

The Power of the Plant: How Fruit and Vegetables work as Nutraceuticals and Supplements?

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Points to cover

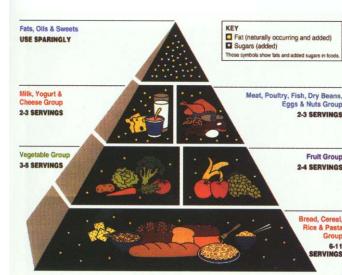
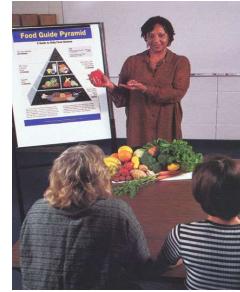
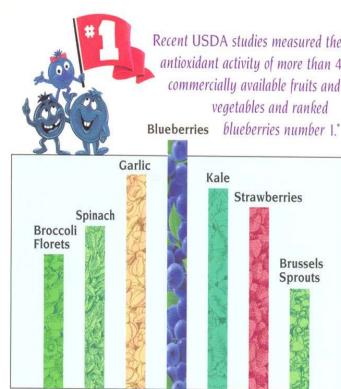


- Molecular mechanisms & Oxidative stress
- Proposed concepts and model of chronic diseases
- Nutraceuticals in plants
- Case studies/examples
- Final thoughts



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Revalue of known crops

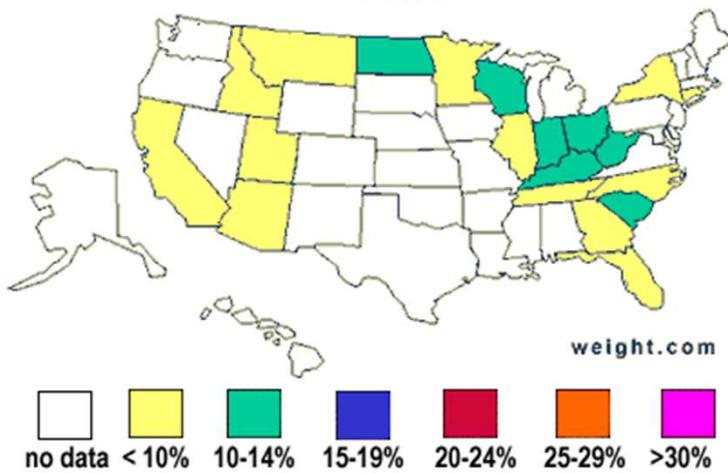


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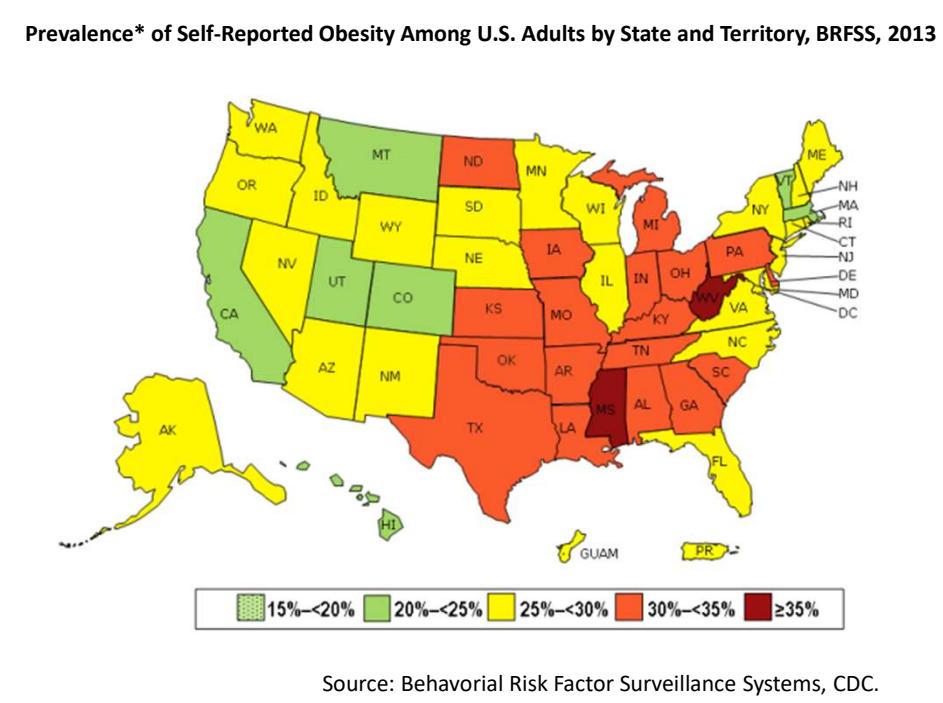
Prevalence of Obesity

Behavioral Risk Factor Surveillance System (BRFSS) Data from U.S. Center for Disease Control

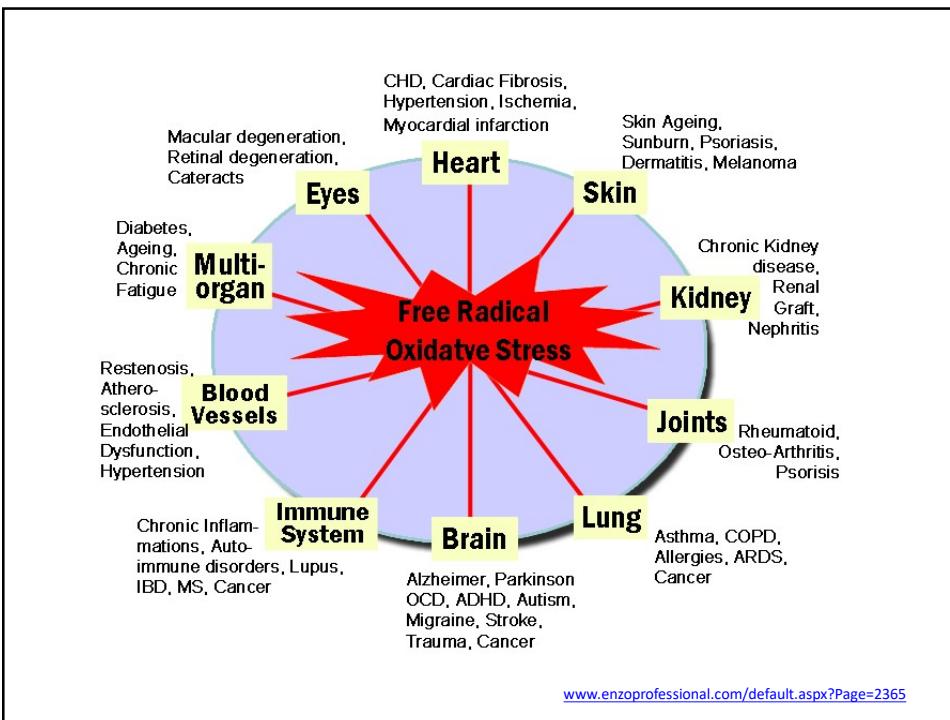
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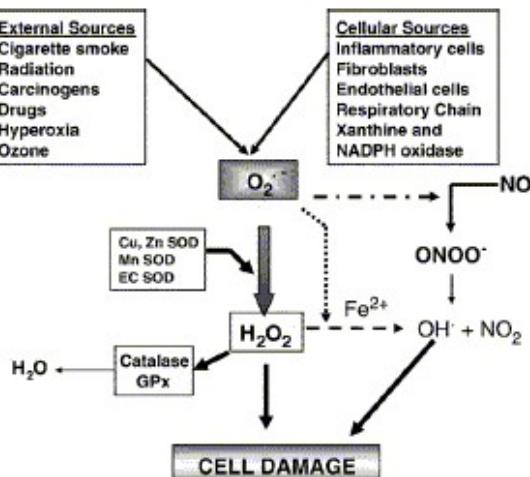
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Oxidative Stress

- It is generally believed that an **imbalance between the production of reactive oxygen species (ROS)** and antioxidant defenses, in favor of the former, leads to an oxidative stress and, in turn, to the oxidation of biologically relevant macromolecules
- The production of **ROS is an unavoidable** consequence of aerobic metabolism
- **ROS** is the term used to describe forms of oxygen that are energetically **more reactive** than molecular oxygen
- **ROS are toxic molecules** because they are able to oxidize various cellular components including DNA, proteins, and membrane lipids, leading to the oxidative destruction of the cells
- ROS play a role as signals** in the cells

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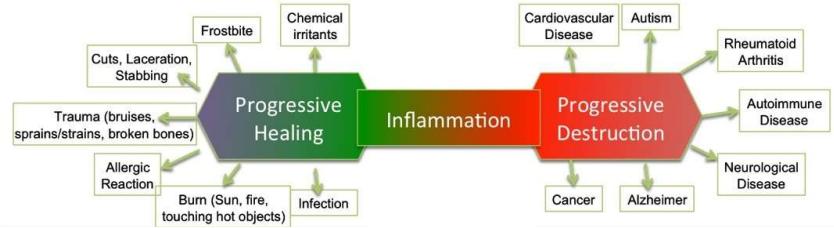
Cellular generation of reactive oxygen species and antioxidant defense system



www.glisodin.org/glisodin_monograph.htm

8

Oxidative stress strongly associated to inflammation



<http://clinicalscienceblogmary.wordpress.com/2013/04/08/the-role-of-inflammation-in-health-and-disease/>

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Plenty of research, a lot of confusion as well

- Nutraceuticals
- Bioactives
- Functional foods
- Dietary supplements
- Botanicals
- Herbal medicine
- etc

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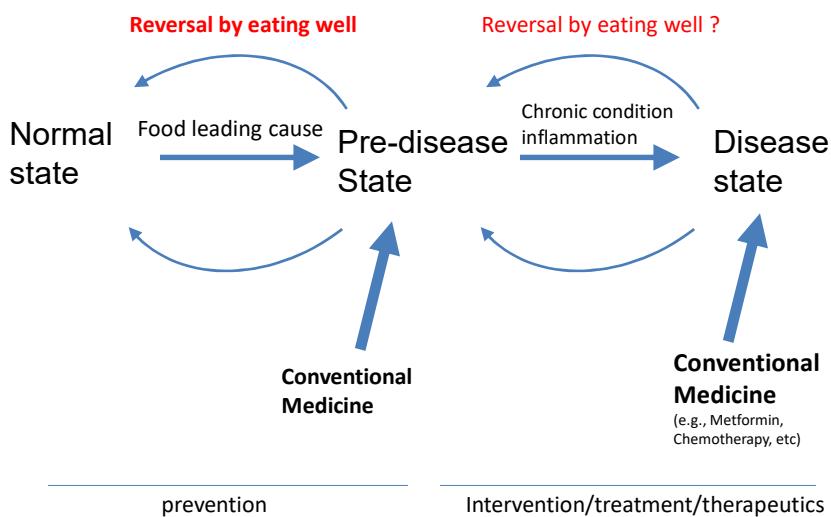
The medicinal action of phenolics is due to...

- Antioxidant capacity
- Free radical scavenging
- Chelation of redox active metal ions
- Modulation of gene expression
- Interactions with the cell signaling pathways

(Soobratee et al., Mutation Research, 2005, 200-213)

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Relationship between chronic disease, food and medicine



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Vegetable-Containing Juices: Carrot, Kale, and Sprout Juices for Prevention and Therapeutics

Daniel A. Jacobo-Velázquez, Erika Ortega-Hernández, and Luis Cisneros-Zevallos

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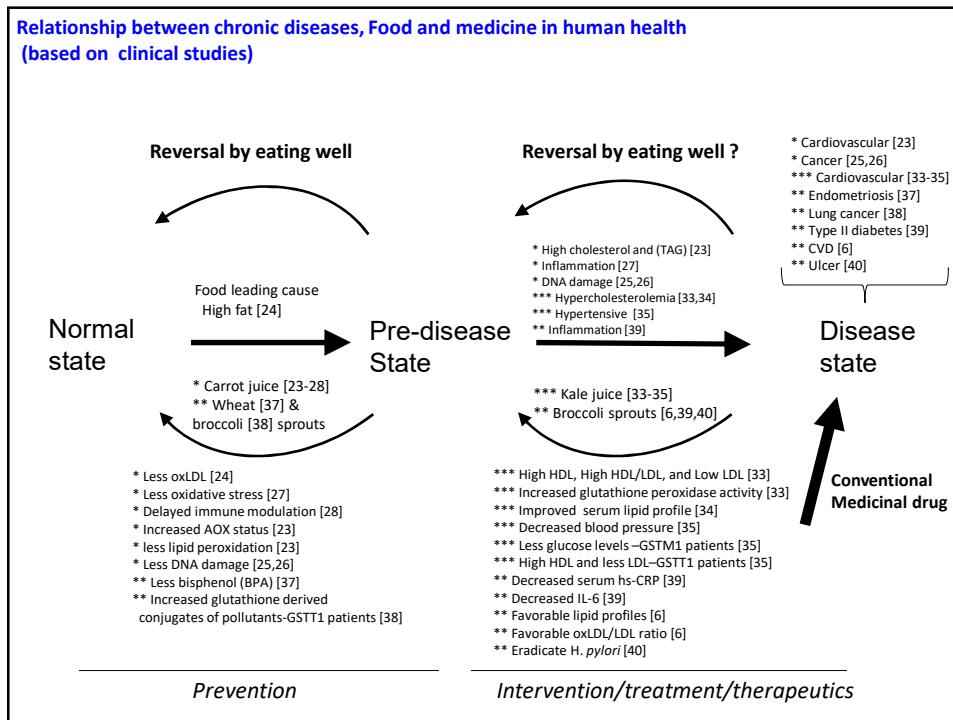
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Handbook of Functional Beverages and Human Health; Shahidi, F., Alasalvar, C., Eds, 2016, pp 609-626

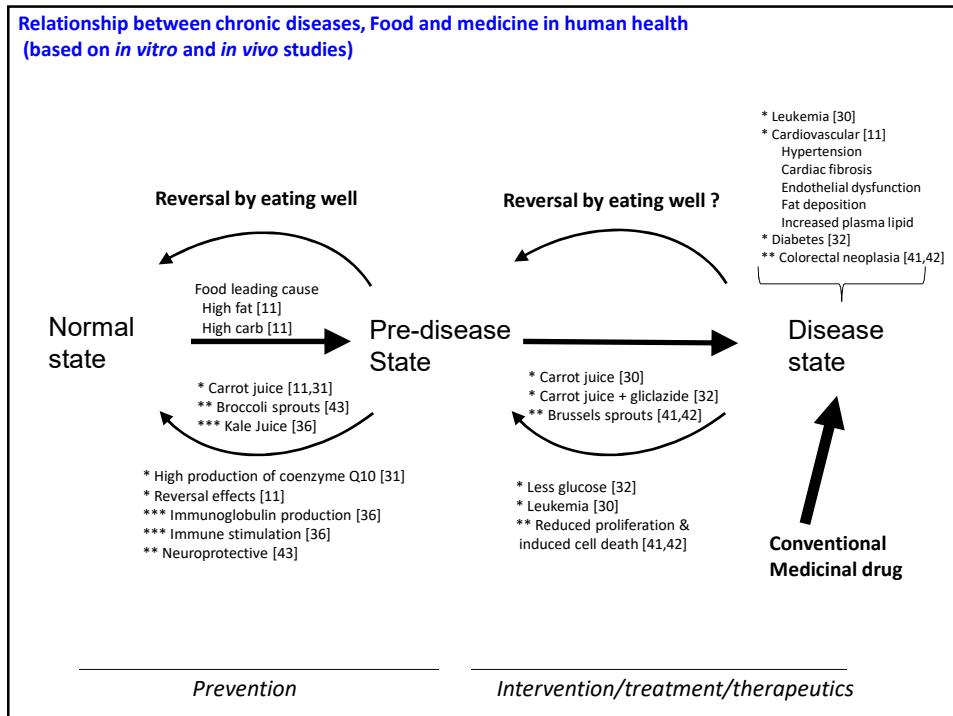
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Golden Berry and Selected Tropical (Açaí, Acerola, and Maqui) Juices

Coralia Osorio, María Elisa Schreckinger, Prerna Bhargava, Woo Young Bang,
Daniel A. Jacobo-Velázquez, and Luis Cisneros-Zevallos

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Handbook of Functional Beverages and Human Health; Shahidi, F., Alasalvar, C., Eds, 2016, pp 251-269

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Aguaymanto (Golden berry)



Acerola



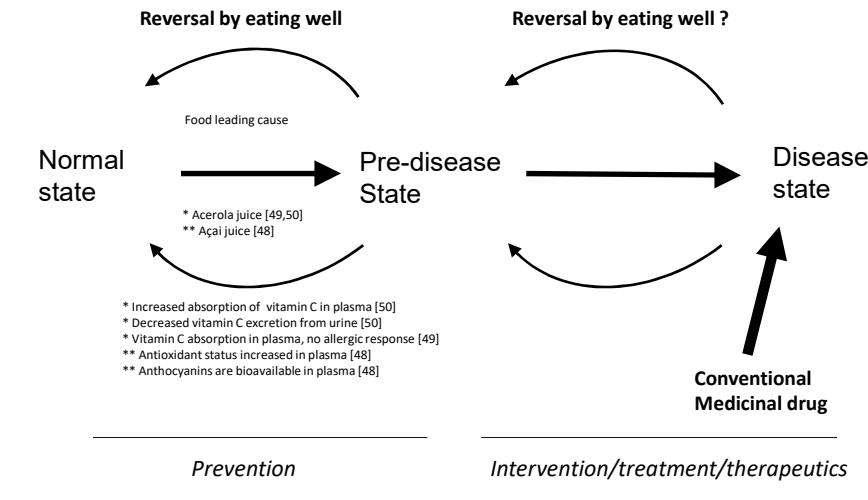
Açaí



Maqui

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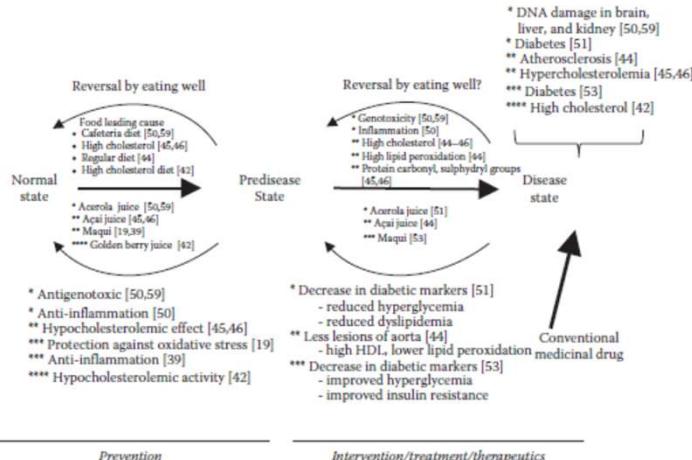
**Relationship between chronic diseases, Food and medicine in human health
(based on clinical studies)**



Handbook of Functional Beverages and Human Health. CRC Press Taylor & Francis Group. In press

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**Relationship between chronic diseases, Food and medicine in human health
(based on *in vitro* and *in vivo* studies)**



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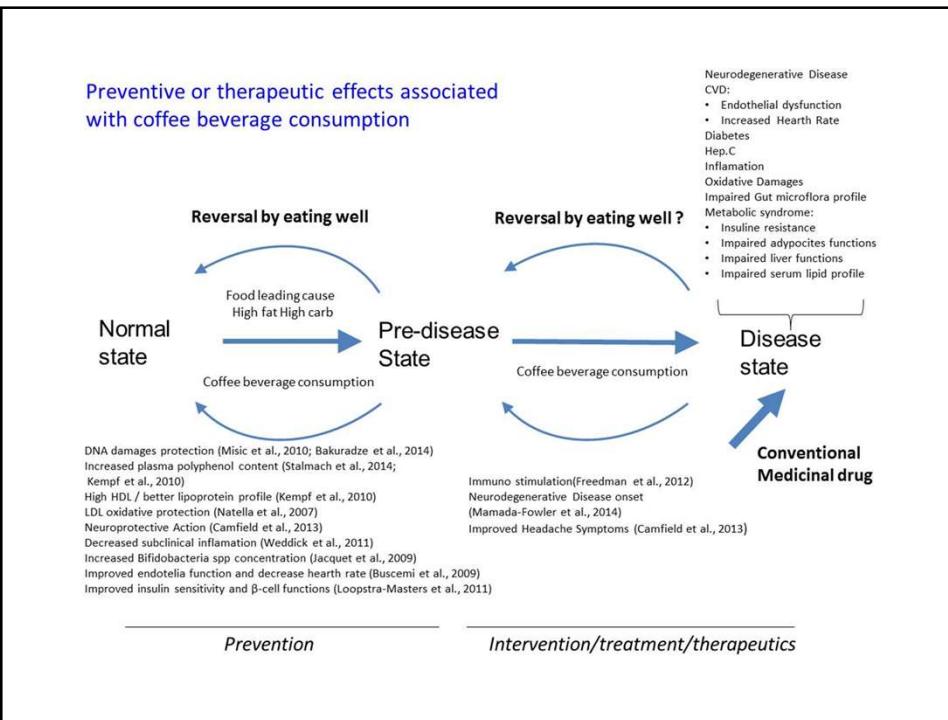
Coffee other than coffee: Green coffee and byproduct for prevention and therapeutics (*unpublished, 2018*)

Federica Galli, Leonardo Lombardini, Luis Cisneros-Zevallos

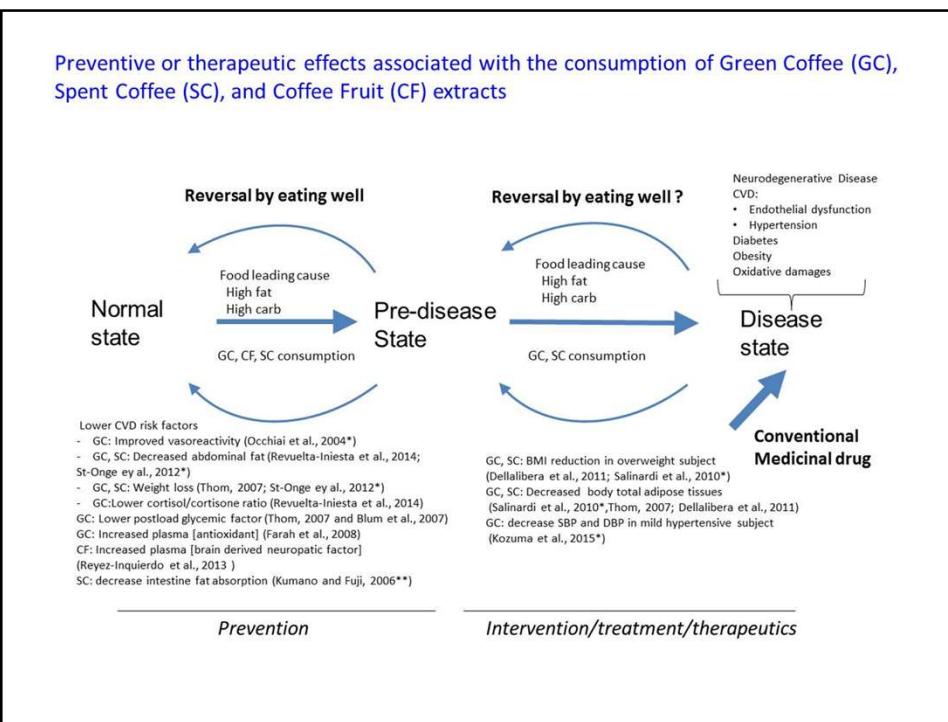
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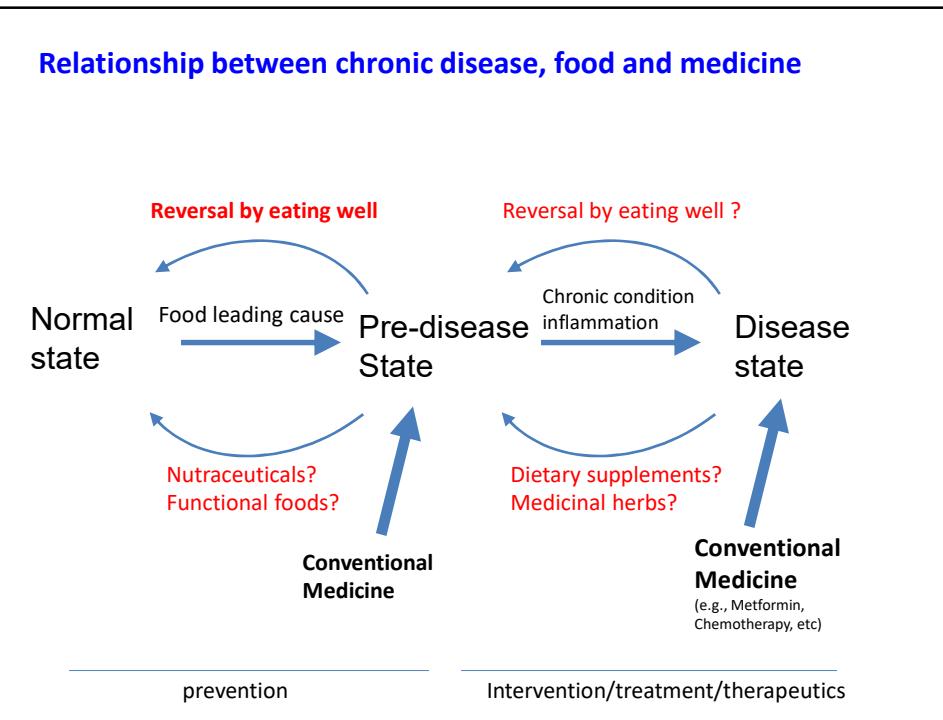
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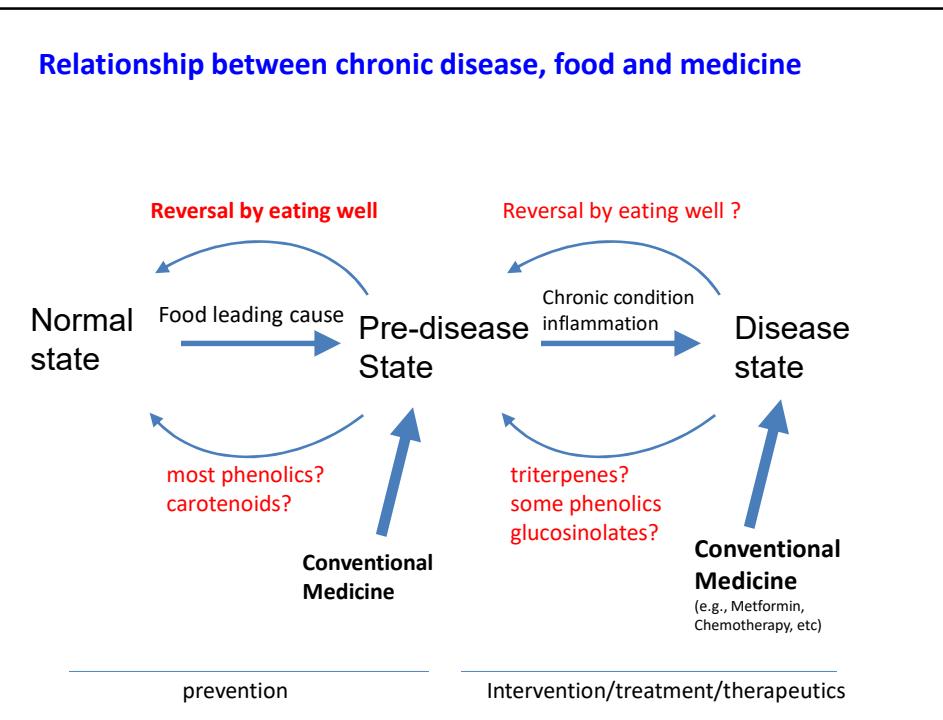
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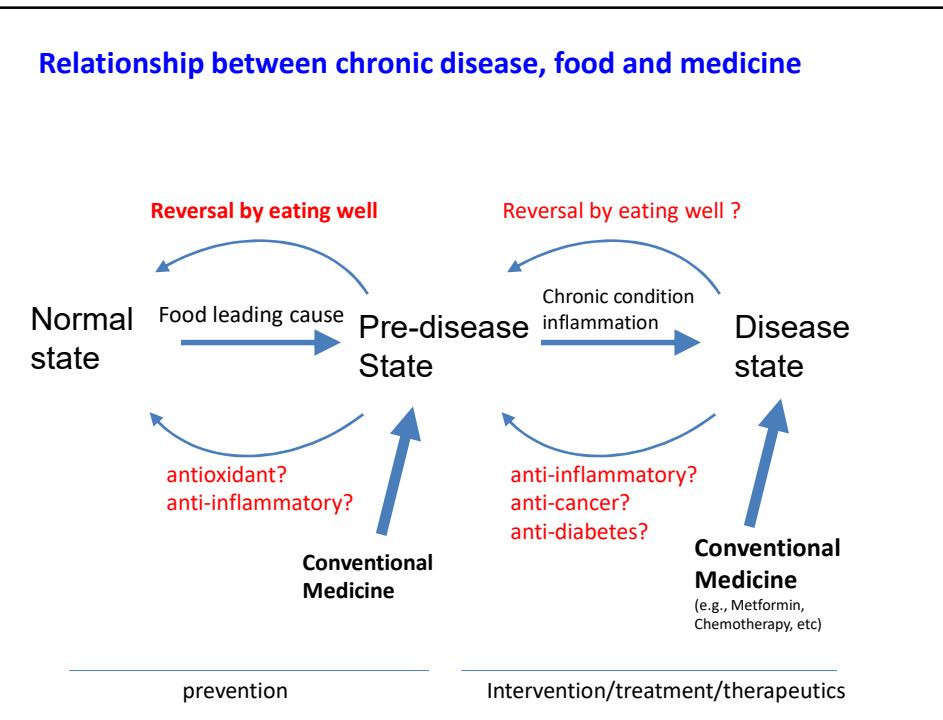
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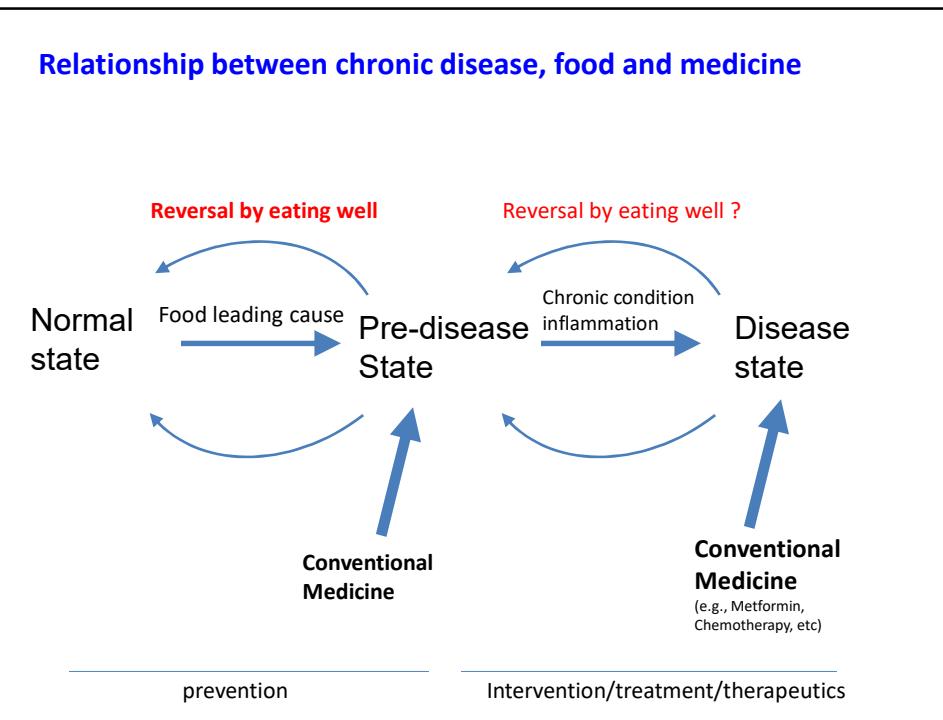
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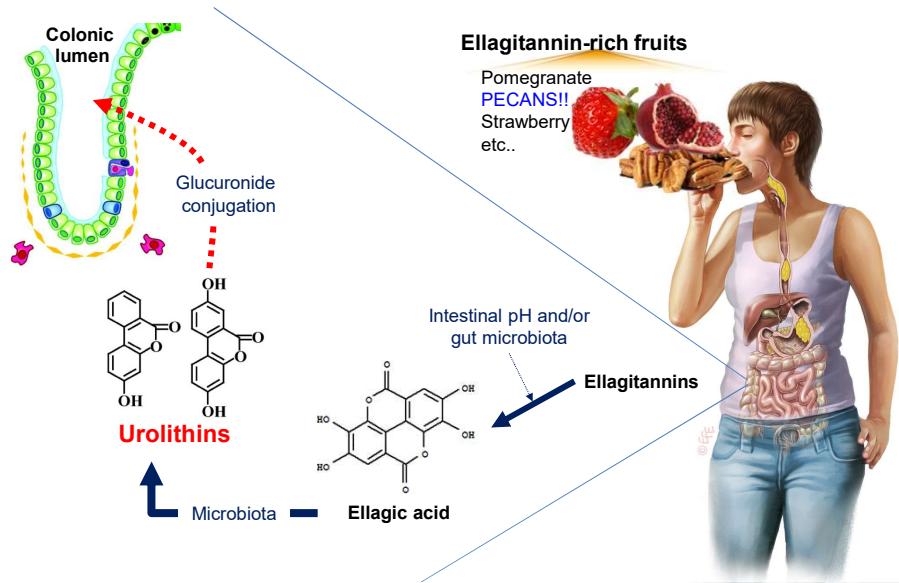
Pecans



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Urolithins

Bio available metabolites of Ellagitannin
Phenolic antioxidants



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What we propose for this year.....

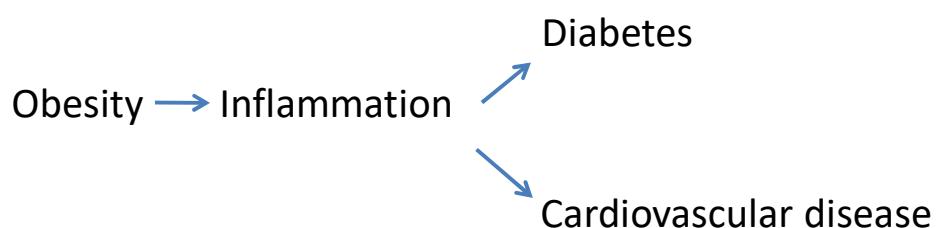
- Study effects against Diabetes
 - **Hypothesis:** We believe that urolithins have the ability to revert insulin resistance and glucose insensitivity in muscle, hepatic and pancreatic cells **in similar way to Metformin!**



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Metabolic Syndrome

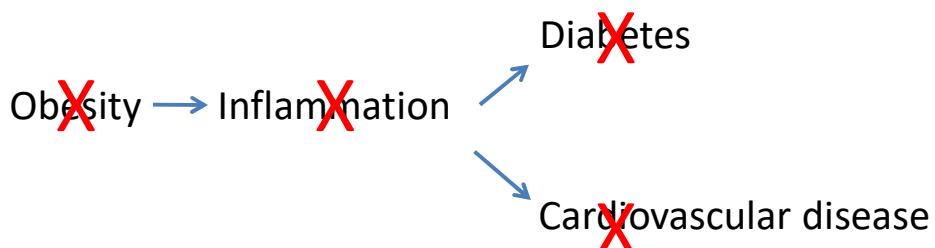
- Takes place when being **overweight** and **obese** increase the chance for **heart** disease and other health problems such as **diabetes** and **stroke**.



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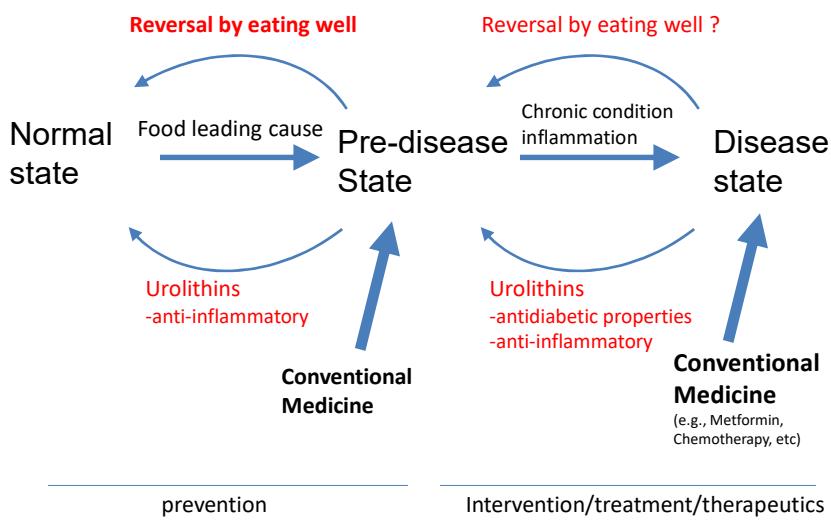
Metabolic Syndrome

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Relationship between chronic disease, food and medicine



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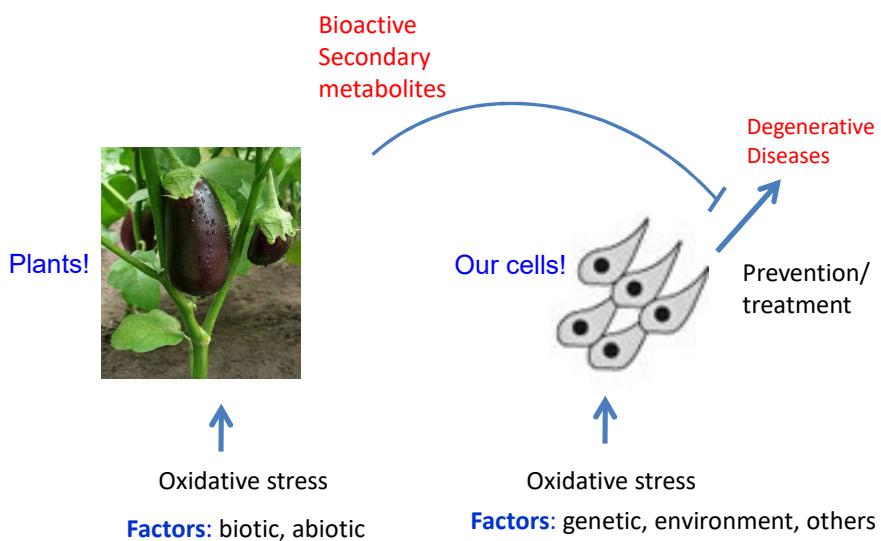
First functional fruit?

Sun World's BLACK DIAMOND® Brand Plum Ranks At
The Top in USDA Antioxidant Study
May 22, 2008



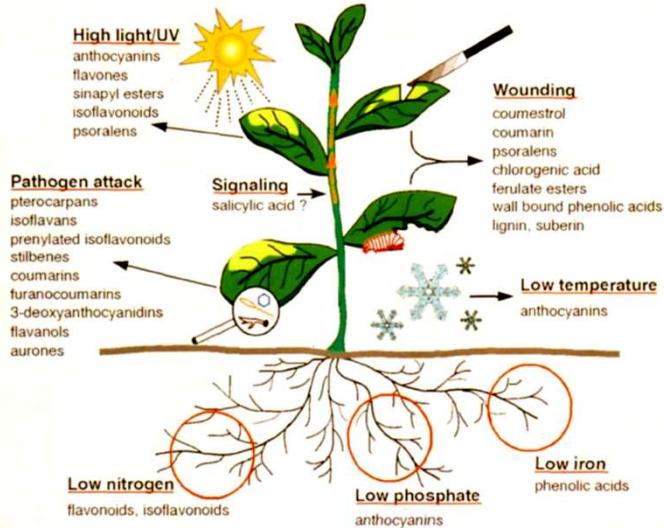
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Where is the link?Oxidative Stress



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Examples of stress-induced phenylpropanoids



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Plants adapt to the environmental stresses affecting the nutraceutical content

Pre-harvest

Genotype



Cultivation Practices

Climatic Conditions

Harvesting stage

Post-harvest

UV/radiation



Light

Wounding

Water stress

Temperature

Altered gas

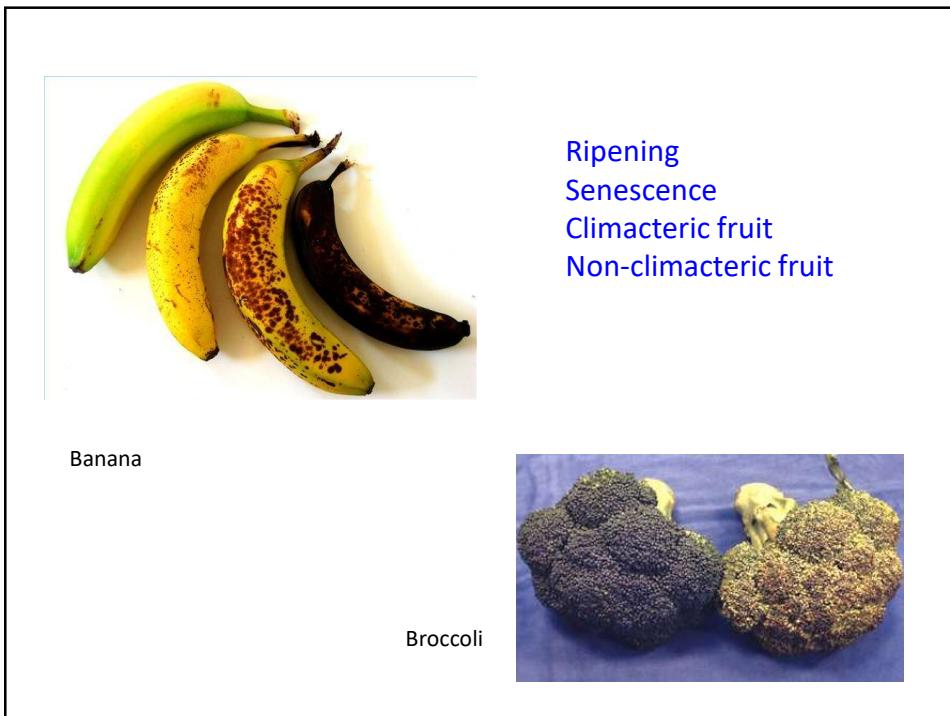
Chemicals

Hormones

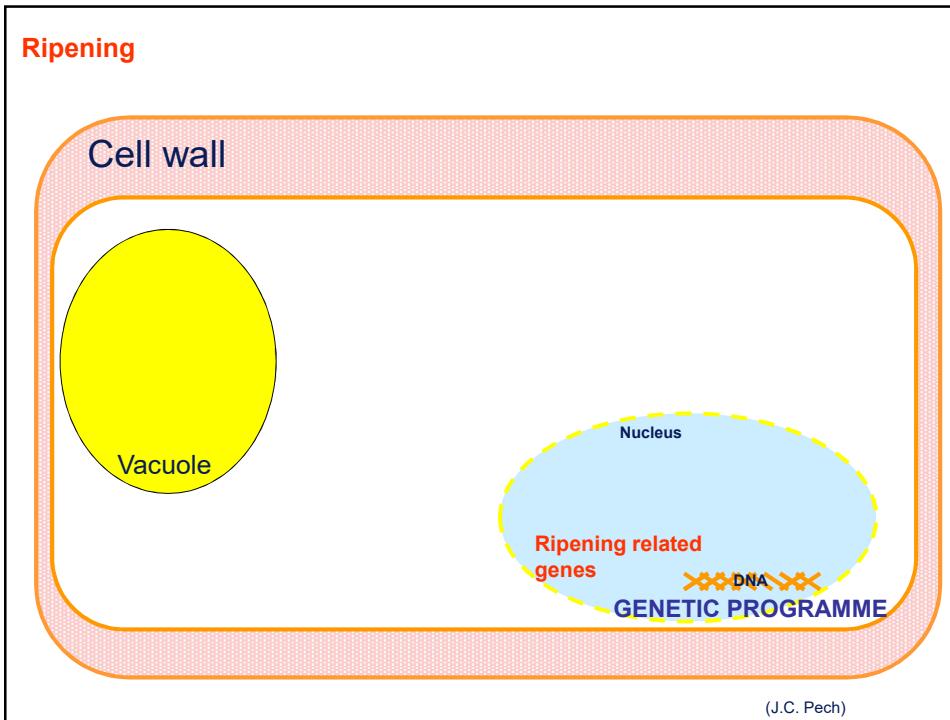
Pressure/gravity

Biotic

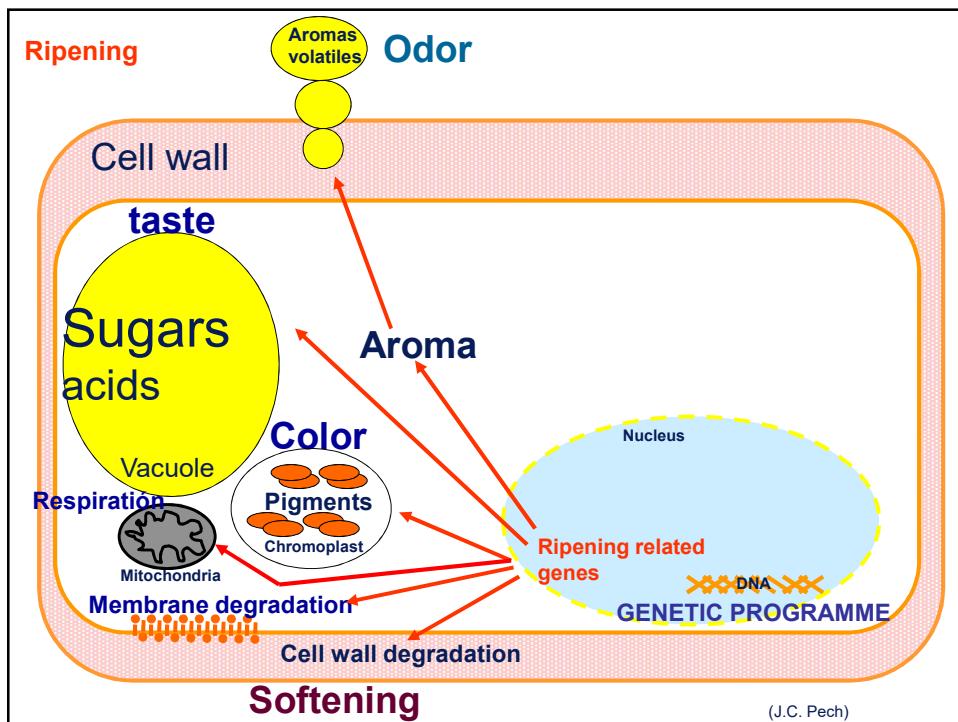
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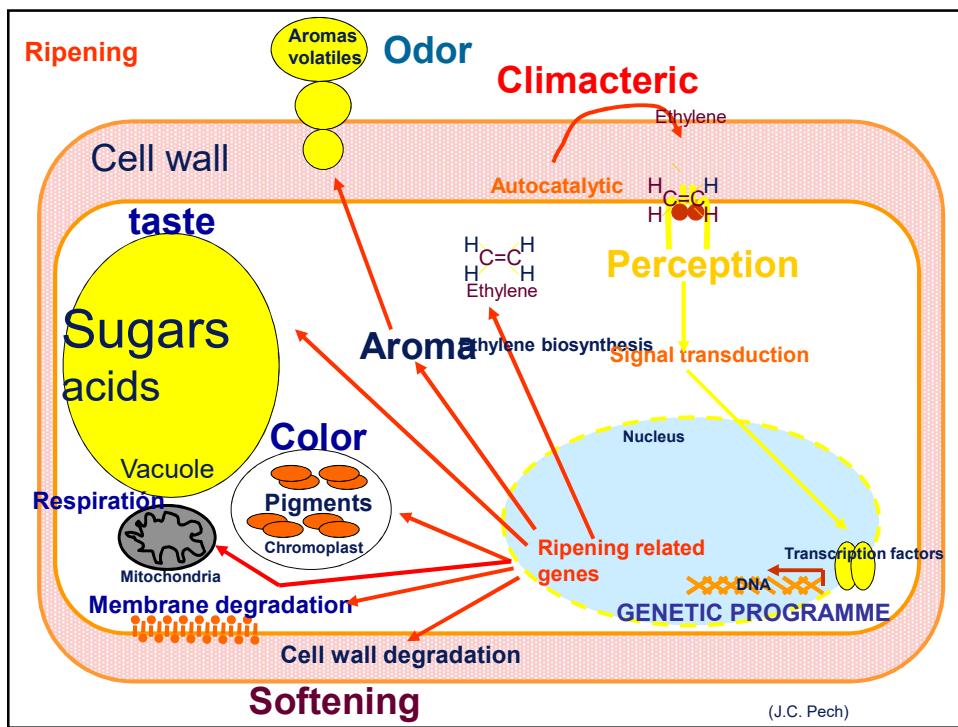
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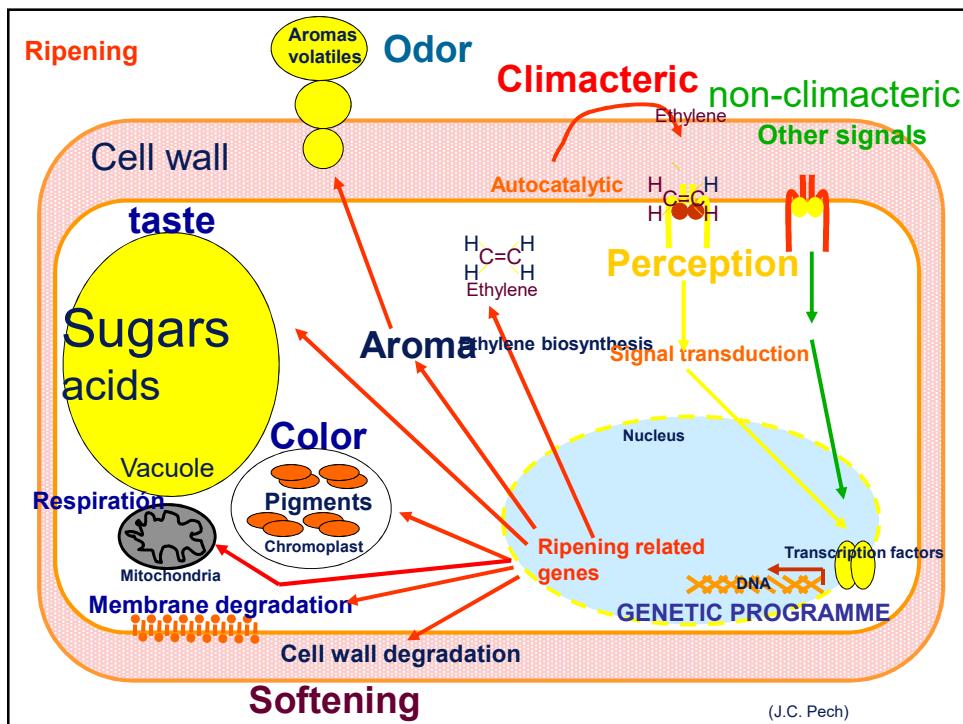
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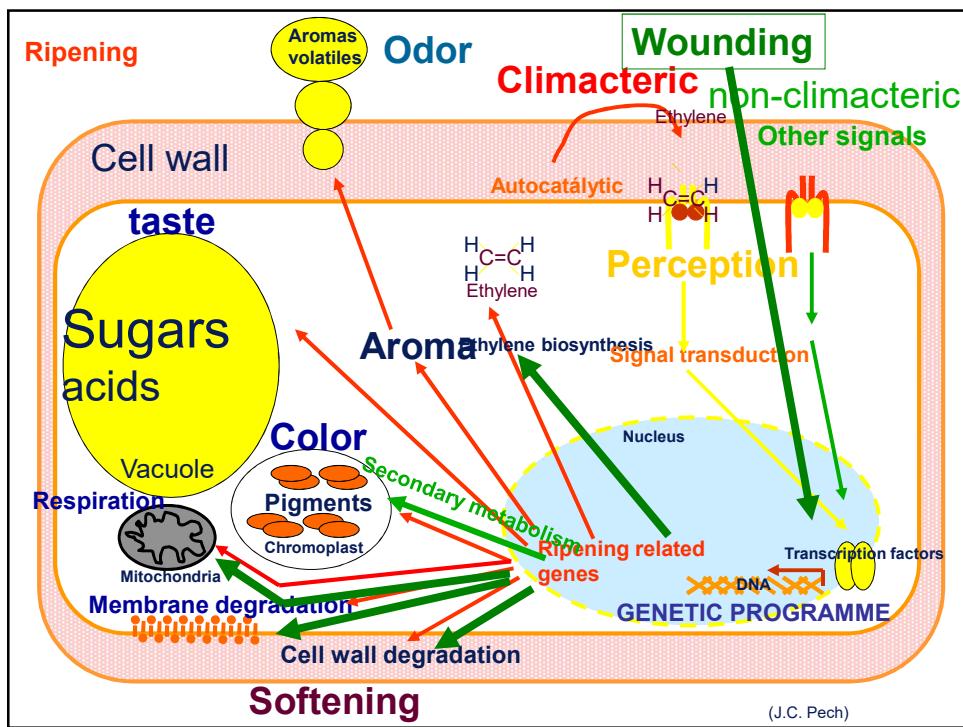
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The Use of Controlled Postharvest Abiotic Stresses as a Tool for Enhancing the Nutraceutical Content and Adding-Value of Fresh Fruits and Vegetables

L. CISNEROS-ZEVALLOS

ABSTRACT: This paper proposes a concept based on applying postharvest abiotic stresses to enhance the nutraceutical content of fresh fruits and vegetables. We hypothesize that selected abiotic stress treatments, such as wounding, phytohormones, temperature, ultraviolet light, altered gas composition, heat shock, and water stress, among others, will affect the synthesis of metabolites with health potential and increase the levels of phytochemicals with nutraceutical activity or reduce the synthesis of undesirable compounds. Controlled stresses may be used as tools by the fresh produce industry to enhance the health benefit properties of fresh-cut or whole fresh fruits and vegetables for food processing, dietary supplement industries to obtain healthier processed products or enhance extractable nutraceutical yields.

Keywords: abiotic stresses, fruits, vegetables, nutraceuticals, value-added, postharvest

Introduction

THE TREND AMONG CONSUMERS IS TO ASSOCIATE HIGH QUALITY

products with healthy diets, safety, and convenience. The fresh fruit and vegetable industry is an important contributor to the U.S. economy, with estimated sales in 1999 of approximately \$76 billion.

The fresh-cut industry sales represented \$10 to \$12 billion in 2000,

with a growth projected at 10% to 15% per year for the next 5 years in the U.S. market (Farrall and others 2000).

Within the last decade, there has been a significant increase in the

increasingly growing market for nutraceuticals and functional foods.

Products containing nutraceuticals have reached a worldwide es-

timation of \$20 billion in 2000, and are projected to reach \$30 billion

by 2005 (Datamonitor 2002). Within the nutraceutical cate-

gory, polyphenols are the most abundant class of secondary

metabolites with well-known and documented protective roles against certain

chronic diseases (Schwarz 2000).

Abiotic stresses can be used for controlling degenerative oxidation reac-

tions caused by reactive oxygen and free radical species in living tis-

sues and the inhibition of polyphenol oxidase enzymes induced by

processing and storage (Halliwell and others 1992; Yes and others 1997). A recent review on nutraceuticals and human health

has been presented by Dillard and German (2000).

Enhancing the quality of fresh fruits and vegetables to produce with

add value and create new opportunities for growers and processors

by reaching these health-oriented markets. To achieve this goal,

there is a need to develop technologies that can produce conditions

of high-quality products with high levels of the desired nutraceuticals.

Plants, when exposed to unfavorable environments, such as

water deficit, chilling, heat stress, oxygen deficiency, and air pollu-

tion, result in some degree of stress and express only a fraction of

the plant's genetic potential to produce favorable conditions

through genetically determined stress resistance (Drew 1986).

Abiotic stresses will affect the pathways involved in the biosynthesis of the 3 principal groups of secondary metabolites: terpenes, phenolics, and nitrogen-containing compounds. These com-

ounds are important in agriculture as attractants and repellents for arthropods, as attractants for pollinators and seed-dispersing animals,

and assist with absorbing harmful ultraviolet radiation or reducing the production of competing pigments among other functions.

For example, volatile organic secondary metabolites are used

commercially as insecticides, fungicides, pharmaceuticals, fragrances, flavorings, medicinal drugs, and industrial materials (Gar-

rett 1998; Halliwell and others 2002).

Within the nutraceutical category, there are several tools for

their enhancement in crop tissues, such as the proposed classical

breeding (Connor and others 2002, 2003a), optimization of pro-

cessing (Connor and others 2003b), and genetic engineering (Kochian and Garvin 1999, Winkel-Shirley 2002).

Abiotic stresses can be used in preharvest activities to enhance

the quality of the crop and reduce postharvest losses (Halliwell and others 2002).

For example, vitamin C can be enhanced in plants exposed to high

or low temperatures or subjected to less frequent irrigation (Lee and

others 2000). Flavonol levels can be increased in apples and red

pepper fruits (Estrella and others 1999), whereas apple skin color

may be improved by applying ethephon and phosphorus-calcium

mixtures applied 4 weeks before harvest (Li and others 2002).

Abiotic stresses can be used in postharvest activities as addi-

tional tools to extend the shelf life of products, focusing mainly on

color, texture, and flavor quality changes (Rader 1992). Among the

most common postharvest treatments are the use of modified atmospheres (MA) and CO₂ levels in controlled and modified atmospheres, or C₂H₄

gassing for ripening and degreening (Rays 1991).

Abiotic stresses can also be used to enhance the levels of secondary

metabolites in crop tissues. For example, anthocyanin accumula-

tion due to ripening has been reported for thornless blackberries

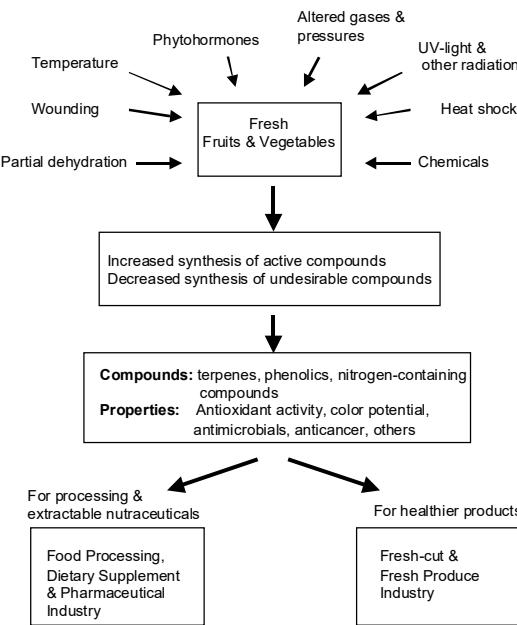
(Bapna and others 1980, 1986), strawberries (Goto and others

1986, Arakawa 1981), and strawberries (Given and others 1988).

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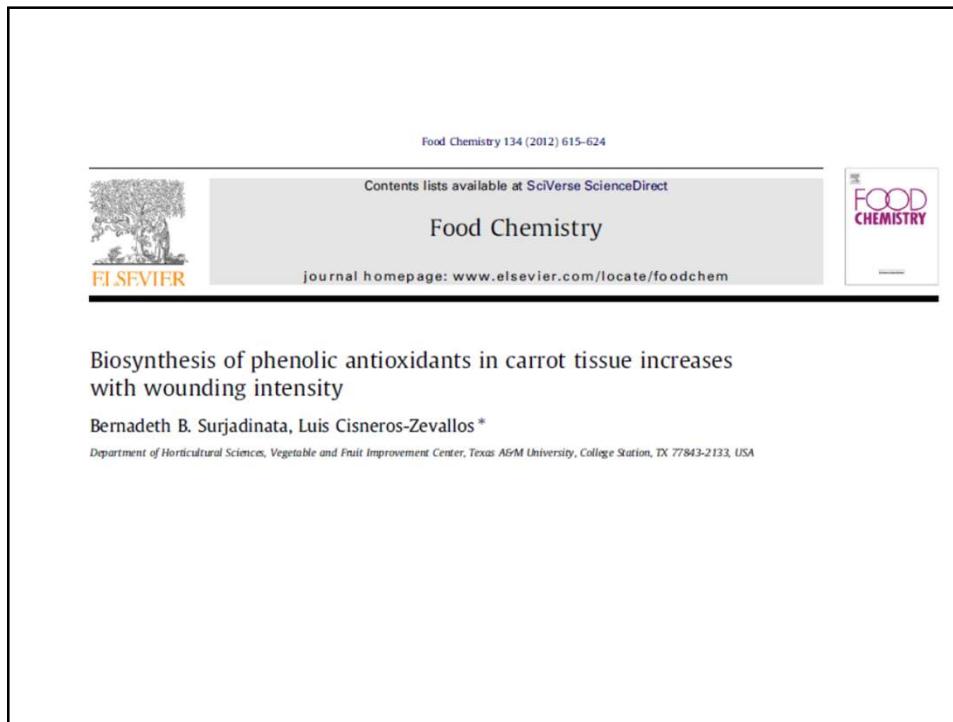
1560 JOURNAL OF FOOD SCIENCE—Vol. 68, Nr. 5, 2003

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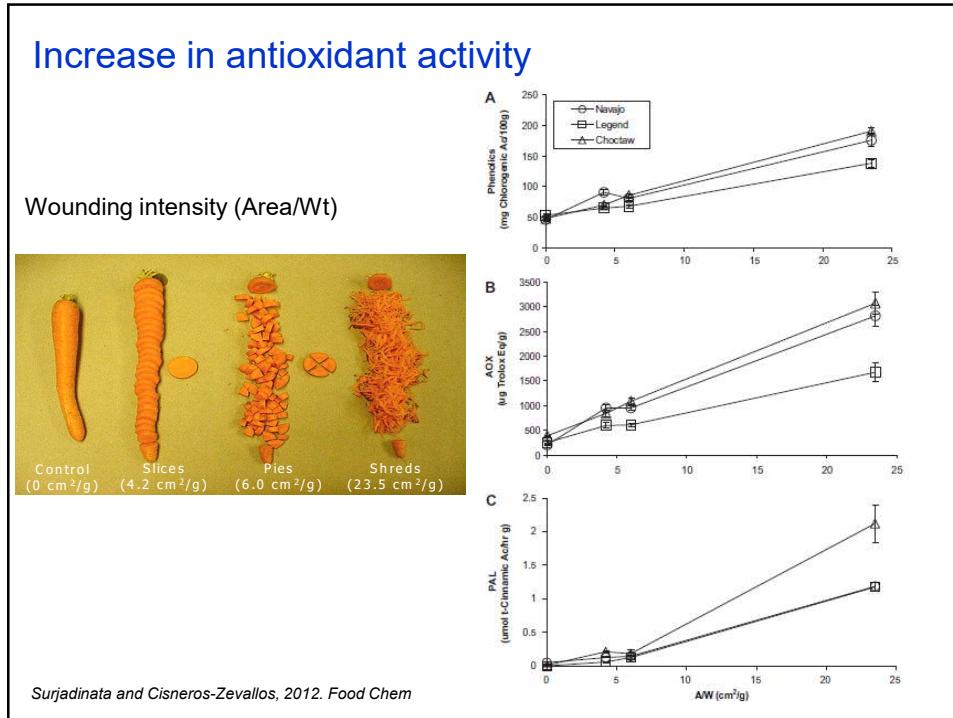


(Cisneros-Zevallos, 2003, J Food Science, V 68, Nr 5)

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Wounding effects on different types of produce

Lettuce, celery, onions, carrots, jicama, bell peppers, asparagus, cabbage, apples, tomatoes, nectarines, radishes, potatoes, pears



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JOURNAL OF
**AGRICULTURAL AND
FOOD CHEMISTRY**

ARTICLE

pubs.acs.org/JAFC

Plants as Biofactories: Physiological Role of Reactive Oxygen Species on the Accumulation of Phenolic Antioxidants in Carrot Tissue under Wounding and Hyperoxia Stress

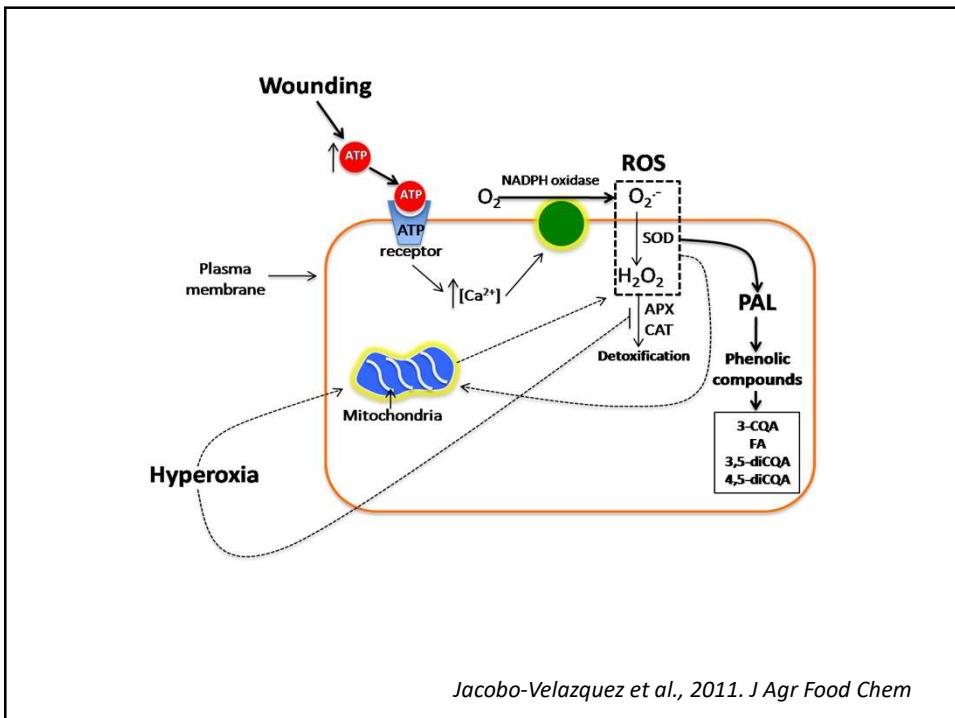
Daniel A. Jacobo-Velázquez,^{†,ll} Ginés B. Martínez-Hernández,[‡] Silvia del C. Rodríguez,[§] Cong-Mei Cao,[†] and Luis Cisneros-Zevallos^{*,†}

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JOURNAL OF
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FOOD CHEMISTRY

Article
pubs.acs.org/JAFC

Plants as Biofactories: Glyphosate-Induced Production of Shikimic Acid and Phenolic Antioxidants in Wounded Carrot Tissue

Alejandro Becerra-Moreno,[†] Jorge Benavides,[†] Luis Cisneros-Zevallos,^{*§}
and Daniel A. Jacobo-Velázquez^{*†}

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[§]Department of Horticultural Sciences, Vegetable and Fruit Improvement Center, Texas A&M University, College Station, Texas 77843-2133, United States

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Blocking Enzymes and adding substrates...

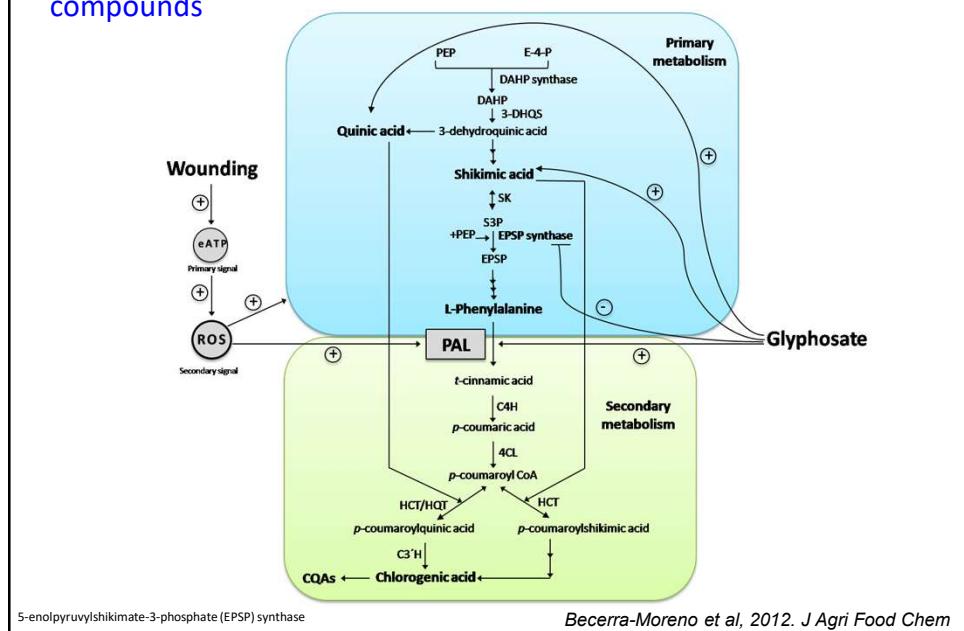
High levels of shikimic acid from Star anise



Intermediate compound before the phenolic metabolism

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Plants as biofactories: High levels of shikimic acid and phenolic compounds



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In the News....



Tortured Veggies Better For You? Discovery News (May 28, 2010)

Most of us make carrots into a salad. Luis Cisneros-Zevallos makes carrots into biofactories capable of producing five times more antioxidants than they otherwise would. He does it not through genetic modification, but rather by using a carrot's natural response to changes in its environment. And by "changes in its environment" he really means assaulting them with knives, shredders, and ultraviolet light...



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The New York Times



Are Baby Carrots as Healthful as Other Carrots?

By Roni Caryn Rabin January 20, 2017 5:05 am

"Wounding" fresh produce "sends a signal to the cells, which perceive that as if they were under attack or facing adverse conditions," explained Luis Cisneros-Zevallos, author of one such study and director of the Plant Bioactives & Bioprocessing Research Lab at Texas A&M University in College Station. "As a result, oxidative stress increases in the cell," he said, and cells "start synthesizing antioxidant molecules to protect the cell from that stress."

https://well.blogs.nytimes.com/2017/01/20/are-baby-carrots-as-healthful-as-other-carrots/?_r=0

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Final Thoughts

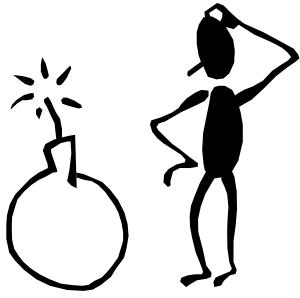
- The need to revisit the role of Food as medicine and many other terms used in the literature including nutraceuticals, dietary supplements, etc
- The need to standardize research studies including preventive and therapeutic strategies
- Plant bioactives may have multiple effects in preventing and treating diseases
- The content of plant bioactives may be enhanced by simple stresses and obtain final products that are healthier
- Others

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A brilliant future for plant natural products



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Collaborative work among different groups

Dr. Daniel Jacobo-Velazquez, Dr Claudia Delgadillo, Dr Ivan Torres, Dr Ricardo Elesba, Dr Margareth Veloso,

Funding from Heifer International, Texas Pecan Board, California Stone fruit Industry, Texas Department of Agriculture

Questions?