

PRESERVING THE QUALITY & SHELF LIFE OF TORTILLAS WHILE MEETING CONSUMER DEMAND

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COMPANY OVERVIEW

- Founded in 1961 by R.W. and Mary Nelson
- Family owned and operated
- More than 500 patents and applications
- Annual revenue exceeds USD \$1 Billion
- Transforming a billion lives every day



1961

WHY SHELF LIFE STILL MATTERS: CONSUMER TRENDS & SPOILAGE LOSS

Consumer Trends

Consumers prioritize fresh products with clean labels and fewer artificial preservatives, increasing innovation pressure.

Impact of Spoilage Loss

Mold spoilage causes up to 30% unsaleable inventory, leading to financial loss and damaged brand reputation.

Preservation Strategies

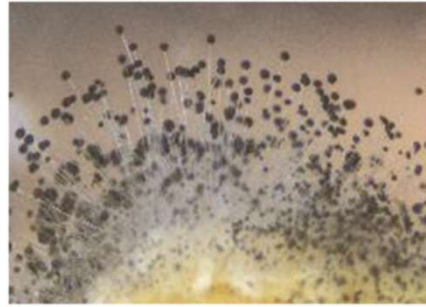
Shelf-life technologies reduce waste by 15-20% while maintaining product quality and clean label integrity.

MICROBES OF CONCERN

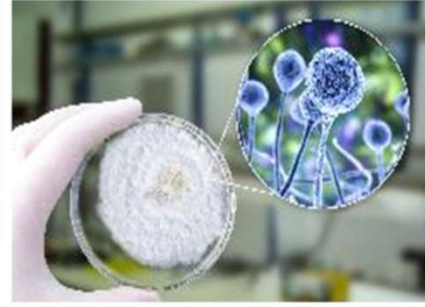
COMMON MICROBES IN TORTILLA



Aspergillus



Rhizopus



Mucor



Neospora



Geotrichum



Bacillus

RESISTANT MOLDS

PENICILLIUM:

- A few species are preservative resistant - e.g., *Penicillium roqueforti*, *P. paneum*, *P. carneum*.
- *P. roqueforti* a sorbate resistant mold, produces 1,3 pentadiene - kerosene smell
- *P. roqueforti* can grow under refrigerated temperature, also called “cold weather mold”



MONASCUS:

- Heat resistant mold
- *Monascus spp*: e.g., *Monascus ruber*, *M. pilosus*
- Survive kill steps e.g., pasteurization, baking
- Also called “summer month mold” or ascospores



FACTORS THAT INFLUENCE SPOILAGE

INTRINSIC FACTORS - MOISTURE & WATER ACTIVITY (a_w)

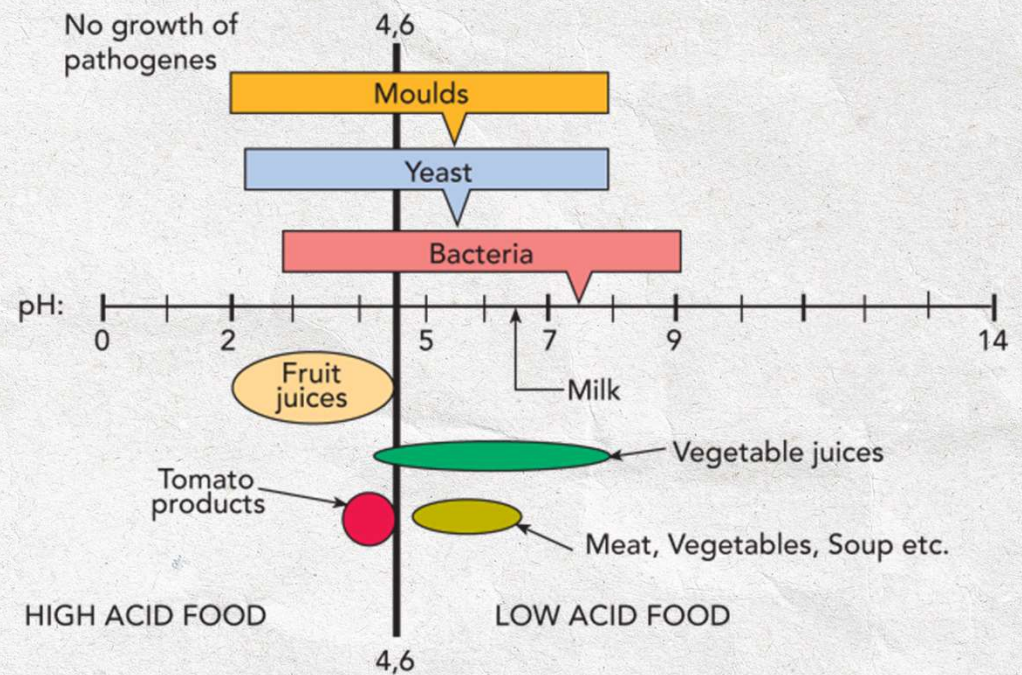
- **Moisture** = total moisture
- a_w = Free water available to microbes
- **Tortilla moisture** = 35 – 50% and a_w of 0.8 to 0.97
- Lowering a_w can hinder microbial growth
- **Solutes** – salt/sugar can reduce a_w
- Could impact sensory and texture

MICROBES	SPECIES	MINIMUM a_w
Most spoilage bacteria		0.90-0.91
Bacteria	Bacillus cereus	0.92-0.95
Bacteria	Clostridium botulinum	0.90-0.98
Most molds		0.80-0.98
Mold	Aspergillus spp	0.68-0.90
Mold	Aspergillus flavus	0.78-0.90
Mold	Aspergillus niger	0.80-0.84
Mold	Fusarium spp	0.82-0.92
Mold	Mucor spp	0.80-0.93
Mold	Penicillium spp	0.78-0.93
Xerophilic molds		0.65
Spoilage yeasts		0.88
Yeast	Saccharomyces bailii	0.80
Yeast	Saccharomyces cerevisiae	0.90-0.94
Yeast	Saccharomyces rouxii	0.62
Osmophilic yeast		0.6

<https://thefooduntold.com/blog/food-science/water-activity-aw-and-food-safety>

NUTRIENTS, pH & OTHERS

- **Excellent nutrition source**
 - Carbs
 - Fat
 - Protein
 - Sugar
- **pH = 4.8 – 12.0**
- **Typical storage = 70 – 90 °F**
- **Oxygen in package**
- **Storage time is favorable for the growth of mold**



EXTRINSIC FACTORS - RAW MATERIALS

Raw Materials – Raw Agricultural Commodity

- Potential source of mold, yeast and bacteria
- Spores of resistant molds - *P. roqueforti*, *P. paneum*, *P. polonicum*, *Monascus*.

Flour dust carrier for spores on equipment surface and/or processing area

- Water quality
- Wooden pallets and cardboard boxes - spores to the packaging area



EXTRINSIC FACTORS - PROCESS

Baking – Temp, Time

- HRM spores (ascospores) can survive baking
- Ascospores contaminate food equipment surfaces

Cooling/Temperature Gradient

- Water condensation
- Surfaces, walls, ceiling, overhead piping
- *Penicillium roqueforti* can grow in colder climates

Recontamination Post Baking



EXTRINSIC FACTORS - PACKAGING & STORAGE

Air Quality

- Create positive air pressure in plant
- Removal external contamination
- Filtration of incoming air – HEPA filter

Cleaning and Sanitation of Equipment

Personal Hygiene

- Wearing Gloves



EXTRINSIC FACTORS - ENVIRONMENT & CLEANING

Packaging Materials

- Vacuum packaging, MAP

Storage Conditions

- Refrigeration, frozen, ambient



EXTENDING SHELF LIFE

HURDLE TECHNOLOGY

Hurdle Technology: Multiple Barriers

- Water activity (a_w)
- Thermal kill step-Baking
- Formulation-Preservatives/pH
- Innovative Packaging/MAP, Vacuum, O_2 Scavengers
- Storage temperature (Refrigerated/Frozen)



SYNTHETIC INGREDIENTS

Antimicrobials are extensively used to inhibit microbial spoilage in tortillas

- **Propionic acid** is commonly used mold inhibitor
- **Sorbic acid** and **benzoic acid** are used as helper molecules

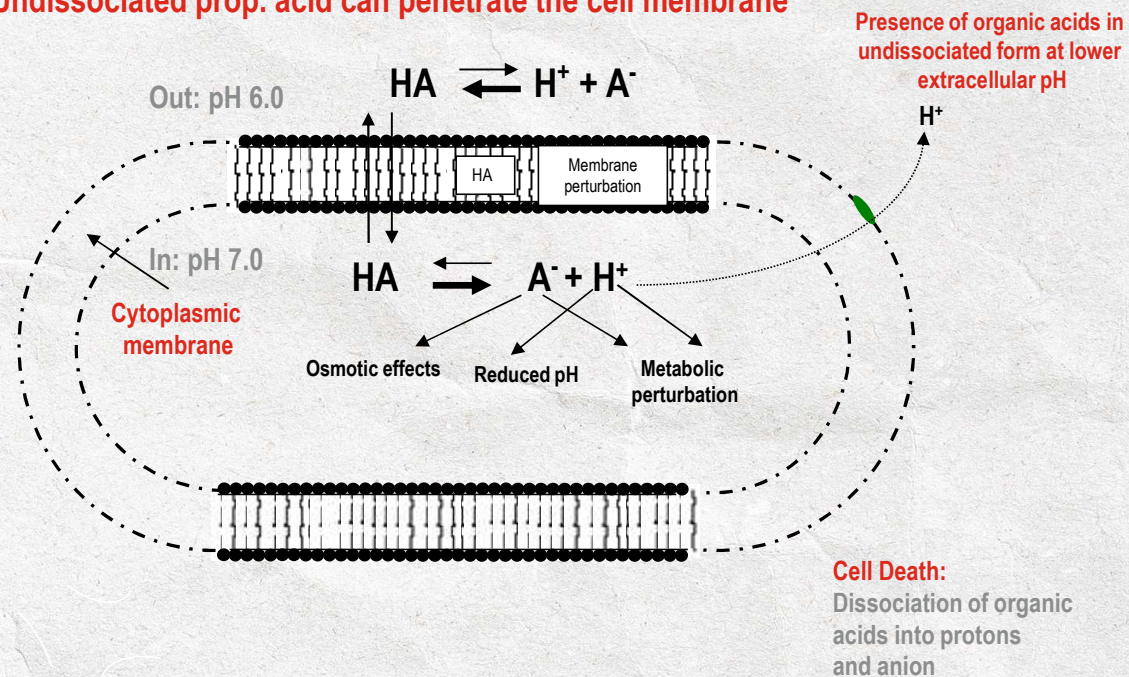


Antimicrobials	SPOILAGE MICROORGANISM		
	Mold	Yeast	Bacteria
Propionic acid	X		X
Sorbic acid	X	X	X
Acetic acid	X		X
Benzoic acid	X	X	X
Parabens	X		X

PRESERVATIVES MODE OF ACTION

- **Propionic acid**
 - Undissociated acid theory/acid stress
- **Sorbic acid**
 - Partly due to undissociated acid
 - Loss of lipid membrane integrity
 - Inhibition of enzymes required for transportation
- **Benzoic acid**
 - Alter membrane fluidity - disruption of membrane trafficking and dynamics

Undissociated prop. acid can penetrate the cell membrane



Adapted from Hirshfield *et. al.*, 2003
Busta *et. al.*, 1986

pH Role in Preservation

Undissociated Propionic Acid (%)	pH
99	2.87
95	3.59
90	3.92
80	4.27
70	4.50
60	4.69
50 (pK_a)	4.87
40	5.05
30	5.24
20	5.47
10	5.82
1	6.87

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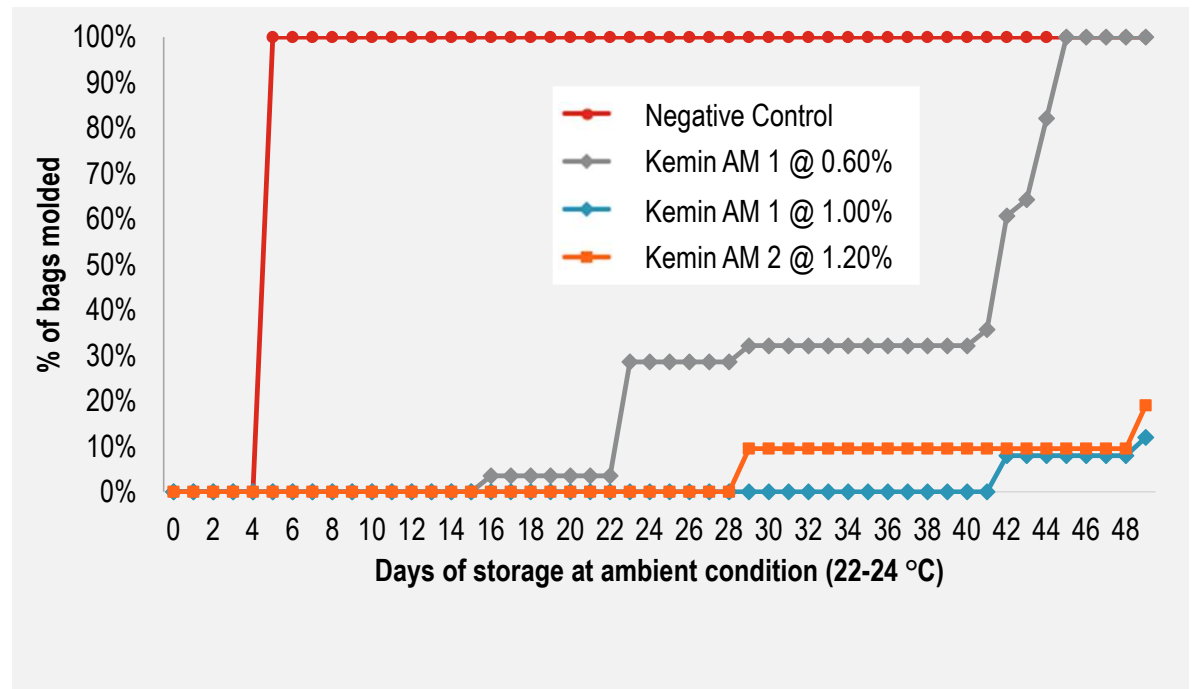
Acidulants

- Lower the pH of finished product
- Improve the efficiency of preservatives
- Disadvantage: affect the after taste of product

pK_a = pH when concentration of acid is equal to its conjugate base i.e., acid is 50% dissociated

EFFICACY OF SYNTHETIC ANTIMICROBIALS

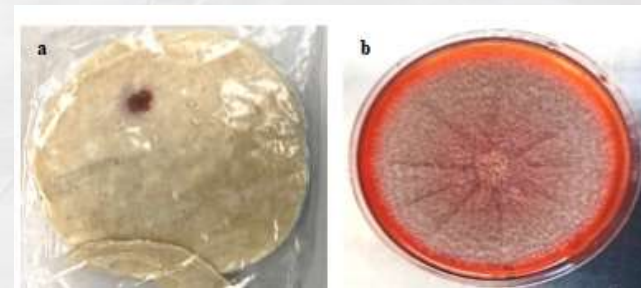
- **Combination of organic acid and other antimicrobials extend the shelf life**
- **Efficacy is based on concentration and ingredients used**
- **Based on the helper molecules used the efficacy can vary.**



Negative control – no antimicrobial, Kemin AM 1 – synthetic liquid antimicrobial, Kemin AM 2 – synthetic liquid antimicrobial.

EFFICACY AGAINST RED MOLD (MONASCUS)

- Monascus are highly resistant to some of the organic acids
- Helper molecules (organic acids, peptides, etc.) can enhance efficacy against these red molds
- Formulation containing propionic acid along with specific helper molecules can control red mold growth during the summer months



Treatment groups	Dosages tested %	Growth at 45 days incubation		
		<i>M. ruber</i>	<i>M. pilosus</i>	<i>M. purpureus</i>
KEMIN AM FORMULA 1	1.00, 1.25, 1.50	No	No	No
SHIELD SPB LIQUID	1.00, 1.25, 1.50	No	No	No
KEMIN AM FORMULA 2	1.00, 1.25, 1.50	Growth at 1%	Growth at 1%	Growth at 1%
KEMIN AM FORMULA 3	1.00, 1.25, 1.50	Yes	Yes	Yes

CLEAN LABEL ANTIMICROBIALS

CLEAN LABEL ANTIMICROBIALS

- **Source – naturally derived**
- **No synthetic ingredients**
- **Fermented products**
 - Cultured sugar
 - Cultured wheat/whey
 - Cultured feedstock
- **Essential oils**
- **Plant extracts – herbal, berry extracts**

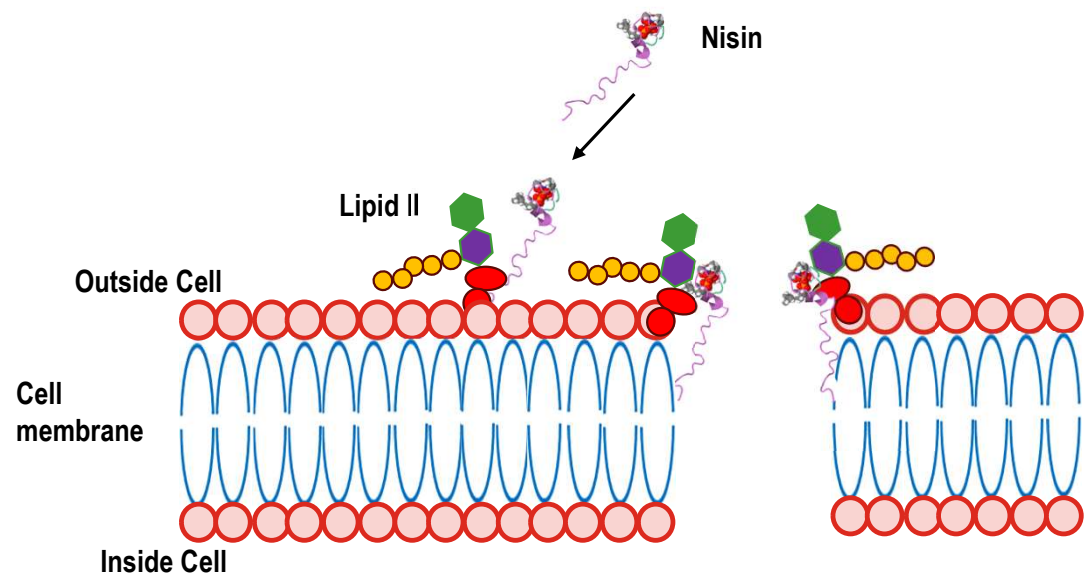
ACTIVE INGREDIENTS - FERMENTED PRODUCTS

Typical actives include

- Short chain fatty acids
- Microbial peptides - bacteriocins

Fatty acids in fermented products

- Propionic acid, acetic acid, lactic acid
- Valeric acid, butyric acid, hexanoic acid and heptanoic acid
- **Mode of action of fatty acids are similar to synthetic**
- **Mode of action of peptides – e.g., nisin**
 - Inhibition of cell wall synthesis
 - Pore formation



Adapted From

Perez *et al*, 2015. Bacteriocins from Lactic Acid Bacteria: A Review of Biosynthesis, Mode of Action, Fermentative Production, Uses, and Prospects
<https://proteopedia.org/wiki/index.php/Nisin>

PRODUCTS AVAILABLE

Based on the microbe used and the process, the products available in the market can vary:

- Efficacy due to the different active molecule and active level – based on process – concentration
- Sensory – based on the feedstock used and downstream process to remove impurities
- Cost/cost-in-use – vary based on manufacturing cost as well as the active concentration (dosage)

LIMITATIONS

- Typical level of actives is low – ranging from 0 – 80%, higher dosage to be used based on the product
- Consistency due to the variability in the fermentation process – if the actives are not standardized
- Impact on color due to the fermented product
- Other sugars and ingredients present in the dried – causing sensory impact
- Increase cost-in-use over synthetics
- May have an impact on the texture of the finished product

SHIELD® PURE LIQUID & DRY

CLEAN LABEL MOLD INHIBITION

SHIELD® PURE offers label-friendly antimicrobials that replace synthetic preservatives for bakery and tortilla systems.

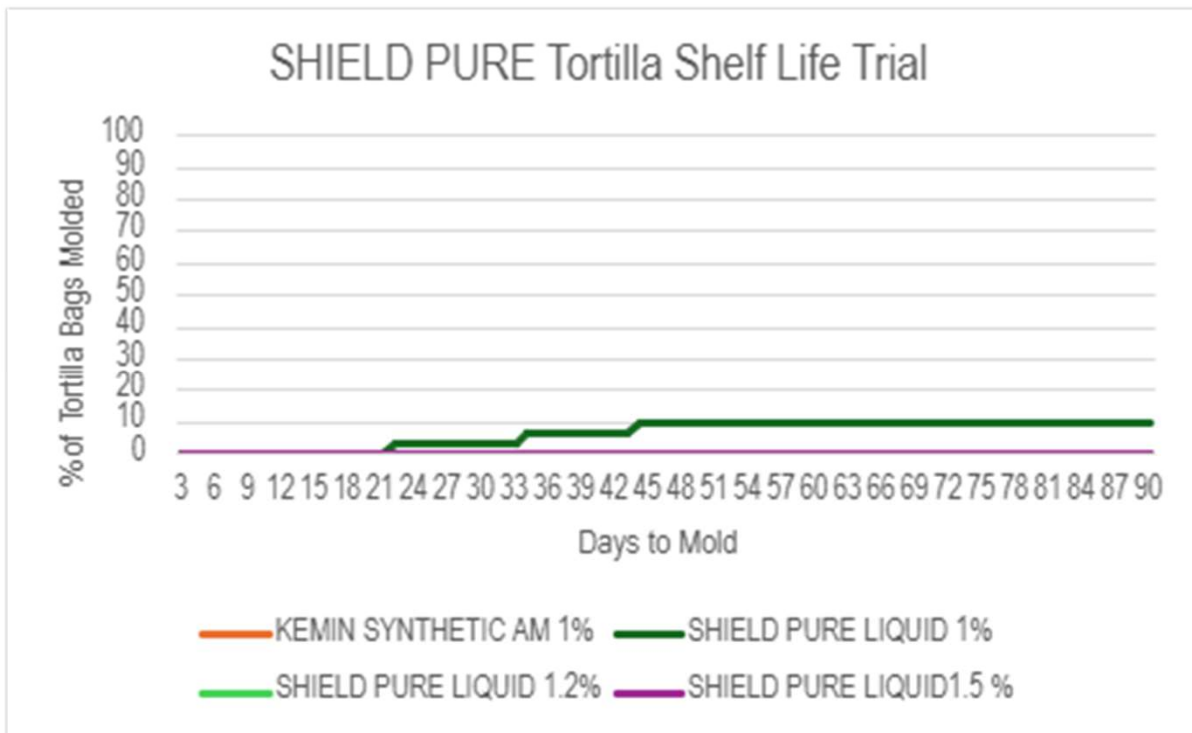
FLEXIBLE FORMATS

Available in liquid and dry formats to suit continuous processing and batch operations respectively.

ENHANCED SHELF LIFE

Designed to deliver robust mold control while maintaining sensory quality and supporting clean label claims.

SHIELD[®] PURE LIQUID: CORN TORTILLAS

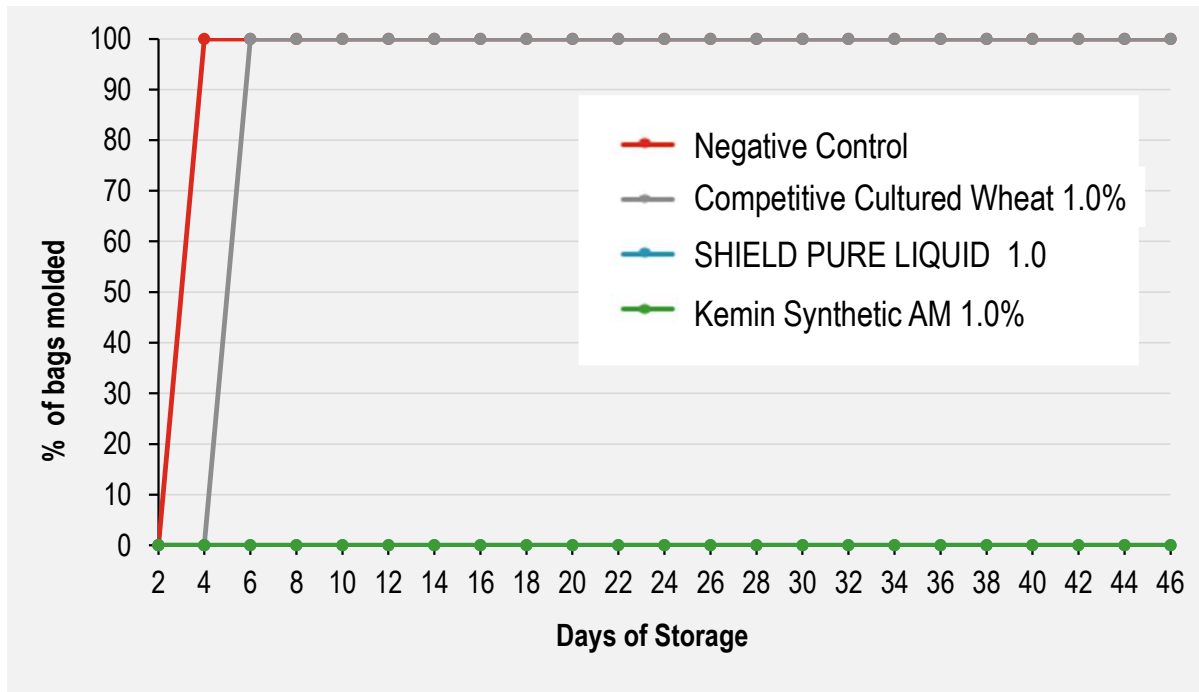


Sensory Results

Groups	Hedonic score
Kemin synthetic AM 1.0%	6.00 ± 1.33
SHIELD PURE Liquid 1.0%	6.90 ± 0.99
SHIELD PURE Liquid 1.2%	6.50 ± 1.78
SHIELD PURE Liquid 1.5%	6.20 ± 1.55

SHIELD PURE LIQUID was similar to synthetic product at equal concentration of actives

SHIELD[®] PURE LIQUID: CORN TORTILLA



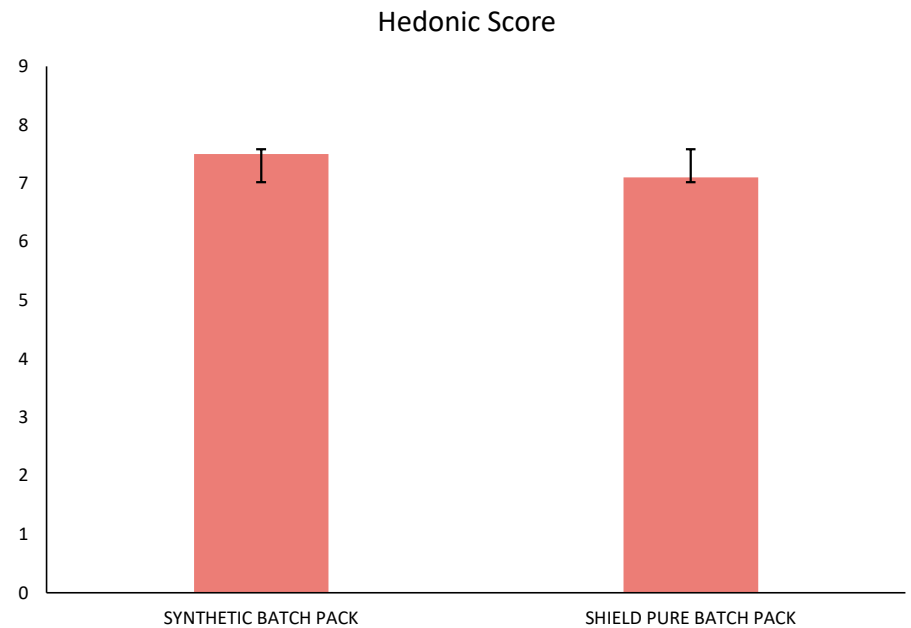
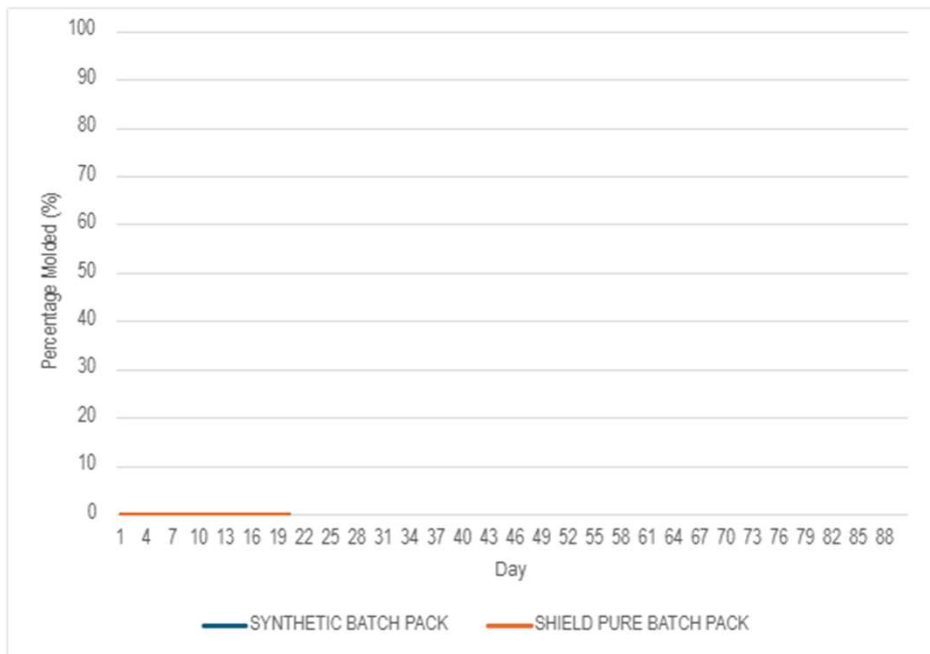
Cultured wheat provided 2 more days of shelf life than negative control.

SHIELD PURE LIQUID was similar to synthetic product at equal concentration.



Negative control – no antimicrobial, CW – cultured wheat, CL Kemin AM liquid – cultured dextrose-based product, Kemin synthetic AM – contains prop & benzoic acid

SHIELD[®] PURE DRY: FLOUR TORTILLA



SHIELD PURE DRY was similar to synthetic product at equal concentration in efficacy, sensory and quality parameters.

BENEFITS OF SHIELD® PURE

CLEAN LABEL MOLD CONTROL

SHIELD PURE offers an effective clean label solution for mold control in bakery and tortilla products.

PERFORMANCE ACROSS FORMATS

Available in liquid and dry forms, SHIELD PURE matches or exceeds synthetic preservatives in multiple product types.

INDUSTRY ADOPTION AND BENEFITS

Leading brands report improved quality, reduced spoilage, and higher consumer satisfaction using SHIELD PURE.

SUSTAINABILITY AND COMPLIANCE

SHIELD PURE supports sustainability, regulatory compliance, and market growth in clean label preservation.

ANTIOMICROBIALS FROM PLANT EXTRACTS

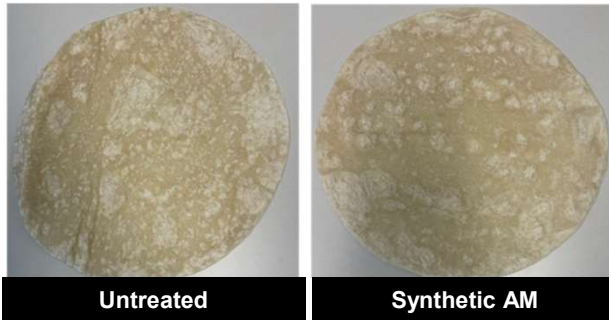
BLEND OF BUFFERED VINEGAR AND ROWAN BERRY EXTRACT FOR MOLD INHIBITION.

TYPICAL APPLICATIONS

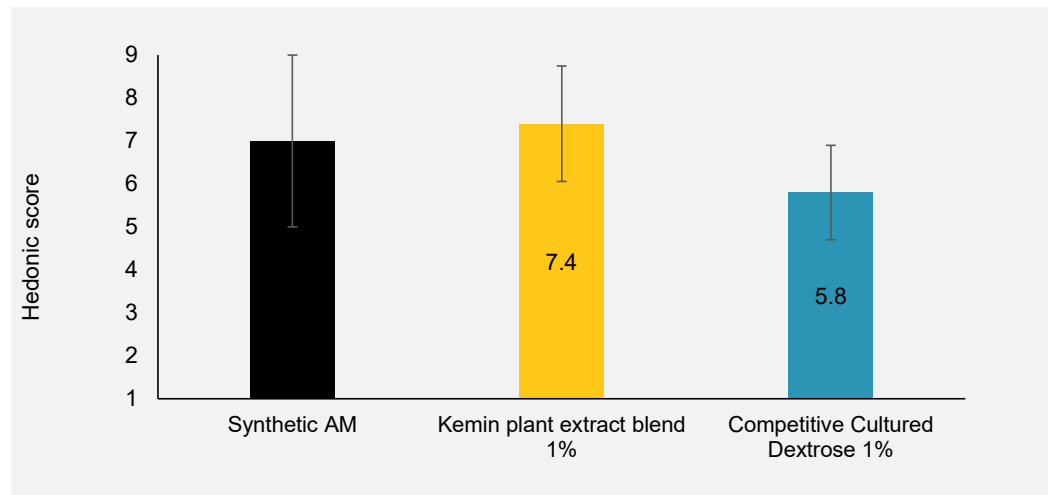
- **BAKED GOODS & TORTILLAS**
- **DRESSINGS & SAUCES**
- **FILLINGS**



EFFICACY IN FLOUR TORTILLA



	Untreated	Kemin plant extract blend	Competitive cultured dextrose
Days to mold	4	8	7



Sensory scores of flour tortillas at week 1 (source: TD-24-10132)

KEY TAKEAWAYS

- Various clean label antimicrobials available – many with sensory limitations
- Vast variability on active content impacting efficacy, cost and sensory
- Appropriate selection and testing is required to choose the most suitable product for your matrix