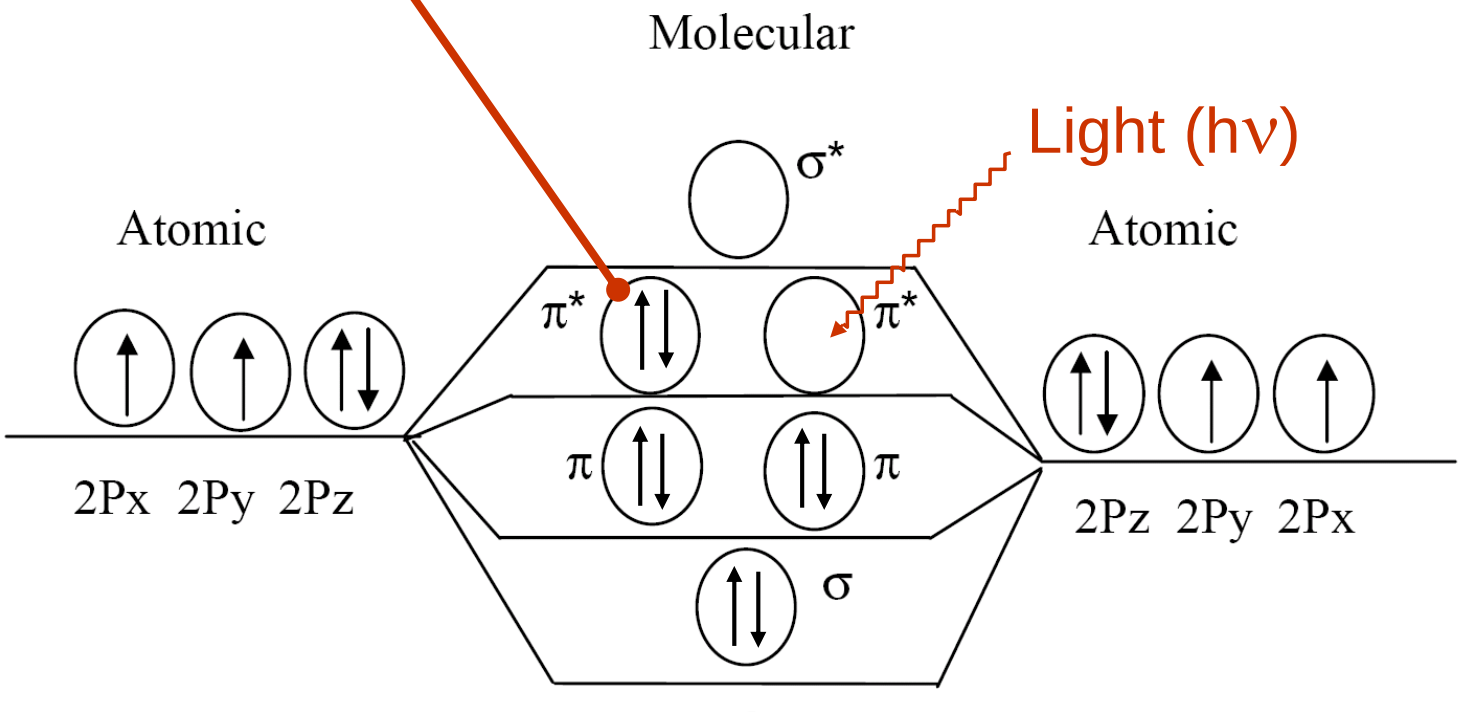
2S+1 = 2 (0.5+ 0.5) +1 = 3 ⟶ Triplet oxygen



Triplet and singlet oxygen

- Why are there 2 types of oxygen and why do they behave so different?

2S+1 = 2 (0) +1 = 1 ⟷ Singlet oxygen



Insight in the oxidation process

T°

$^{3}O_{2}$

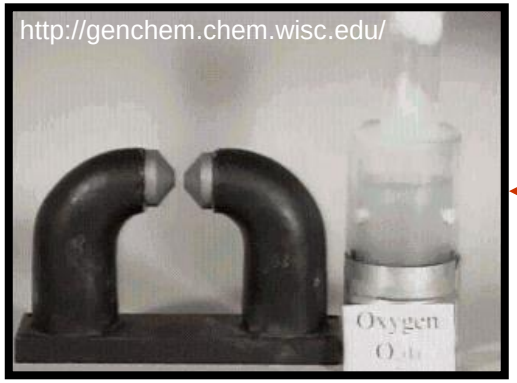
$^{1}O_{2}$

Shutterstock Images

Triplet and singlet oxygen

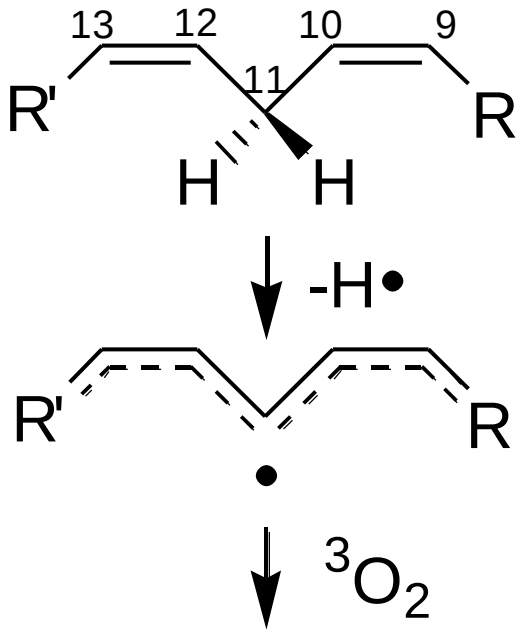
	$^3O_2$	$^1O_2$
Electron spin	↑ ↑	↑↓ ○
Energy level	0 kcal/mole	22.4 kcal/mole
Nature	diradical	electron rich
Reacts with	radicals	non-radicals
Rate C18:1 oxidation	1	3×10^4

Diamagnetic



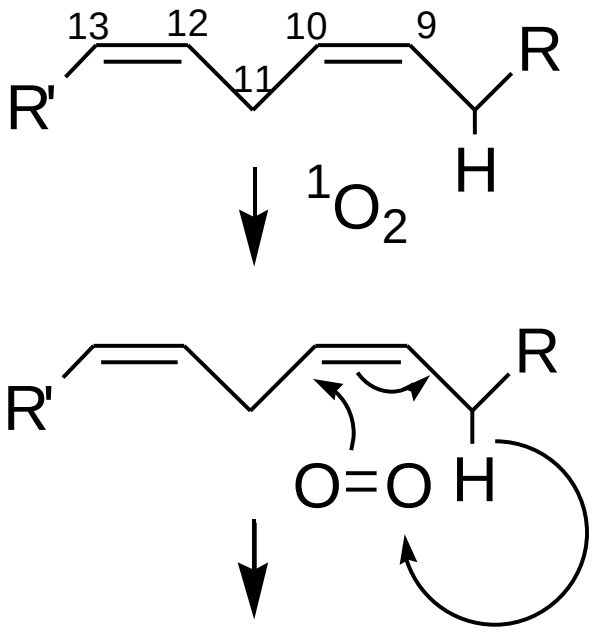
Reaction of oxygen with lipids

$^3O_2$



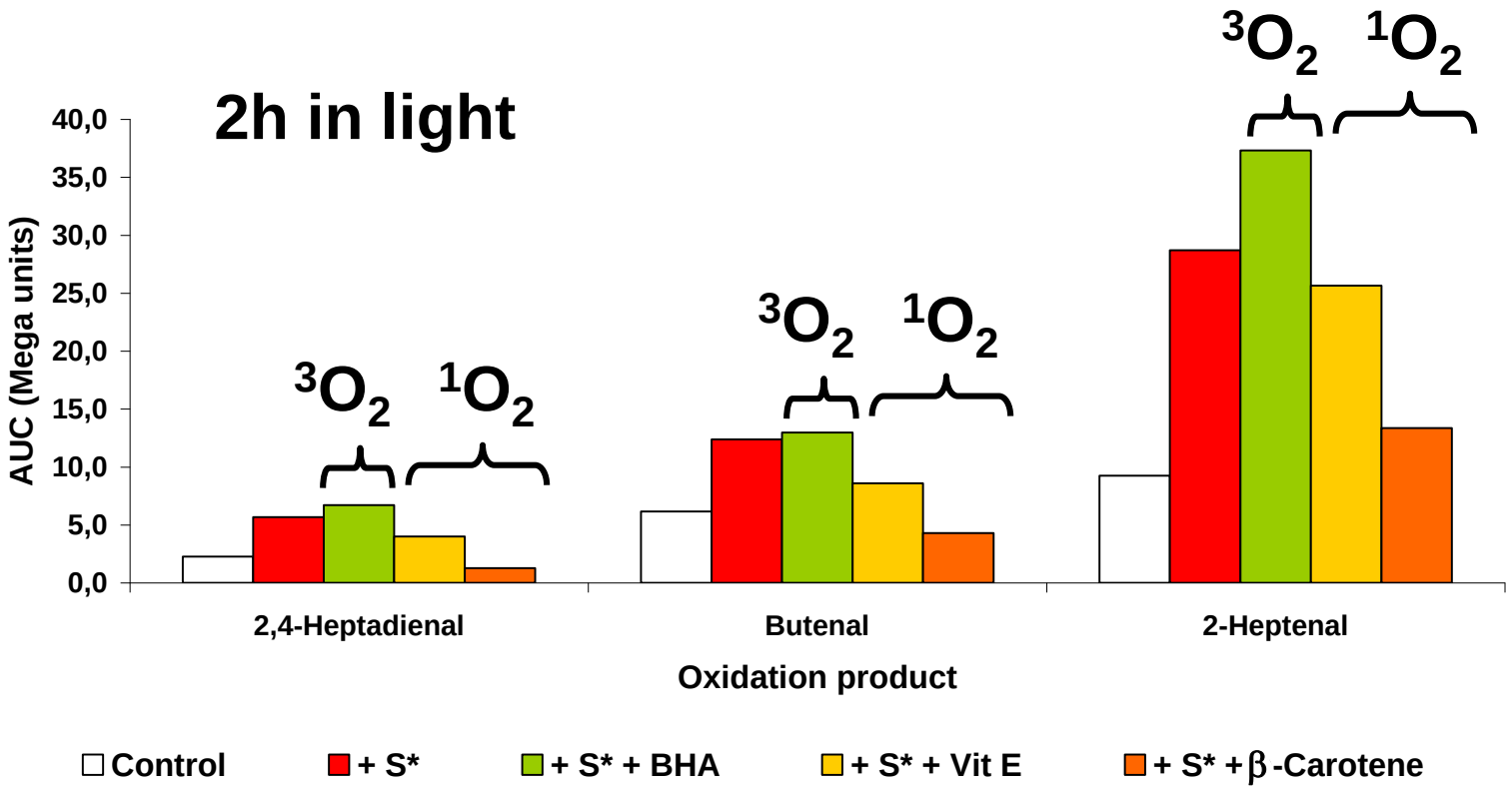
9- and 13-hydroperoxide

$^1O_2$



9-, 10-, 12- and 13-hydroperoxide

Effect of antioxidants on $^1O_2$-degradation products



- $^1O_2$ quencher has no impact on typical $^3O_2$ degradation products like hexanal






Measuring shelf life in foods

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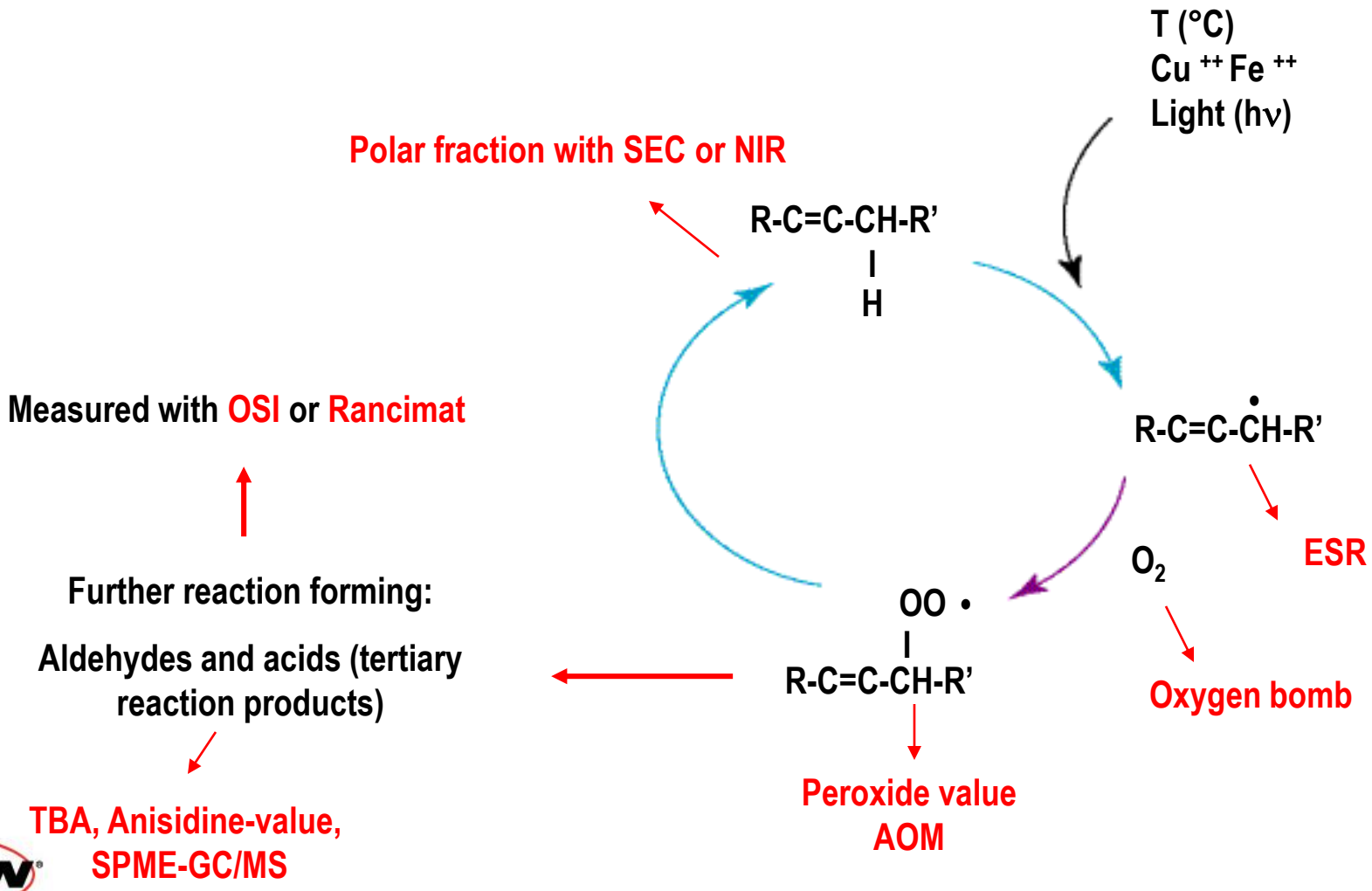
Overview -starting from the oxidation cycle



Oxidation studies




Method	Analysis	Temp. (°C)	Testing time	Stress factor
Shelf life	Sensorial, chemical	25-30	Months	Low
Standard	Sensorial, chemical	30-50	Weeks	Medium
Accelerated	OSI	80-100	Hours	High

Analysis of lipids

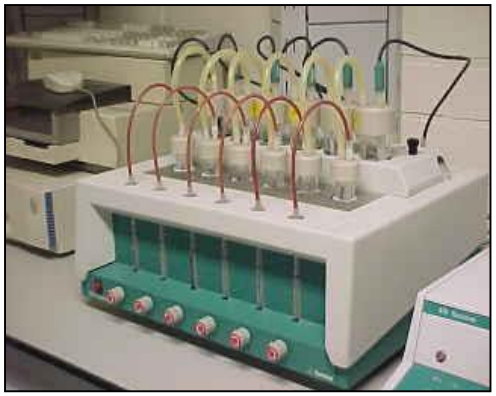



Traditional methods

- Peroxide value
- TBA value / p-Anisidine value
- Polar lipid fraction
- GC-MS headspace of volatiles

Accelerated methods

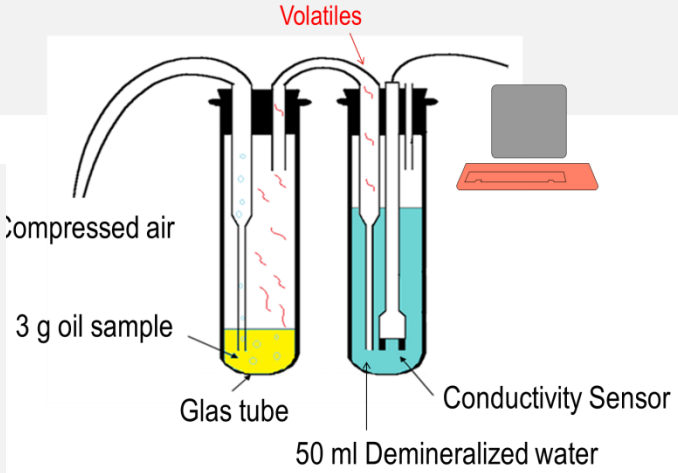
- AOM (Active oxygen method)
- OSI (Oxidative Stability Index)/Rancimat
- Oxygen bomb



Accelerated Oxidation




- **Oxidative Stability Index (OSI) - (AOCS Official Method Cd 12b-92)**
- The oil stability index (OSI) method measures the formation of volatile organic acids by monitoring the change in electrical conductivity when the effluent from oxidizing oils is passed through water
- The oxidation process is accelerated by exposing oil samples to elevated temperatures in the presence of air or oxygen
- The OSI method differs from ambient storage conditions by using a flow of air and high temperatures to accelerate oxidation
- Used for antioxidant screening



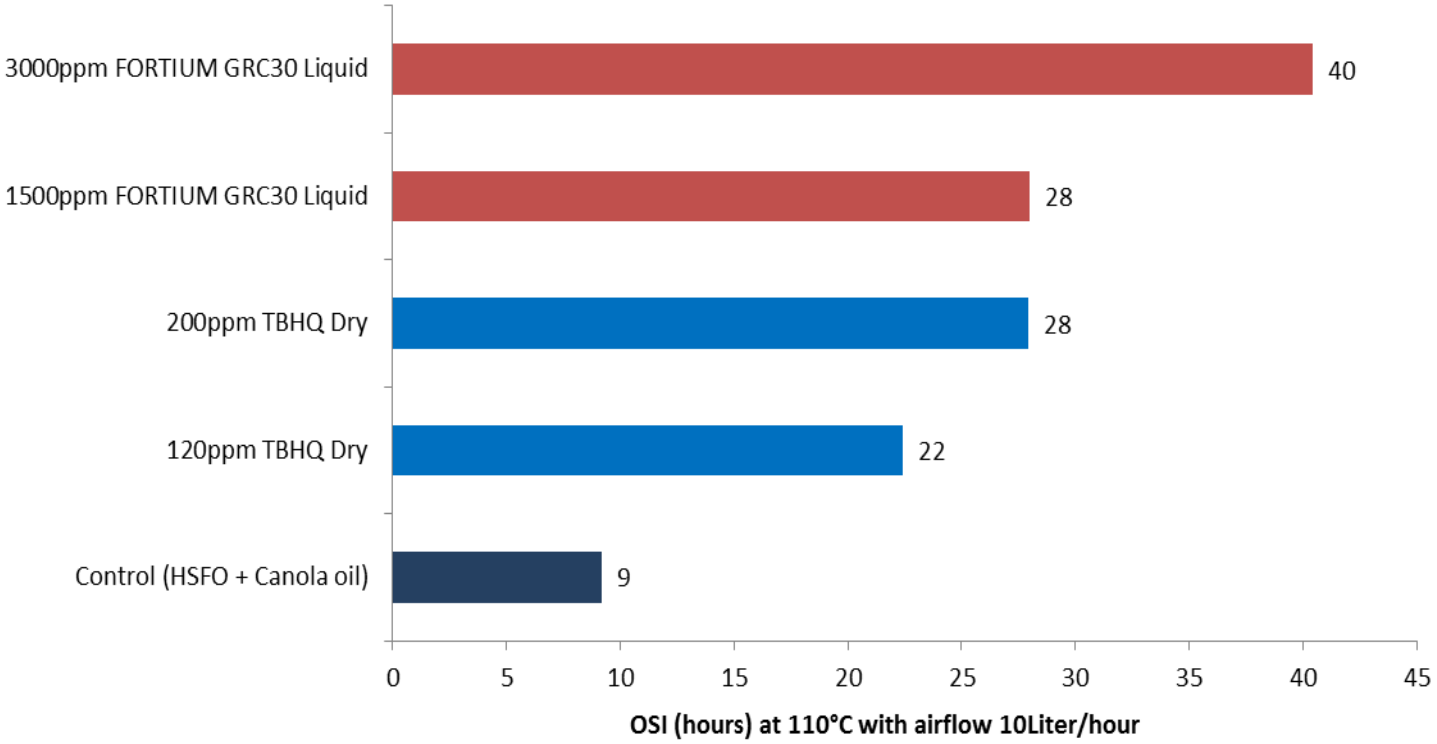
Conditions

- Substrate: 50% High Oleic Sunflower oil with 50% canola oil
- 3 gram oil sample
- Temperature: 110°C
- Air flow: 10 Liter/ hour

Accelerated Oxidation

Antioxidants tested in 50% high oleic sunflower oil (HSFO) + 50% Canola oil:

- TBHQ dry (Tertiary butyl hydroquinone)
- FORTIUM® GRC30 liquid: gallic acid, rosemary extract and citric acid



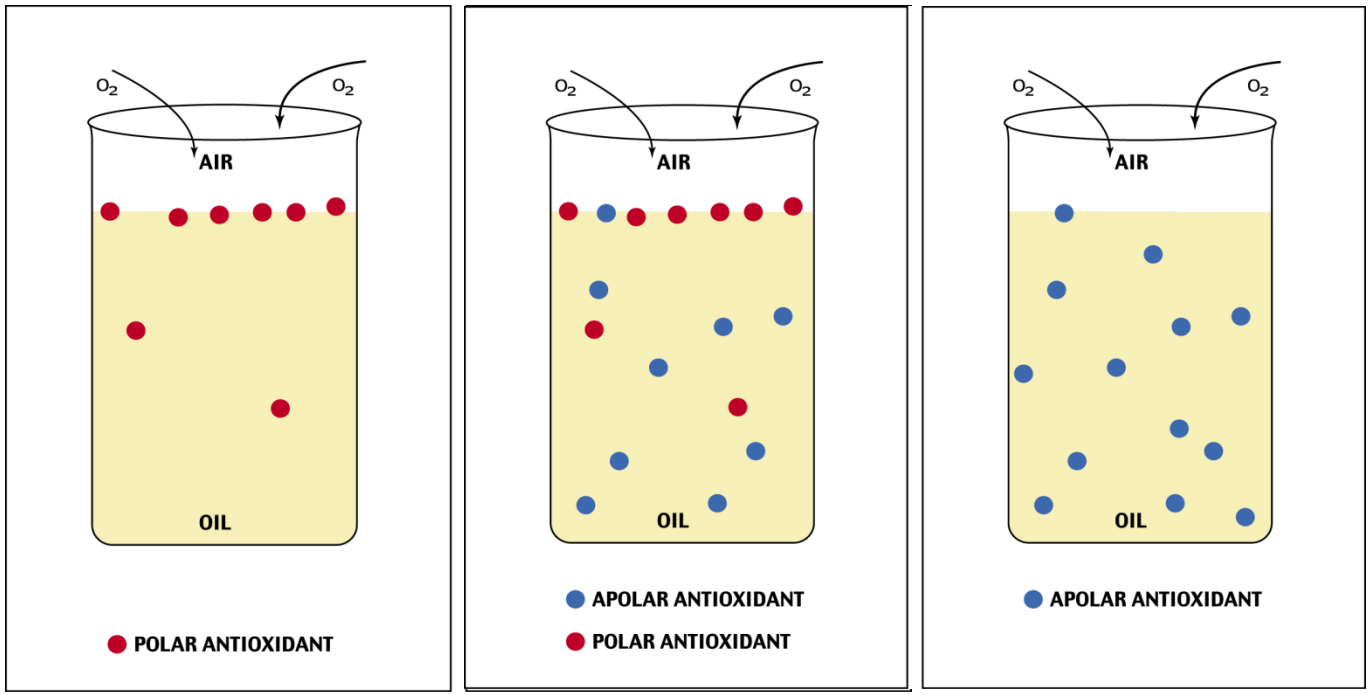




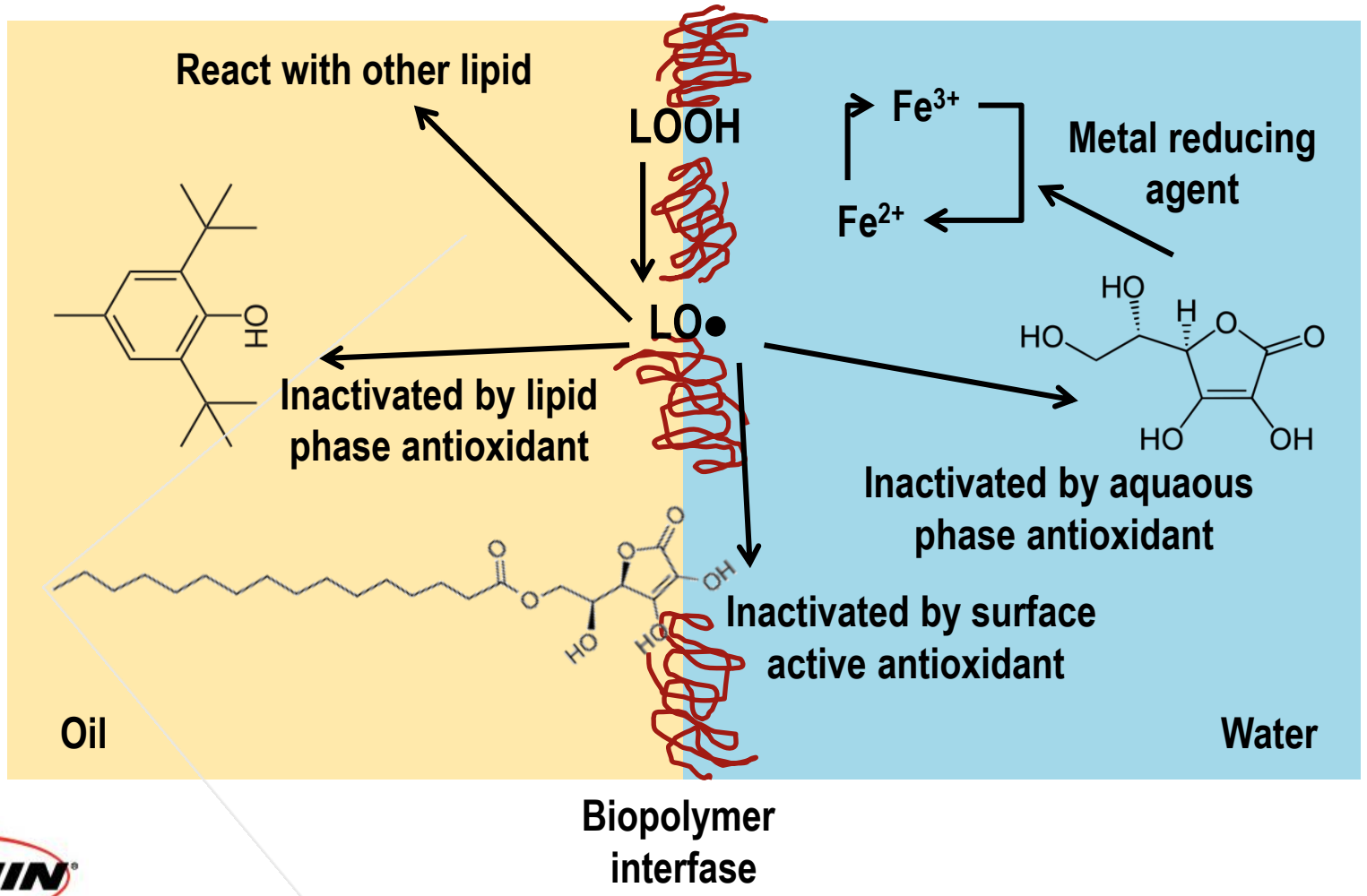

Impact of formulation

Formulations:
The polar paradox

- Polar antioxidants should be used to stabilize apolar lipids !
- Polar antioxidants partition at the surface
- Drawback : how to introduce polar AO in lipids?



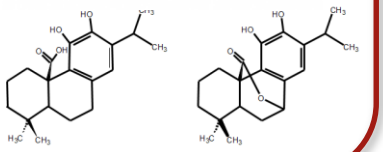
Oxidation at the interphase



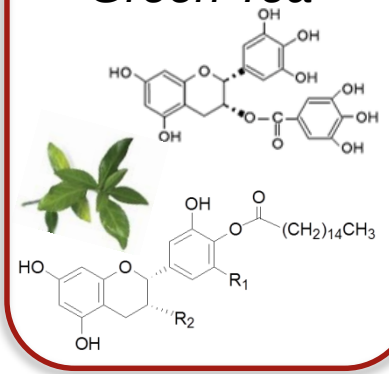
The antioxidant toolbox



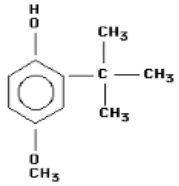

Rosemary

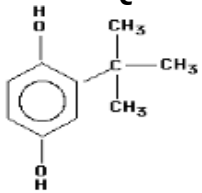
Green Tea



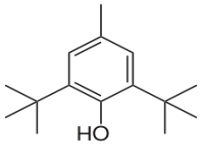
BHA



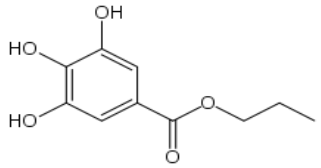
TBHQ



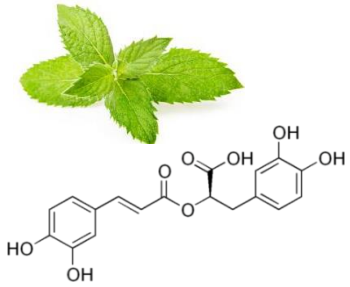
BHT



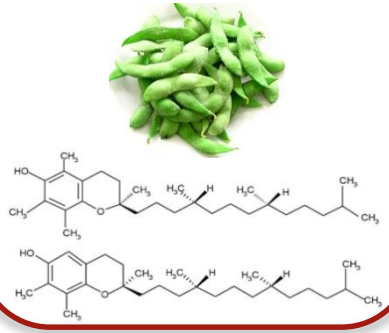
Propyl Gallate



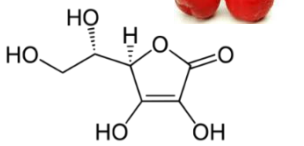
Spearmint



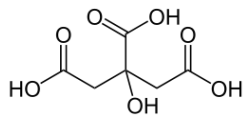
Tocopherols



Acerola



Citric Acid



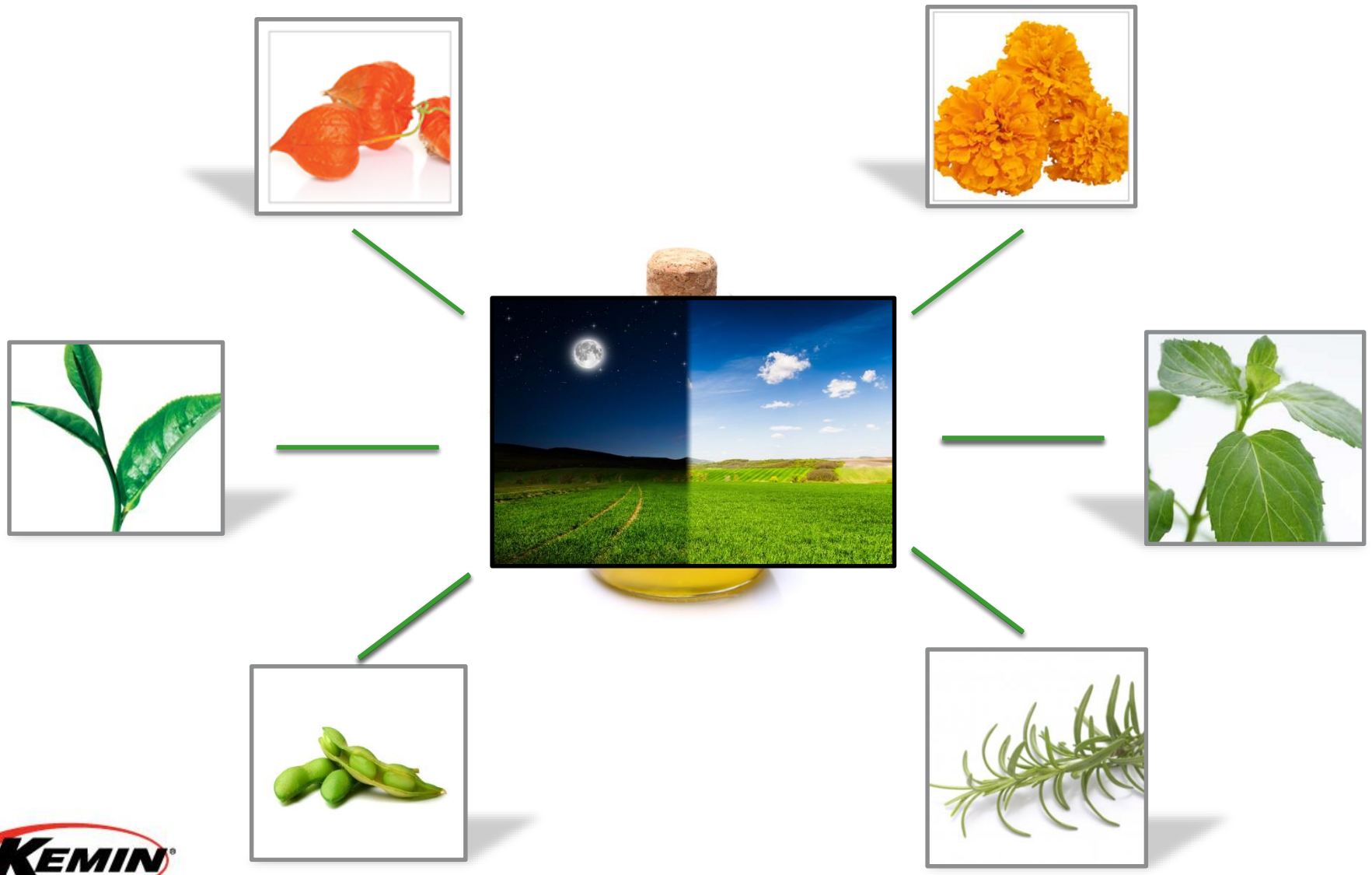
Free Radical Scavengers

Oxygen Reducer

Chelator

KEMIN

Which extract to choose?



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(Anti)oxidation in practice

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Food Technologies

- Delivers innovative, market-driven technologies that target the food industry's toughest challenges.

Antioxidants

...to extend shelf life

Plant-derived Antioxidants

FORTIUM™ brand
Plant-derived Antioxidants & Extracts

Plant Extracts

NaturFORT™ brand
Natural Plant Extracts

GT-FORT™ brand
Natural Plant Extracts

FORTRA™ brand
Natural Plant Extracts

Synthetic

EN-HANCE™ brand
Synthetic Antioxidants

Food Safety

...to control microbial growth

Synthetic

AMPLIFRESH™ brand
Antimicrobials

AMPLIVITA™ brand
Antimicrobials

BactoCEASE™ brand
Food Safety Solutions

SHIELD® brand
Antimicrobials

Natural

BactoCEASE™ NV brand
Antimicrobial Systems

SHIELD® NV brand
Antimicrobials

KEMIN®

LOW FAT (65%) MAYONNAISE

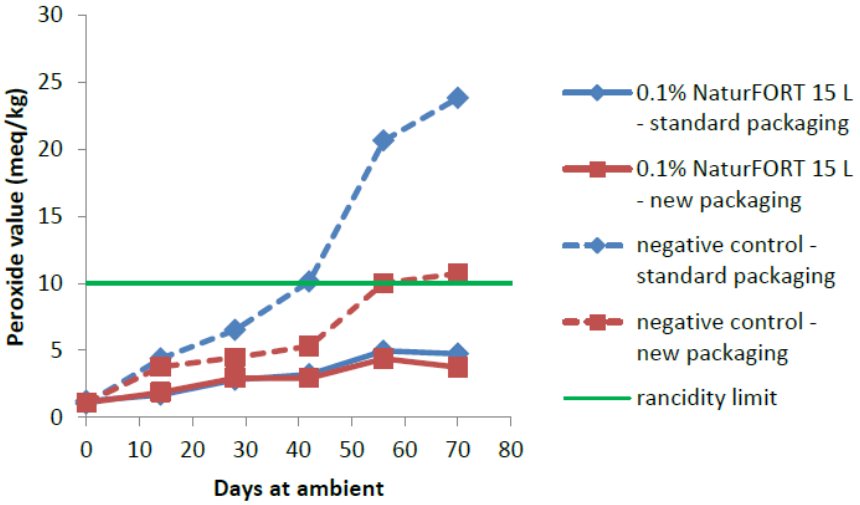


Figure 2. Peroxide values of mayonnaise samples during ambient storage in the dark

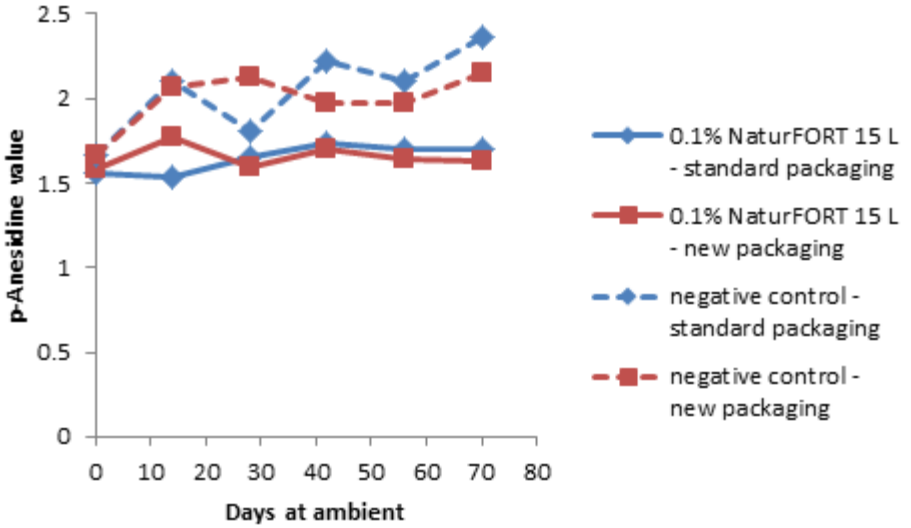


Figure 3. p-Anisidine values of mayonnaise samples during ambient storage in the dark

Conclusion:

The shelf life of mayonnaise could be increased by changing the packaging but NaturFORT™15 L was still required to reach the desired shelf life

Reference: Kemin Internal Document 14-00002

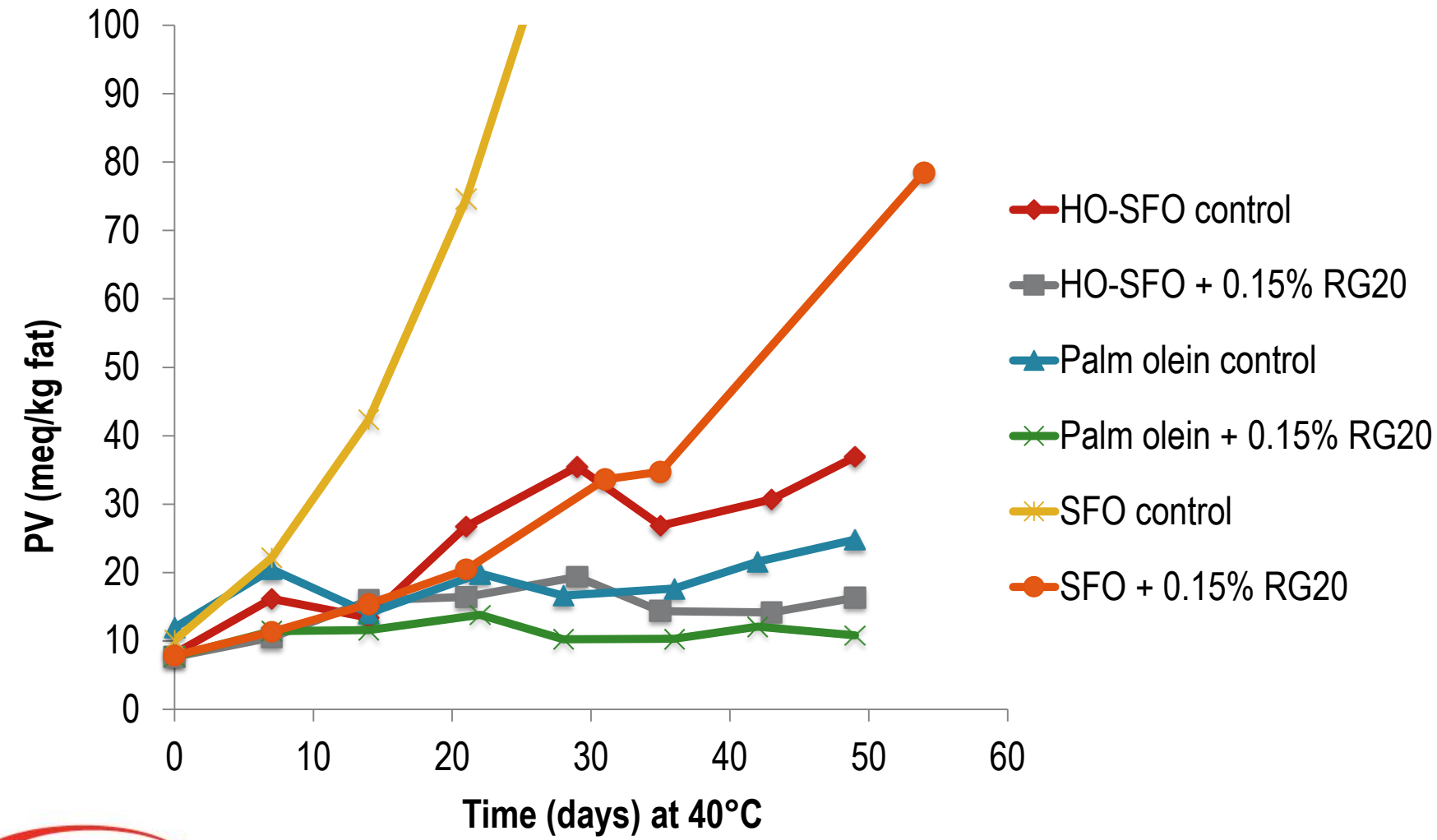
Shelf-life Extension of Frying Oils and the Effect on the Fried Product




- Matrix:
  - **Sunflower oil** (SFO)
  - **High oleic sunflower oil** (HOSFO)
  - **Palm olein** (PO)
- Treatment:
  - **Tocopherols** (FORTIUM®TG20)
  - **Rosemary extract** (FORTIUM® RG20)
- Finished product: tortilla crisps
- Accelerated storage, peroxide values

Reference: Kemin Internal Study INF-2011-00007

Effect on the Fried Product



Reference: Kemin Internal Study INF-2011-00007






Dairy

Whole fat milk

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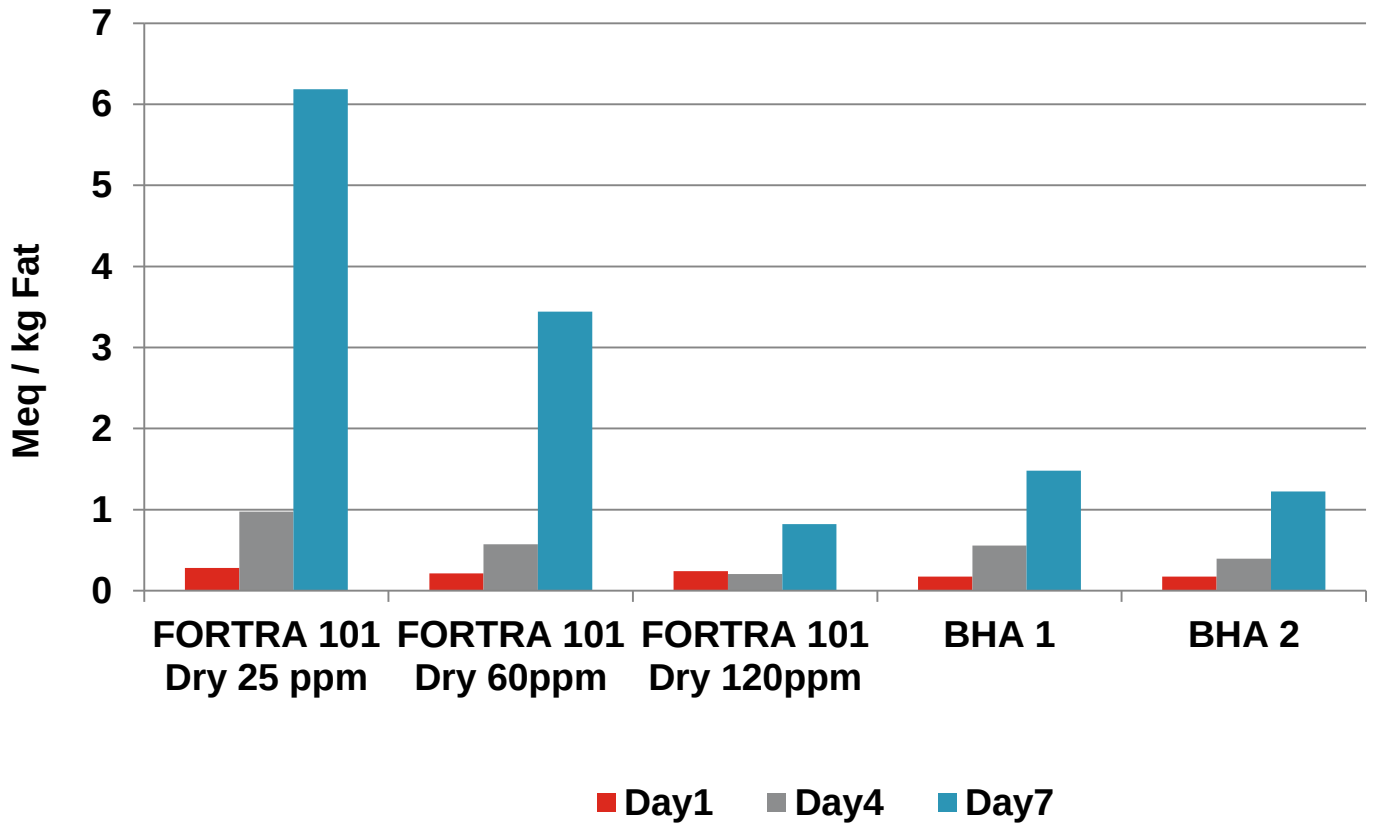
Whole fat milk

Figure 1. PV in whole fat milk



"BHA 1" is 200 ppm BHA based on dry weight (the upper legal limit in the European Union) and "BHA 2" is 200 ppm BHA based on fat weight (the upper legal limit in the United States).

Reference: Kemin Internal Study 15-00045 Development of Ingredients For Delaying Milk Fat Oxidation






The challenge of consistency and safety of plant extracts

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SCS GLOBAL SERVICES
SPEARMINT

KEMIN® INSPIRED MOLECULAR SOLUTIONS™

Plant Breeding Program




Search for Genetic Variation

Screen

Breeding

Screen

Optimize Selected Clonal line(s)

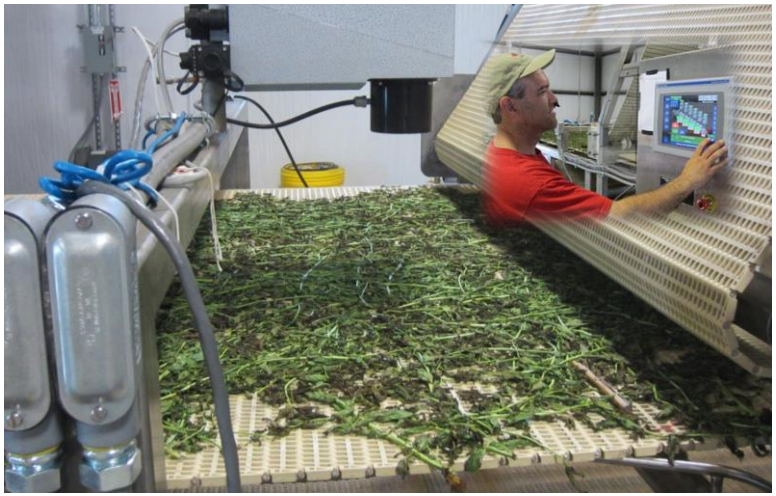
Propagation

Agronomic Scale-up

Reference: Kemin Internal Pictures

Innovation

- Microwave drying
  - 4 chambers per line
  - Reduces water from 80% to <15%
  - Protects flavour and rosmarinic acid



Microwave drying – patent pending

Reference: Kemin Internal Pictures

Plant science & sustainability

- ‘Sustainably Grown’ is one of the most stringent certification standards, supporting long-term sustainable agricultural production
- Kemin is the first and one of the only to acquire third-party ‘Sustainably Grown’ certification for rosemary and **spearmint**

SUSTAINABLY GROWN CERTIFIED™ SCS GLOBAL SERVICES SPEARMINT

References: Kemin Internal Pictures
SCS global services




THANK YOU FOR YOUR ATTENTION

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