

Extending the Shelf Life of Consumer Produce: Ethylene Remediation Products
for the Consumer Market:

Introducing the...

bluäpple™
prolongs produce freshness


aureus™
product innovations

I. Introduction

Are you tired of throwing out wilted produce every week? Would you like to waste less food? American households throw out 25% of produce purchased - because it has gone bad, tossing out an average of \$600 of food per year per family, according to an eight year USDA funded study. The study reveals that restaurants, convenience stores and most families could help their bottom lines if they just learned to buy, store and use food more wisely.

Official surveys indicate that every year more than 350 billion pounds of edible food is available for human consumption in the United States. Of that total, nearly 100 billion pounds - including fresh vegetables, fruits, milk, and grain products - are lost to waste by retailers, restaurants, and consumers.

By contrast, the amount of food required to meet the needs of the hungry is only four billion pounds, according to advocacy groups.

Food waste is unfortunate not only in terms of the lost opportunity to feed hungry people, but also in terms of the negative effects on our environment and our wallets. The nation spends an estimated \$1 billion a year to dispose of excess food.

Of note, many households are now paying 10% - 30% over standard prices for organic products. Throwing away 25% of produce purchased at premium prices adds even more to the total amount of money households are spending on food they do not eat.

What can be done to help Americans consume the produce they purchase instead of wasting one quarter of it?

Is it possible to keep the produce purchased by households fresher, longer?

II. Mitigating Ethylene

The ripening of fruit and vegetables is a chemical process that is caused by ethylene gas, a natural plant hormone. It initiates and accelerates the ripening of fruit and vegetables, and then causes them to deteriorate. By lowering the level of ethylene gas surrounding fruits and vegetables, their shelf life can be greatly increased, slowing the maturation of fruit, protecting vegetables, and greatly reducing spoilage (See Table 1 - Ethylene gas sensitivity for more details regarding specific produce items.)

When produce is shipped, trucked, and flown from farm to market, both the commercial and organic produce industries utilize devices to absorb the ethylene gas that fruits and vegetables

emit as they ripen. The use of these devices essentially stops the ripening process so that produce can be shipped to market looking freshly picked, and not wilted or fuzzy.

These ethylene gas absorbing or neutralizing devices (with an organic carrier medium of volcanic ash) have been utilized safely by both the organic and commercial produce industries for over 20 years.

Aureus Products Innovation has taken proven ethylene gas remediation technology found in commercial ethylene control products and created the Bluapple™ - a simple, organic, non-toxic and recyclable device for the home that extends the storage life of produce up to three times longer. The BluApple™ provides a solution to the problem of keeping expensive produce fresh, adapting technology that has been used safely and successfully by the commercial and organic produce industries for decades.

III. How Ethylene Gas Absorption Works

Ethylene gas is a harmless, odorless, colorless gas that is produced from both natural and man-made sources. The ethylene gas molecule is very reactive and is readily oxidized into a state that will not do damage to produce.

There are several ways that may be used to remove ethylene gas from produce storage areas. One of the simplest and safest methods is to oxidize it with sodium permanganate. This reaction can reduce ethylene gas to extremely low levels. Sodium permanganate (NaMnO_4) is used in a number of familiar applications, such as in drinking water and air treatment systems.

The carrier medium for sodium permanganate can vary, however, for the home market, a natural zeolite is used. Zeolite is a pure form of ancient volcanic ash that has a very high crystalline surface area, providing an ideal substrate for the ethylene gas oxidation to occur.

Natural zeolite is often used as an odor absorber and a humidity stabilizer in refrigerators, closets, and automobiles. The very high surface area traps molecules and absorbs water when humidity is too high - releasing it back into the atmosphere when it gets too dry. Of course, the zeolite used in the BluApple™ serves those purposes as well, but its primary function is to remove ethylene gas from the produce bin.

The reaction between the ethylene gas and sodium permanganate oxidizes the ethylene gas away and, of course, decreases the available sodium permanganate too. *(For a detailed explanation of the chemical reaction, see Figure 1.)* The amount of sodium permanganate available will typically last at least 3 months in most home refrigerators and dry storage areas. After 3 months the packet inside the BluApple™ should be replaced with a fresh refill packet.

The makers of the BluApple™ recommend that consumers recycle the spent zeolite by sprinkling it onto plants and flowers in the household. Zeolite is a natural soil and the MnO_2 provides trace minerals to the soil, making it a very good fertilizer.

Additional Information on Storing Fruits and Vegetables

The BluApple™ can extend the storage life of produce up to three times longer. However, ideal storage conditions can also impact the process, and can significantly impact taste.

Research produced by the Post Harvest Technology Research and Information Center at the University of California - Davis stresses that to maintain the freshness and flavor of produce purchased at the market or grown in the garden, it is important to know how to store it at home. Many fruits and vegetables should be stored only at room temperature because refrigerator temperature damages them, or prevents them from ripening to full flavor. Other produce can be ripened on the counter and then stored in the refrigerator. A few fruits and fruit-type vegetables gain sugar or soften when stored at room temperature.

For more information, please refer to *Table 2. Handling Information for Fruits & Vegetables*

IV. Independent Research Supports Claims

Aureus Product Innovations, a developer of unique consumer products, brings the technology used by the industrial produce growers and shippers to the consumer retail market through the BluApple™.

In an independent study in 1997 at the University of California - Davis, research reported that the removal of ethylene gas is "critical to prevent concentrations that exceed the threshold for ethylene gas injury." In this study, several products that claim to eliminate ethylene gas were tested.

In the study, only permanganate products were found to remove ethylene gas. Whether in the laboratory or in actual application, permanganate ethylene mitigation products are overachievers. They not only succeed in their primary function of counteracting ethylene gas, but also in killing air-borne bacteria, viruses, sour rot, blue mold and brown rot fungi.

Ethylene mitigation is an essential link in the commercial "cold chain" that keeps food fresh as it moves (sometimes half way across the world) from farm to market. As markets expand across the nation and the globe, preserving freshness is one of the biggest challenges. While refrigeration and humidity slow decay, they don't halt the production of harmful ethylene gas. Ethylene mitigation products are used during post-harvest handling of fruit, vegetables and floral commodities during storage and shipment by truck or sea container.

Commercial uses include:

Distribution Centers
Restaurants
Specialty Packers
Floral Reach-ins Packer/Shippers
Institutions
Retail Walk-ins
Re-packers

Ethylene filtration and absorption systems are safe. Ethylene gas is oxidized by nascent oxygen, converting the absorption pellets of volcanic zeolite into manganese dioxide, which is an organic fertilizer. Independent quality consultants have proven that the ingredients utilized in the BluApple™ also retards the growth of mold and rot. Unlike other products on the market, there are no disposal problems with this product.

Although other products market themselves as providing the similar benefits, only permanganate products are proven to be highly effective. Some other competitors' products absorb moisture and odor, but are not true ethylene neutralizers because they contain no permanganate absorption material.

V. What about the so-called "green" plastic bags for produce?

Some plastic bag makers claim that their bags absorb ethylene gas. Though we have seen instances where some manufacturers have blended ethylene gas absorbent material into the plastic resin, the amount of absorbent material is necessarily tiny. Because micro-pore plastic bags create a high-humidity environment inside the bag they do offer more protection than nothing, but the truth is that a plastic bag cannot absorb and destroy ethylene gas on any effective scale. Actively absorbing and neutralizing ethylene gas from the entire storage space is a much better solution. The Bluapple™ ethylene gas removal solution is comprehensive, cheaper, more effective, and does not add plastic bags to landfills.

A recent analysis by Consumer Reports (<http://www.consumerreports.org/cro/food/news/2008/07/debbie-meyer-green-bags/overview/storing-fruit-ov.htm>) reports disappointing results from so-called "green" bag products.

VI. Conclusion

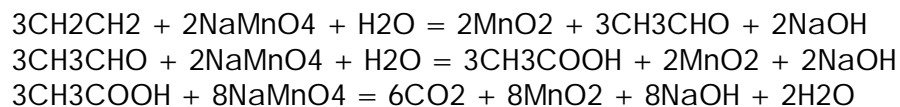
The BluApple™ brings industrial strength technology to your home to reduce spoilage and extend the useful life of your produce. The product can simply be placed in the refrigerator produce drawer and the contents are protected from ethylene gas. On the countertop, produce should be placed in a container or paper bag together with The BluApple™ to absorb the ethylene gas released from fruits and vegetables. It's as simple as that. By changing the packet inside every three months, consumers have a permanent solution to the produce storage problem. Bluapple™ users will reduce waste and save money.

The BluApple™ is only available from fine retail grocers, co-ops and natural food stores in North America. Safe, non-toxic, organic and recyclable - this simple solution is a proven value.

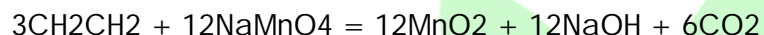


Figure 1. Chemistry in Action

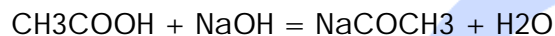
The chemical reaction is as follows:



Combining equations 1-3 generates:



Even if the reaction does not go all the way through to the carbon dioxide-producing step, many of the intermediate products formed either become irreversibly bound to the media or act as reactants themselves. Such is the case of the sodium hydroxide (NaOH) formed in equation 1 and 2. The NaOH will react with the acetic acid formed in equation 2 to produce the sodium acetate salt (NaCOOCH₃) through a simple acid-base neutralization reaction. This is shown below.



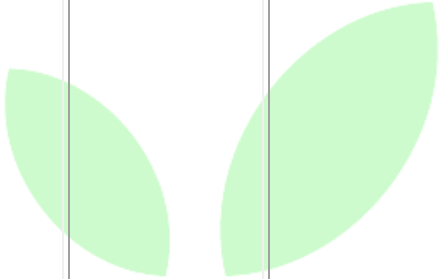
Combining equations 1, 2, and 5 generates:



Table I. Ethylene Sensitivity - How Ethylene Gas Effects Your Produce

Fruits & Vegetables Types	Rate of Ethylene Production	Level of Ethylene Sensitivity	Principal reaction to Ethylene Gas
	VH		Scald (*1)
Apples	H	H	Decay
Apricots	H	H	Decay
Asian Pears	VL	H	Toughness
Asparagus	H	M	Decay
Avocados	M	H	Decay
Bananas	L	H	Mold
Berries	VL	L	Yellowing
Broccoli	VL	H	Yellowing
Brussel Sprouts	H	H	Decay
Cantaloupe	VL	M	Bitterness
Carrots	VH	L	Decay
Cherimoya	VL	H	Softening
Cherries	L	L	Yellowing
Cucumbers	L	H	Brown Spots
Eggplant	VL	M-H	Mold
Grapefruit	VL	M	Mold
Grapes	L	L	Decay
Kiwifruit	VL	H	Mold
Lemons, Limes	VL	M	Russet spotting
Lettuce (*2)	M	H	Decay
Mangoes	M	H	Decay
Melons (*3)	H	H	Decay
Nectarines	VL	H	Odor, sprouting
Onions, Garlic	VL	L	Mold (*4)
Oranges	H	M	Decay
Papaya	VH	H	Decay
Passion Fruit	H	H	Decay
Peaches	H	H	Decay
Pears (*5)	L	H	Decay
Persimmons	M	H	Decay
Plums, Prunes	VL	H	Sprouting
Potatoes (*6)	L	M	Decay
Quinces	M	H	Shrink, decay
Tomatoes	L	H	Lose firmness
Watermelons	VL	H	Sleepiness (*7)

Floral & Nursery Commodities			
Carnations -Cut	VL	H	Prem. opening
Roses -Cut	VL	H	Shrink (*8)
Flower Bulbs	VL	H	Slower start
Nursery Stock			



TM

VL = Very low, L = Low, M = Moderate, H = High, VH = Very High

- *1. Lose crunch
- *2. Leafy greens
- *3. Crenshaw, Honeydew, Persian
- *4. Rind breakdown
- *5. Anjou, Bartlett, Bosc
- *6. Processing, Seed
- *7. Leaf curl
- *8. Retards flower formation

* Source: *Fresh Produce Manual* for 1997 from the Produce Marketing Association and the 1991 *Sea Land Shipping Guide for Perishables*. This is only a partial list. For more information on specific commodities and about the impact of ethylene under various storage and shipping conditions call us toll free in the U.S. (800) 200-1909 or (559) 896-1909.

Table 2. Handling Information for Fruits & Vegetables

Most fruit (including avocados and tomatoes) should be stored at room temperature until ripe. Exceptions to this are berries, grapes, fresh figs, melons, pineapple, coconut and tangerines. Apples can be refrigerated or stored in a cool dark place.

To speed ripening, place fruit in a loosely closed paper bag. Leave at room temperature, out of direct sunlight. The paper bag holds in ethylene, a gas produced naturally by the fruit, which helps speed up the ripening process. Don't use a plastic container as it traps moisture and air which causes spoilage.

Once ripe, fruit can also be refrigerated, and with the BluApple, will remain fresh for days extra.



Vegetables Table 2

CROP	RELATIVE PERISHABILITY ¹	DESIRABLE HARVEST QUALITY	OPTIMUM STORAGE CONDITIONS		CHILLING SENSITIVE? ²	COMMENTS
			Temp (°F)	Humidity (%)		
Beans, Lima	M	Seeds developed and plump with tender green seed coats.	40-45	95	Yes	Sprinkle lightly.
Beans, pole & snap	H	Seeds immature; crisp pods free from blemishes	38-42	95+	Yes	Sprinkle lightly.
Beets	M	Roots firm, deep red, 1.5 to 3" diam.	32	98-100	No	Sprinkle lightly; remove tops.
Broccoli	VH	Green heads, flower buds developed but tight.	32	95+	No	Sprinkle lightly.
Brussels Sprouts	H	Firm sprouts, 1" diameter	32	95+	No	Sprinkle lightly.
Cabbage	M	Crisp, firm, compact heads.	32	95+	No	Sprinkle lightly.
Cantaloupes	M	Stem scar at maturity; skin yellowish tan; sweet, firm flesh with deep color.	38-41	95+	Yes	
Carrots	M	Tender, crisp, sweet roots, deep orange.	32	95+	No	Sprinkle lightly; remove tops; ethylene exposure may cause bitterness.
Cauliflower	VH	Heads with compact, white curds.	32	95+	No	Sprinkle lightly.

CROP	RELATIVE PERISHABILITY ¹	DESIRABLE HARVEST QUALITY	OPTIMUM STORAGE CONDITIONS		CHILLING SENSITIVE? ²	COMMENTS
			Temp (°F)	Humidity (%)		
Celery	VH	Stalks with crisp and tender petioles; no seed stalks.	32	95+	No	Sprinkle lightly.
Chard & Collards	H	Leaves fresh, green, young, and tender.	32	95+	No	Sprinkle lightly.
Corn, Sweet	VH	Kernels plump, sweet, milky, tender	32	95+	No	Sprinkle or top ice.
Cucumbers	H	Pickling: (1-4" long), crisp, green. Slicing: (6" long), crisp, green.	50-55	95+	Yes	
Eggplants	H	Shiny, deep purple skin; seeds immature.	50-55	95+	Yes	Sprinkle lightly
Endive & Escarole	VH	Leaves fresh, crisp, and tender, free from discoloration.	32	95+	No	Sprinkle lightly.
Honeydew Melons	M	Surface waxy, white to creamy white in color; blossom-end springy under moderate pressure; characteristic aroma.	45-50	95+	Yes	
Lettuce	VH	Heads compact and firm, fresh, crisp.	32	95+	No	Sprinkle lightly; ethylene exposure may cause russet spotting.

CROP	RELATIVE PERISHABILITY ¹	DESIRABLE HARVEST QUALITY	OPTIMUM STORAGE CONDITIONS		CHILLING SENSITIVE? ²	COMMENTS
			Temp (°F)	Humidity (%)		
Mustard & Turnip Greens	H	Leaves tender and crisp; plants without flower stalks.	32	95+	No	Sprinkle lightly.
Onions, Dry	L	Firm bulbs, tight necks, dry leaf scales.	32	65-70	No	
Onions, Green	VH	Crisp, green stalks with long white shanks.	32	95+	No	Sprinkle lightly.
Parsley	VH	Tender, crisp, green leaves.	32	95+	No	Sprinkle lightly.
Peas, English	VH	Seeds developed, but tender and sweet; pods still green.	32	95+	No	Sprinkle lightly.
Peas, Snow/Chinese	VH	Crisp, tender, green pods; seeds immature.	32	95+	No	Sprinkle lightly.
Peppers, Green	H	Crisp, firm, with shiny appearance.	50	95+	Yes	
Potatoes, Irish	M	Well-shaped tubers free from sunburn and other defects.	55-70	90	Yes	If washed, dry thoroughly.
Potatoes, Sweet	L	Firm, smooth-skinned roots free from growth cracks and other injuries	55	90	Yes	All open surfaces should be well healed.
Pumpkins	L	Hard rinds, good color; heavy.	50-60	60	Yes	

CROP	RELATIVE PERISHABILITY ¹	DESIRABLE HARVEST QUALITY	OPTIMUM STORAGE CONDITIONS		CHILLING SENSITIVE? ²	COMMENTS
			Temp (°F)	Humidity (%)		
Radishes	M	Firm, crisp roots; red should be bright red, sizes up to 1.25" in diameter.	32	95+	No	Remove tops; sprinkle lightly.
Rutabagas	L	Firm roots with smooth surface.	32	95+	No	Sprinkle lightly.
Spinach	VH	Tender leaves, dark green, fresh, crisp	32	95+	No	Sprinkle lightly.
Squash, Yellow and Zucchini	H	Firm, shiny fruits, 4 to 6" long.	50	95+	Yes	
Squash, Acorn	L	Fruits with hard, dark green skin with small, yellowish-orange areas.	50-60	60	Yes	Trim close, allow to heal.
Squash, Butternut	L	Fruits with hard, cream-colored skin.	50-60	60	Yes	Trim close, allow to heal.
Strawberries	VH	Berries firm, plump and red.	32	95+	No	
Tomatoes, Green	H	Solid fruit with light green color, mature seeds, and locular jelly.	70	95+	Yes	
Tomatoes, Ripe	VH	Solid fruits with uniform pink or red.	50-70	95+	Yes	Avoid storage below 50°F.
Turnips	M	Firm, heavy roots with good color.	32	95+	No	Remove tops; sprinkle lightly.

CROP	RELATIVE PERISHABILITY ¹	DESIRABLE HARVEST QUALITY	OPTIMUM STORAGE CONDITIONS		CHILLING SENSITIVE? ²	COMMENTS
			Temp (°F)	Humidity (%)		
Watermelons, Whole	L	Mature with good flesh color; flesh sweet and crisp.	>55	80-90	Yes	Trim stems close to fruit and allow to heal.
Watermelons, Sliced	H	Mature with good flesh color; flesh sweet and crisp.	32	95+	---	Overwrap slices for protection.

¹Relative perishability under good storage conditions: L = Low, M = Moderate, H = High, VH = Very High.

¹Chilling sensitive crops should not be stored below their optimum temperature.

Vegetable Handling Information Provided by the UC Davis Small Farm Center