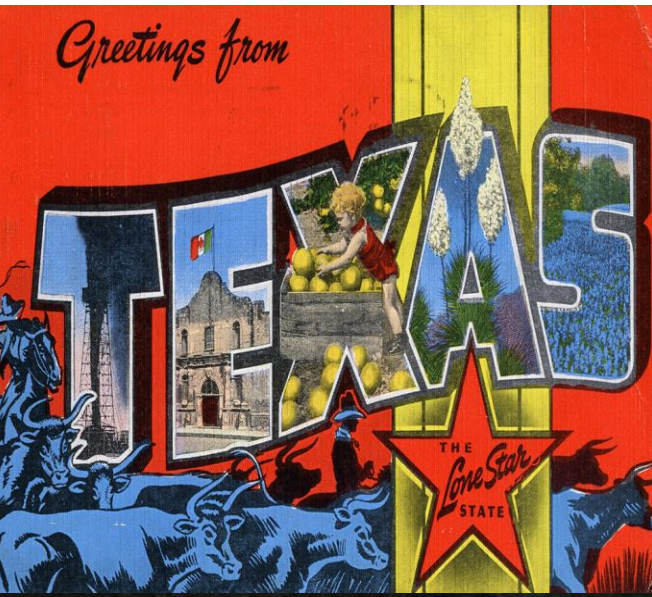


# Phytomelatonin: Helping Plants to Survive and to Thrive

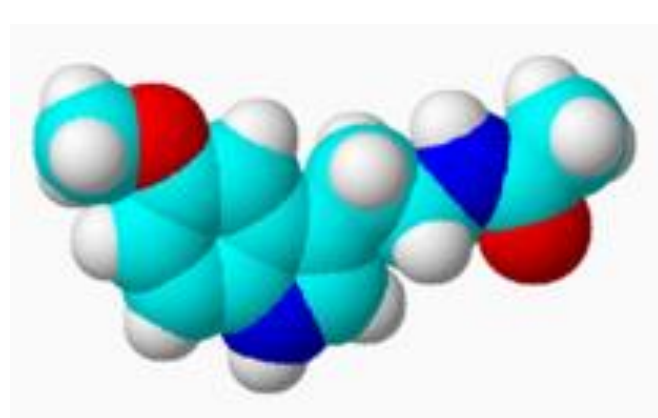
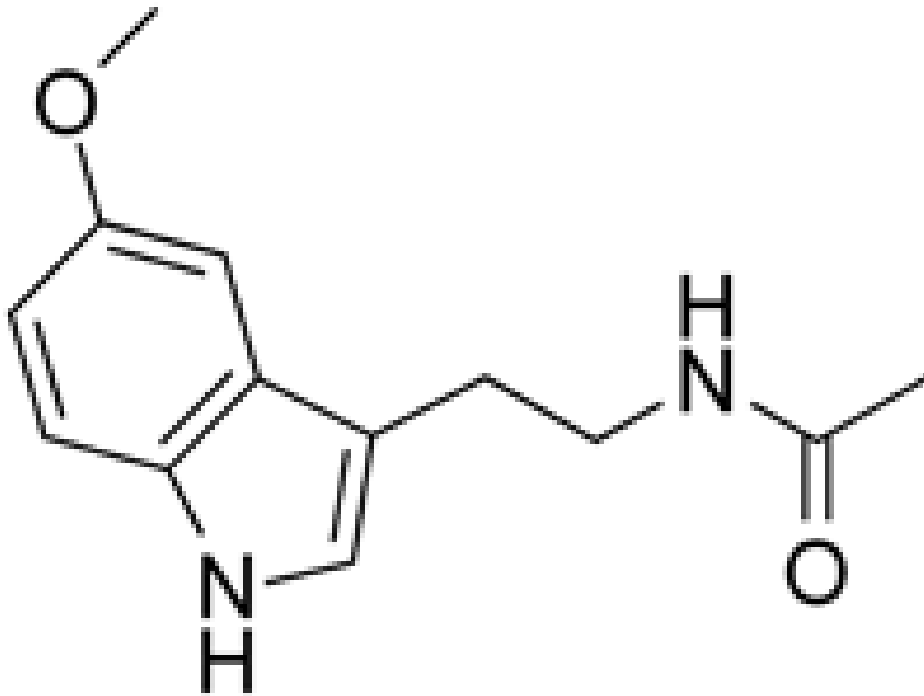
**Russel J. Reiter, Ph.D., M.D.(*hc*), D.Sc.(*hc*)**  
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**Department of Cellular and Structural Biology**  
**University of Texas Health Science Center**  
**San Antonio, Texas**

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# Melatonin (N-acetyl-5-methoxytryptamine)

“mela” from melanin  
“tonin” from serotonin



## Melatonin:

- i*) an extremely old molecule
- ii*) exists in every species
- iii*) structure never changed thru out evolution

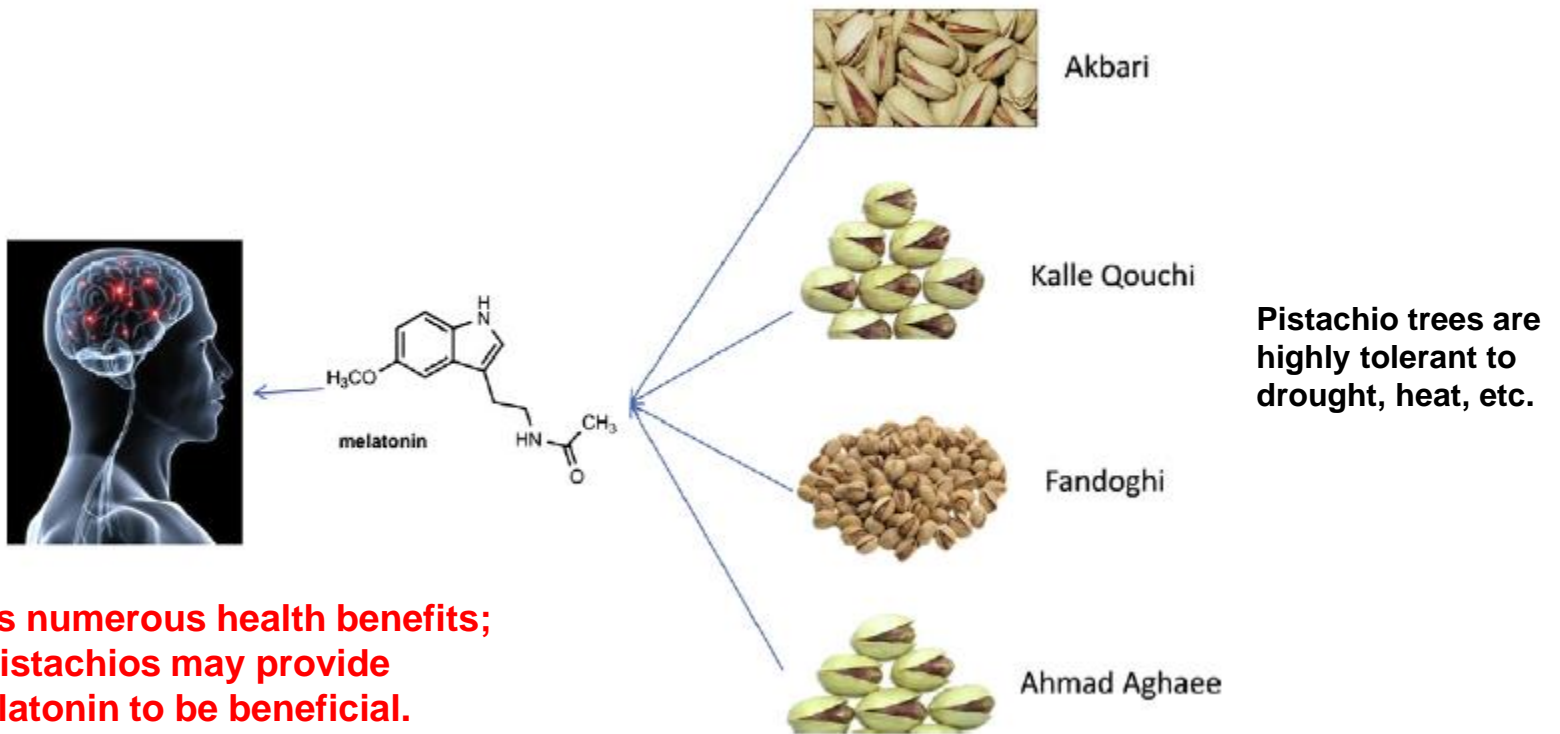
**Stromatolites** in Shark's Bay, Western Australia,  
were **formed by cyanobacteria**



**Cyanobacteria** are photosynthetic and  
**released oxygen** into the atmosphere

Determination of melatonin in the kernels of four different pistachio varieties.

Pistachio variety	Fluorescence		GC/MS ( $\mu\text{g/g}$ )
	Fluorescence intensity	Total value ( $\mu\text{g/g}$ ) <sup>a</sup>	
Ahmad Aghaei	134.36	230.7	233.0
Akbari	146.21	229.2	226.9
Kalleqouchi	189.42	229.1	231.4
Fandoghi	172.60	230.7	228.4



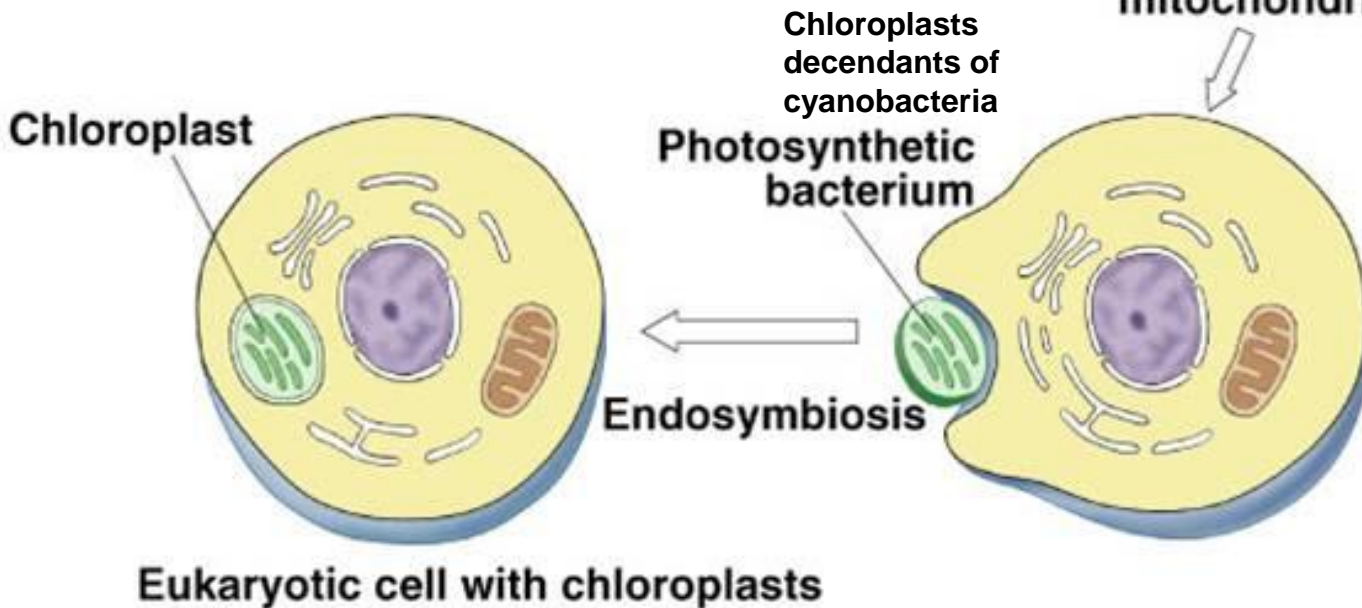
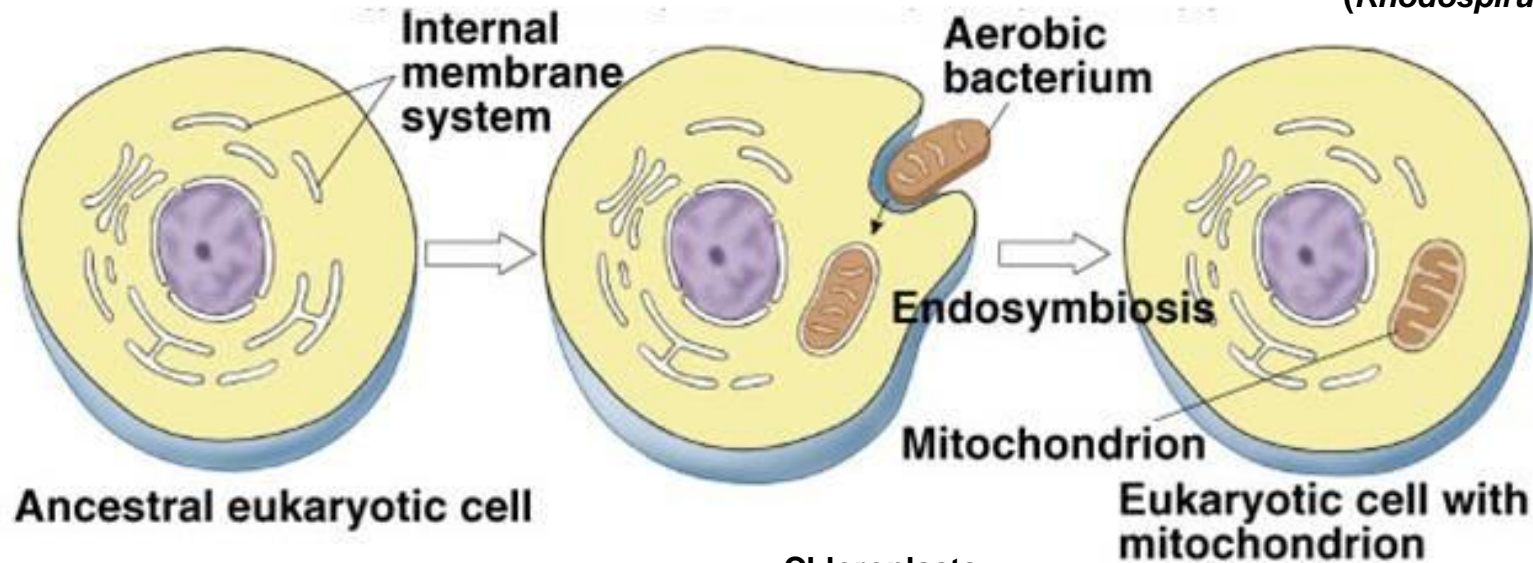
**Melatonin has numerous health benefits; consuming pistachios may provide sufficient melatonin to be beneficial.**

**Melatonin is absorbed from consumed foods**



# Endosymbiotic theory of the origin of mitochondria and chloroplasts

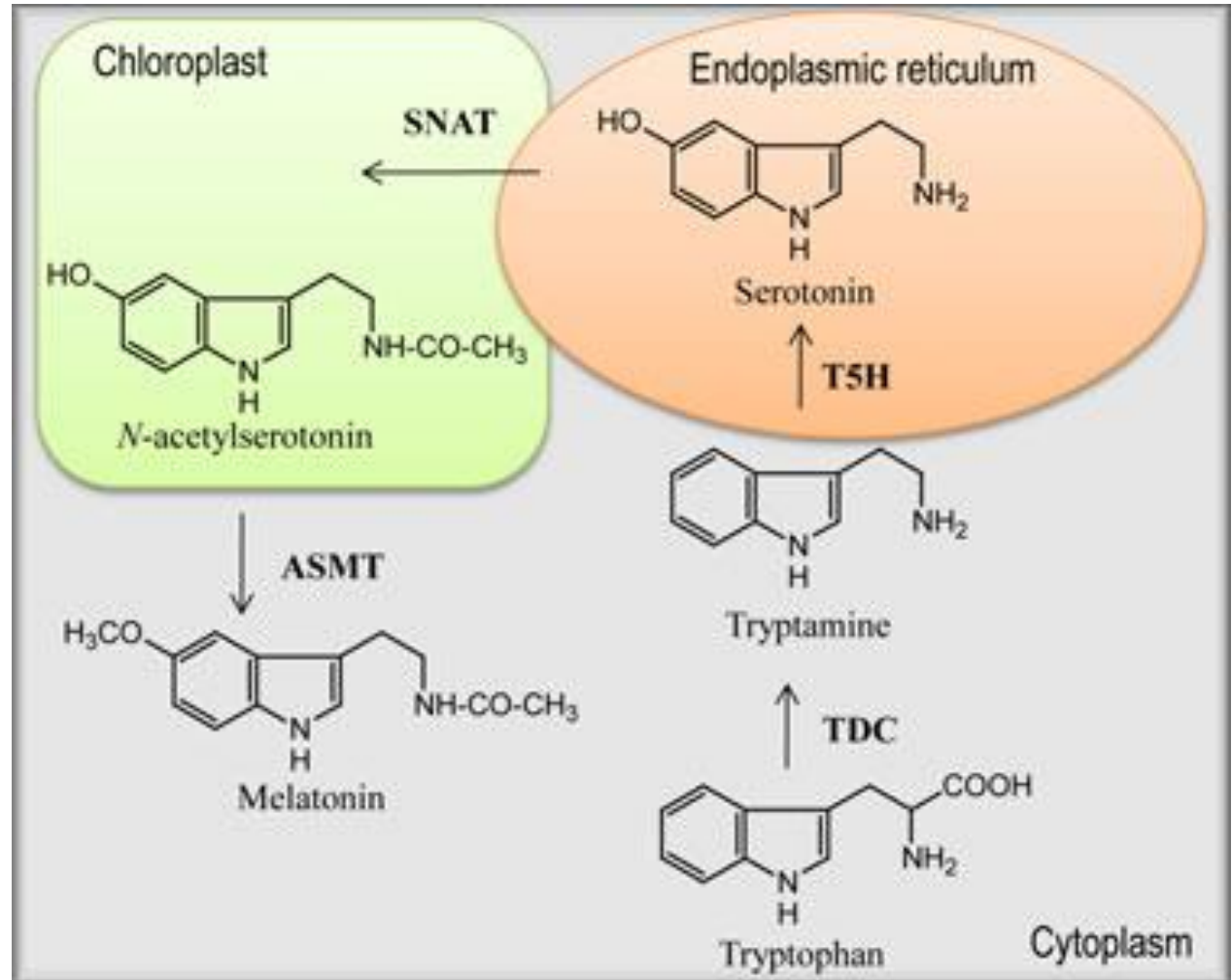
Mitochondria from purple non-sulfur bacterium (*Rhodospirillum rubrum*)



Lynn Mrgolis, PhD

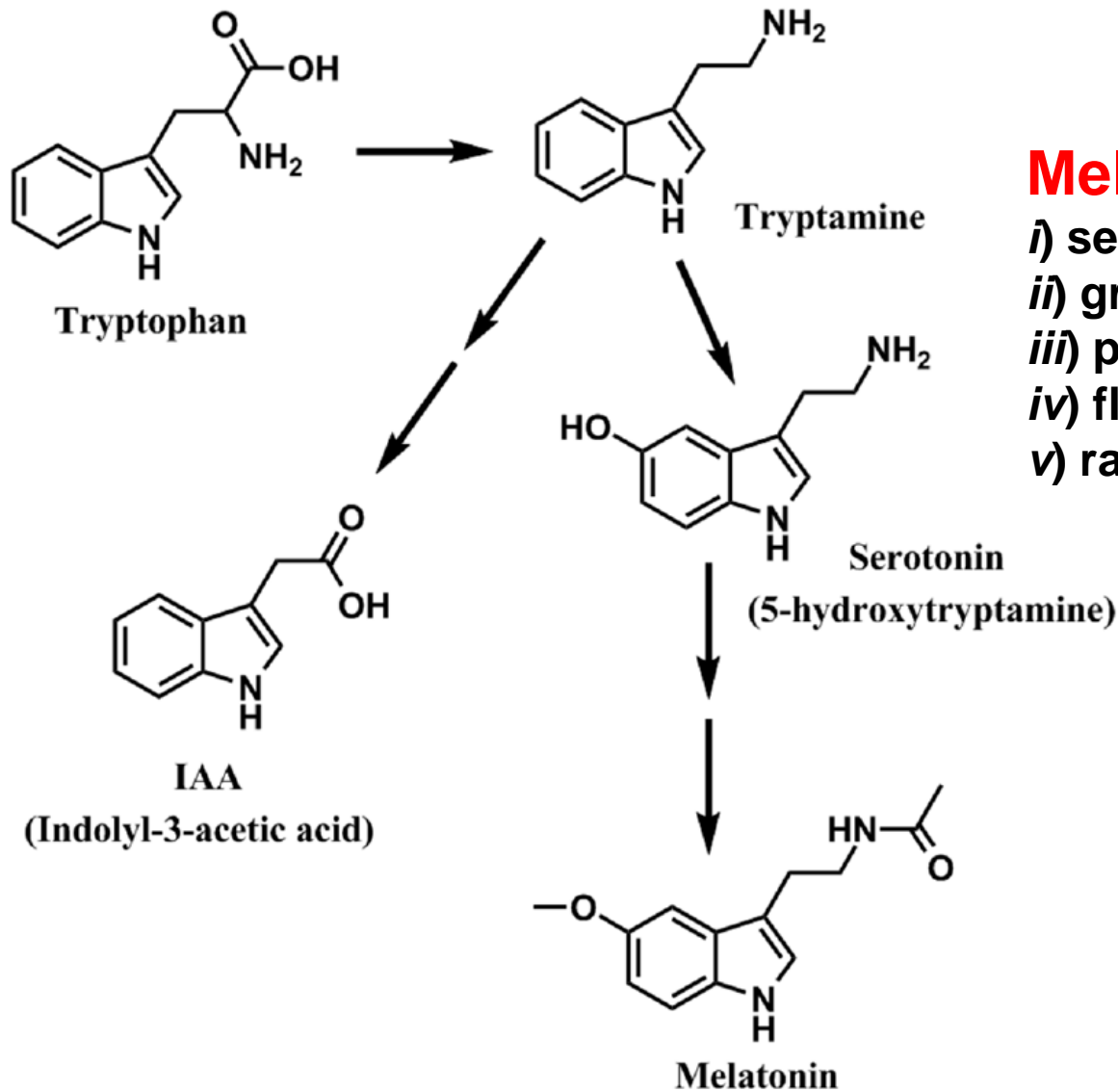
# Melatonin production may involve the chloroplasts and mitochondria

N-acetyltransferase  
has been localized  
In chloroplasts



**Two sites of melatonin synthesis**  
may explain why plants have  
higher concentrations of melatonin than animals

# Melatonin has auxin-like activity in plants

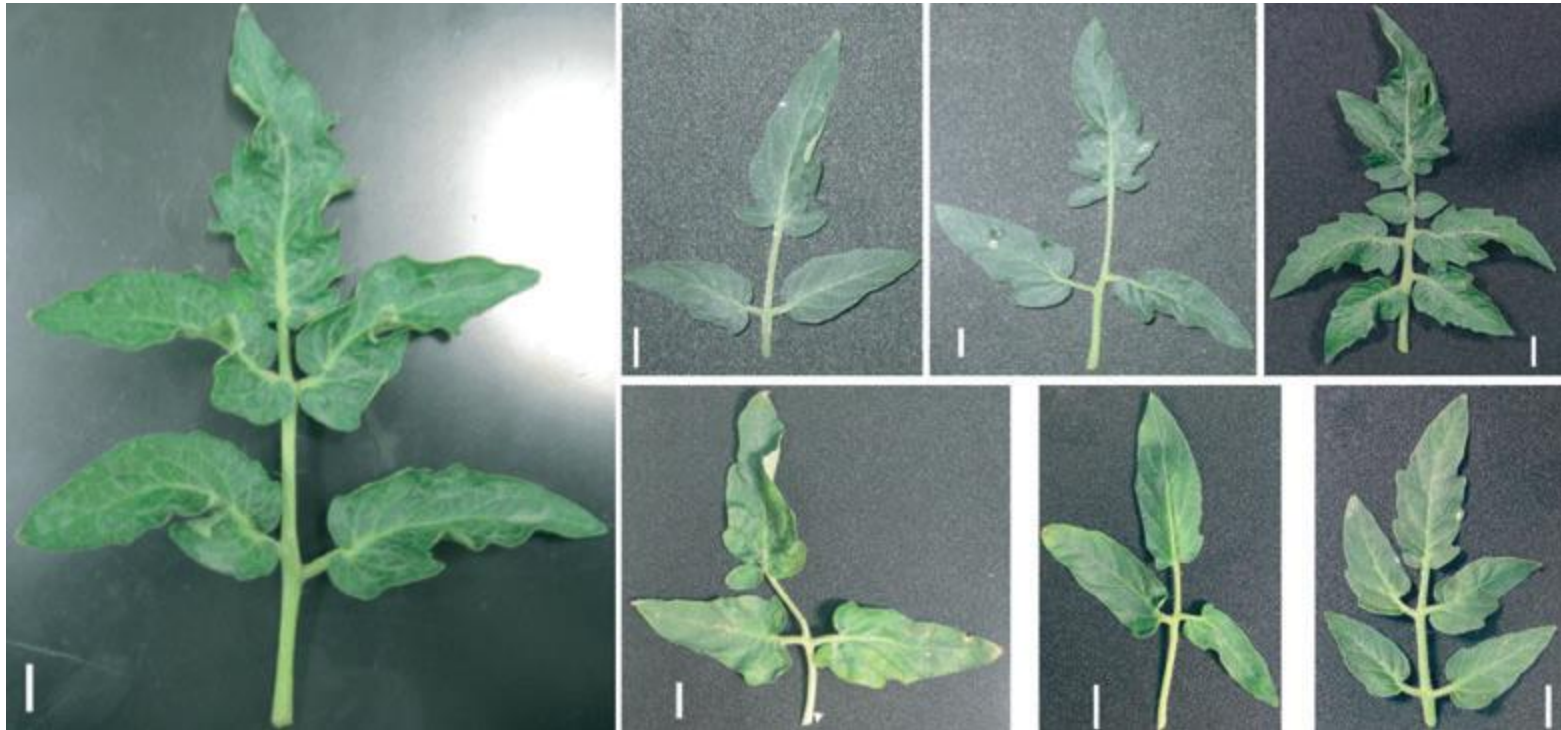


## Melatonin impacts:

- i)* seed germination
- ii)* growth and maturation
- iii)* product yield
- iv)* flower development
- v)* rate of fruit development



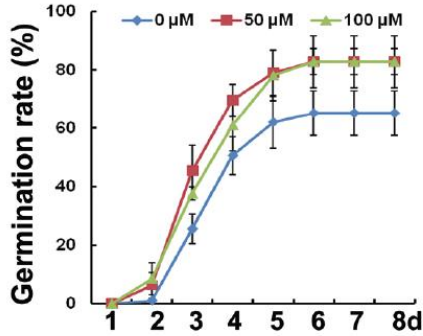
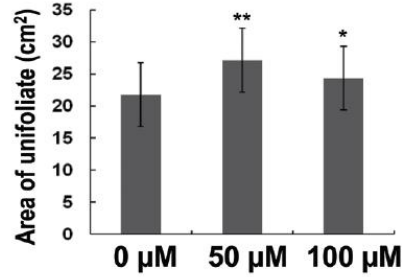
**Leaves of the micro-tom tomato  
(plants made **melatonin deficient** with  
indolamine 2,3-dioxygenase)**



**Normal leaf** of  
wild type plant

**Abnormal leaves** of plants  
deficient in melatonin

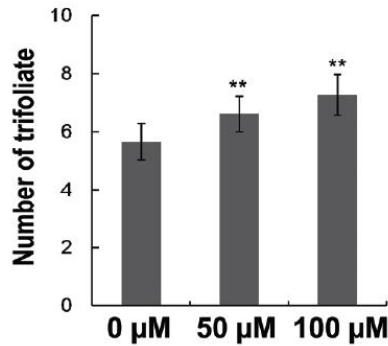
**Melatonin levels depressed** in  
tomato plants transgenic for IDO

**A****B**

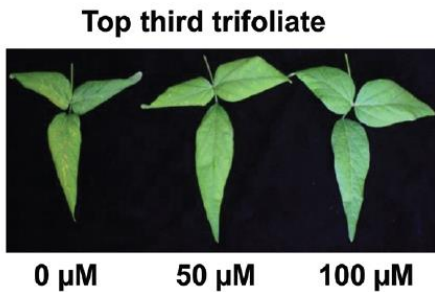
**Melatonin improves plant growth in soybean**

**C**

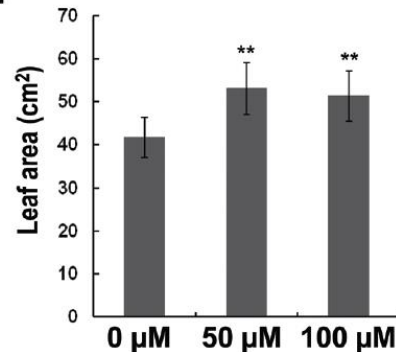
0 μM 50 μM 100 μM

**D**

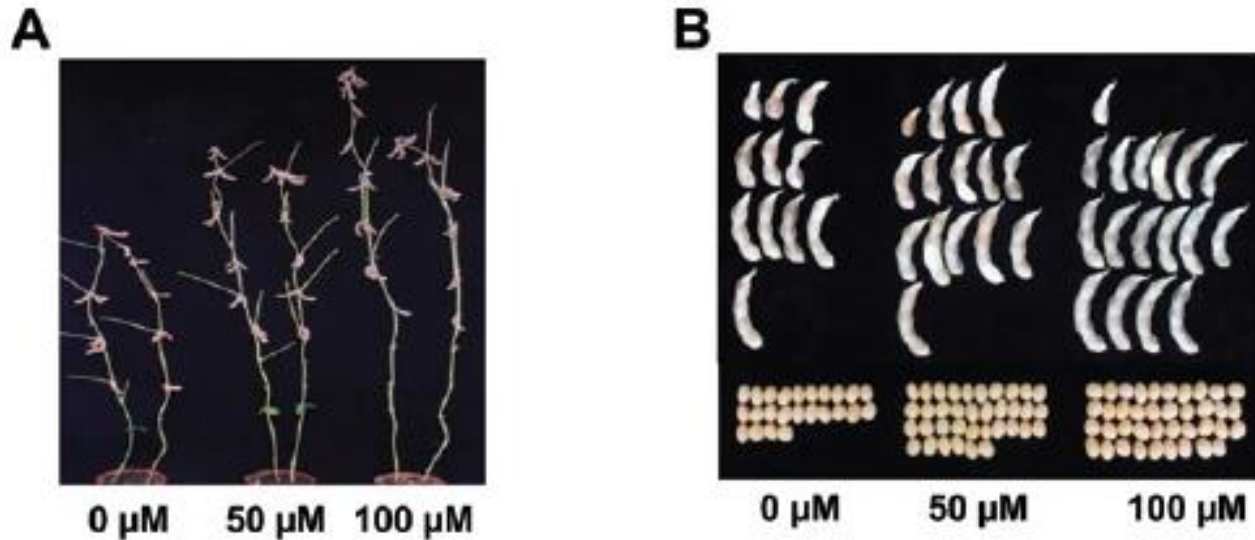
**Soybeans were coated with melatonin in seed-coating solution before planting**

**E**

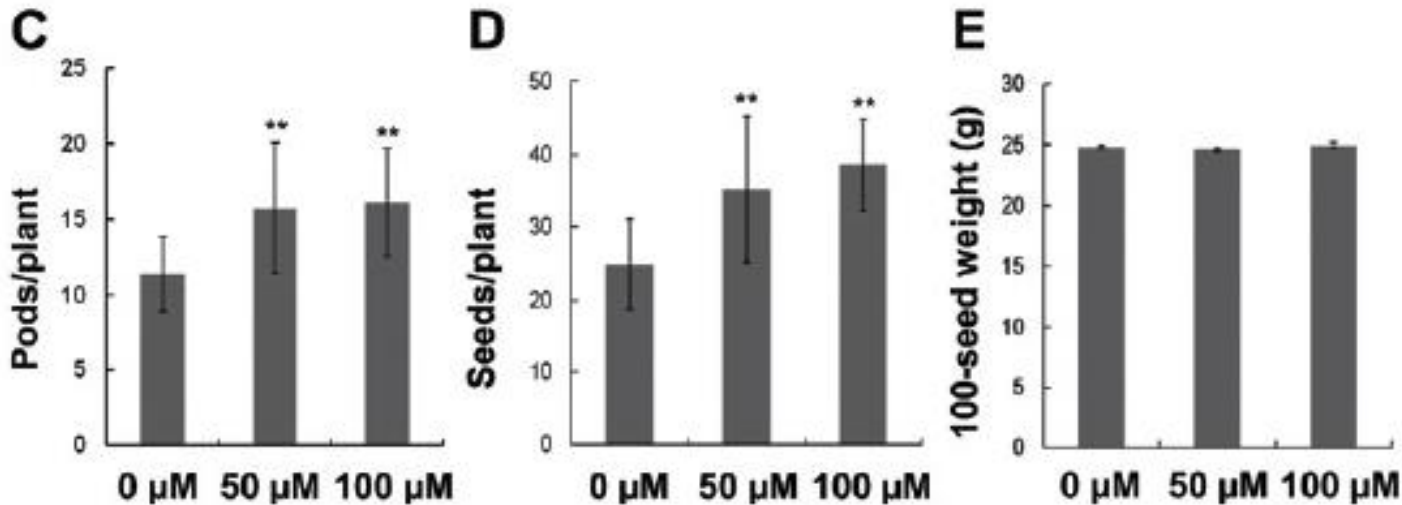
0 μM 50 μM 100 μM

**F**

## Melatonin improved crop production of soybean

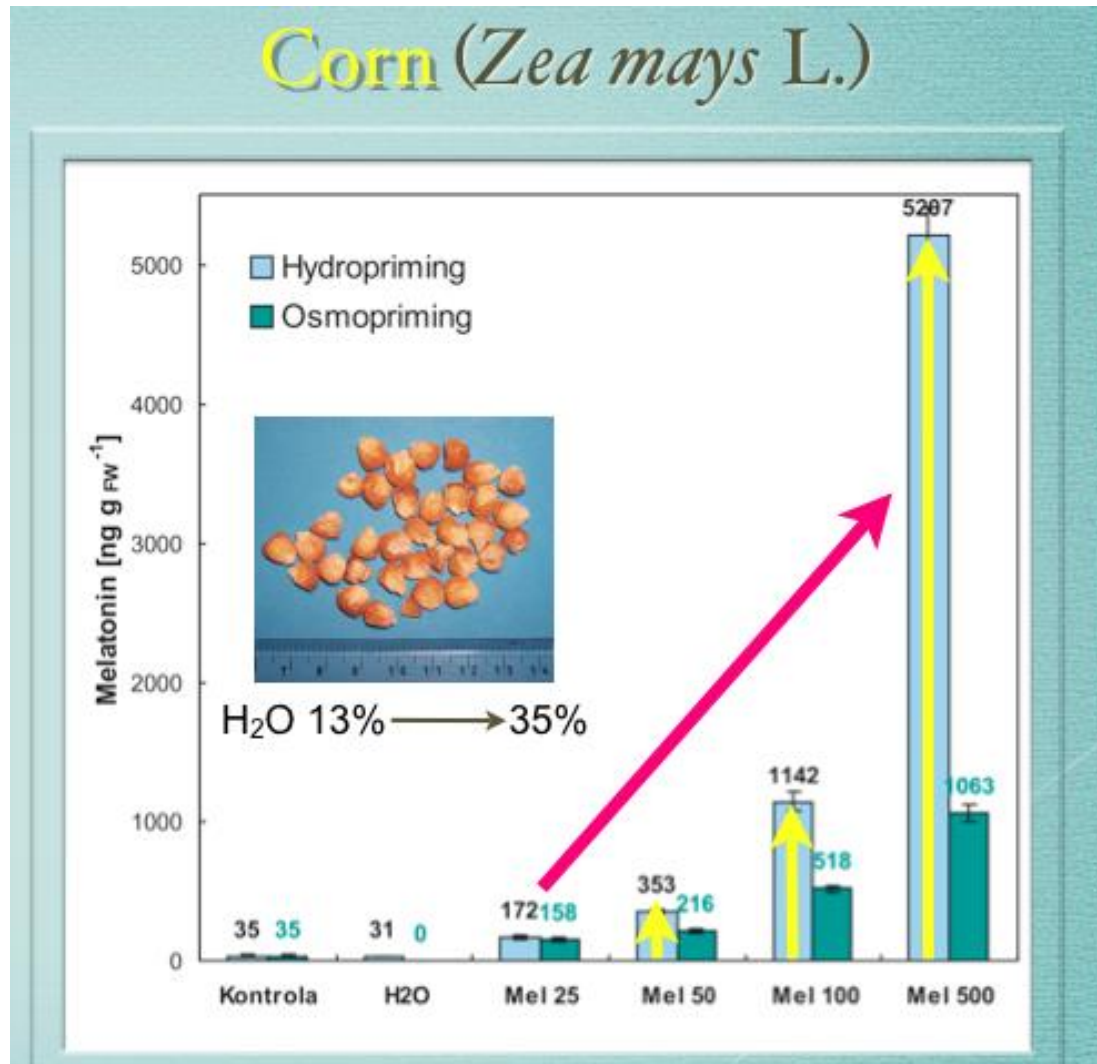


**300 million tons**  
per year; to increase  
to **370 million**  
tons by **2030**



**Land available**  
for soybean  
cultivation will  
**not increase**

# Incubating corn seeds in a solution of melatonin (**osmopriming**) increases the melatonin concentration in the **seeds**

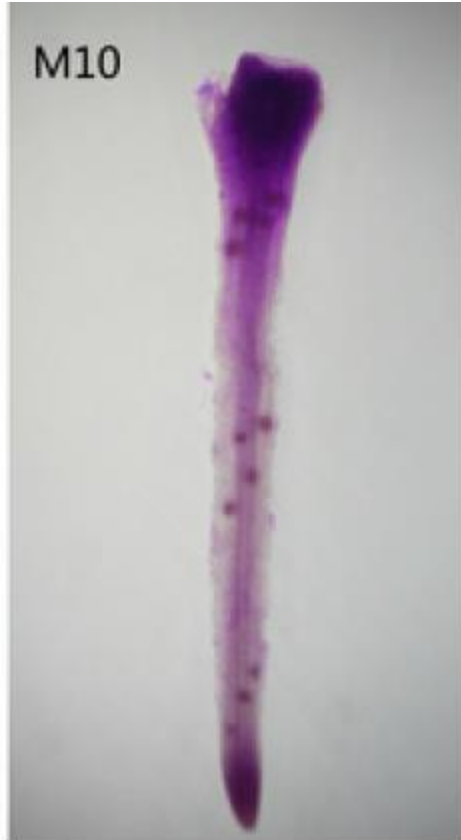
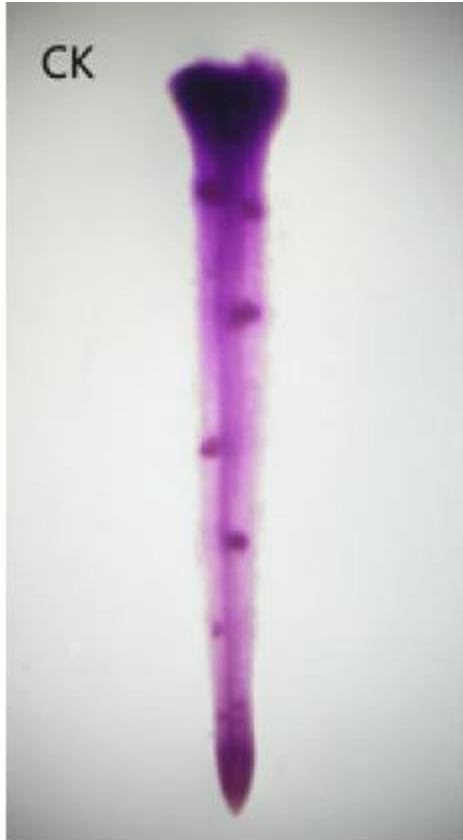




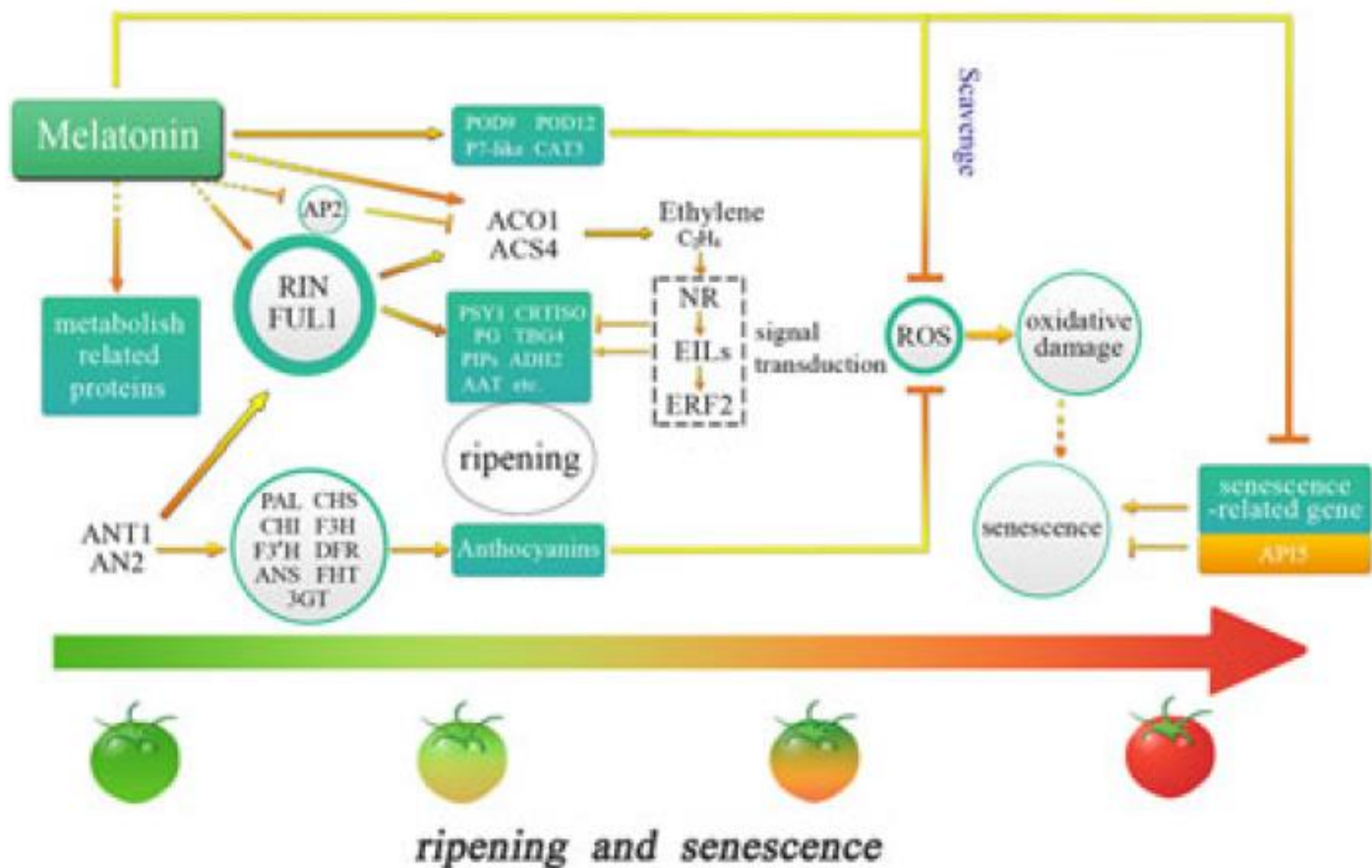
**Mung bean (*Vigna radiata* L.); Posmyk et al, 2013**



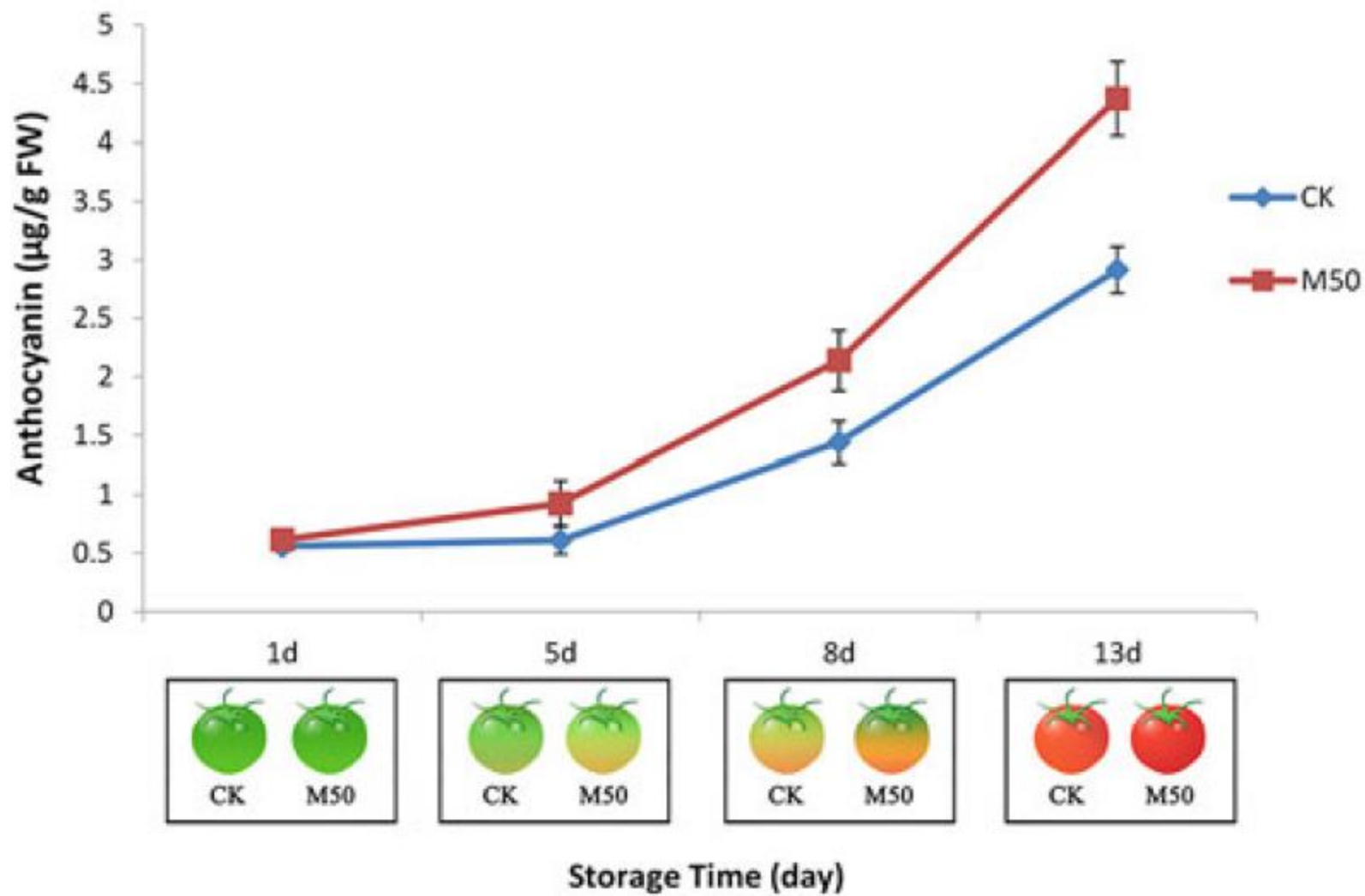
**Corn (*Zea mays* L.); Posmyk et al, 2013**

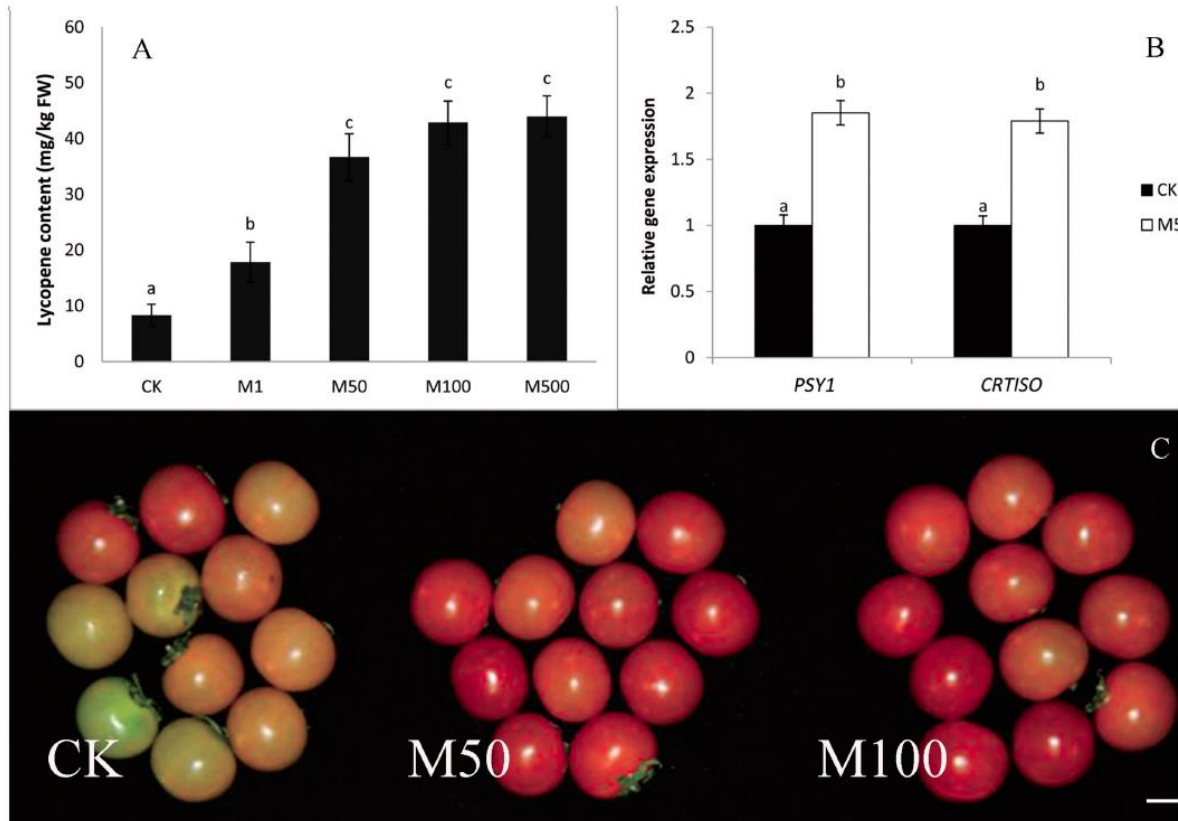










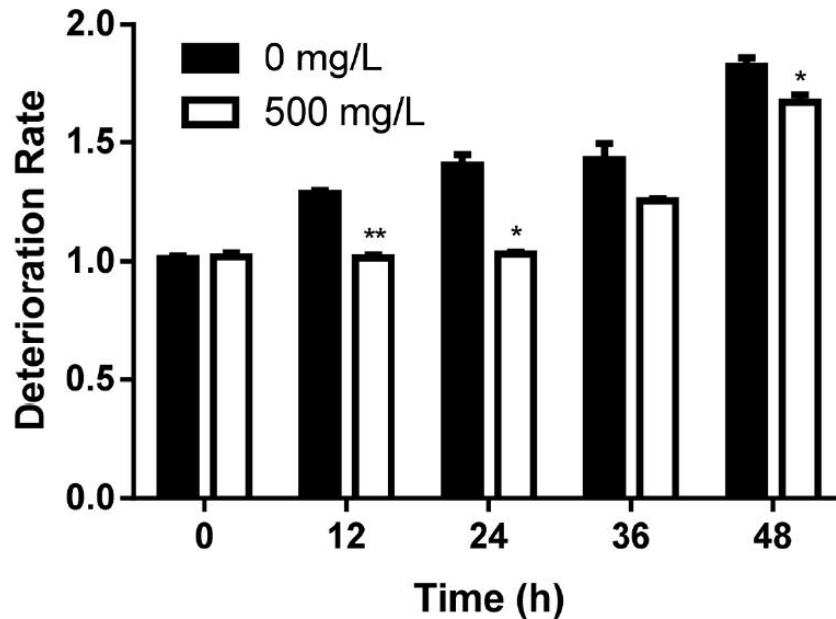


# Melatonin delays postharvest physiological deterioration (PPD) of cassava root

(A)



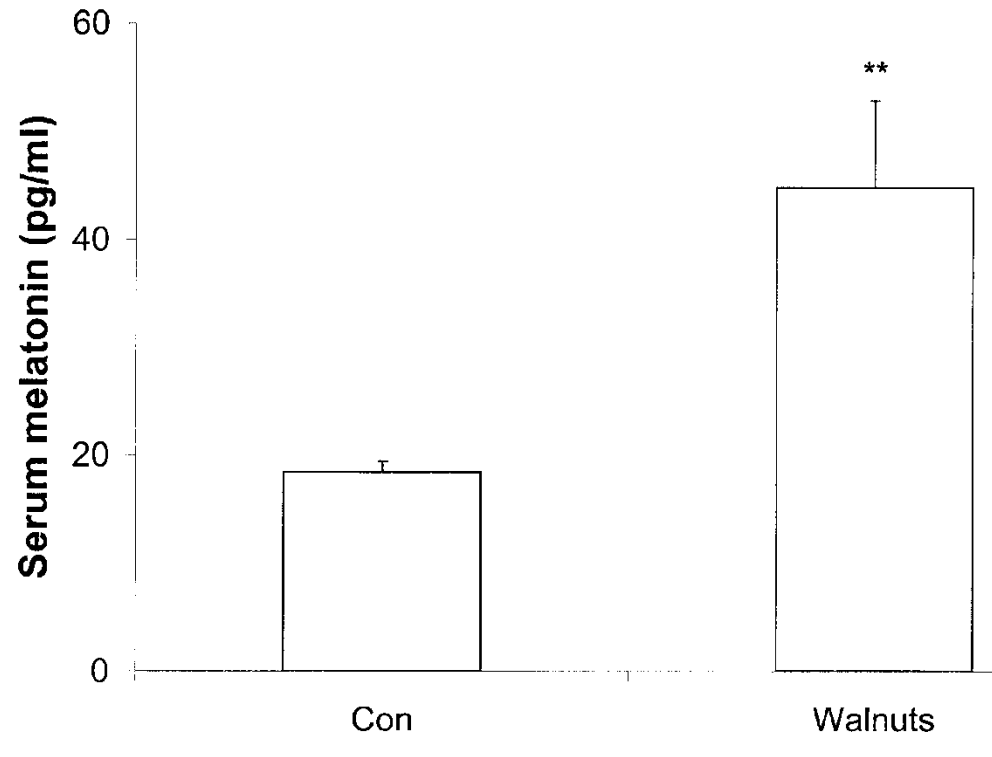
(B)



Fresh cut roots were incubated for 2 hours in a melatonin solution (500 mg/liter)



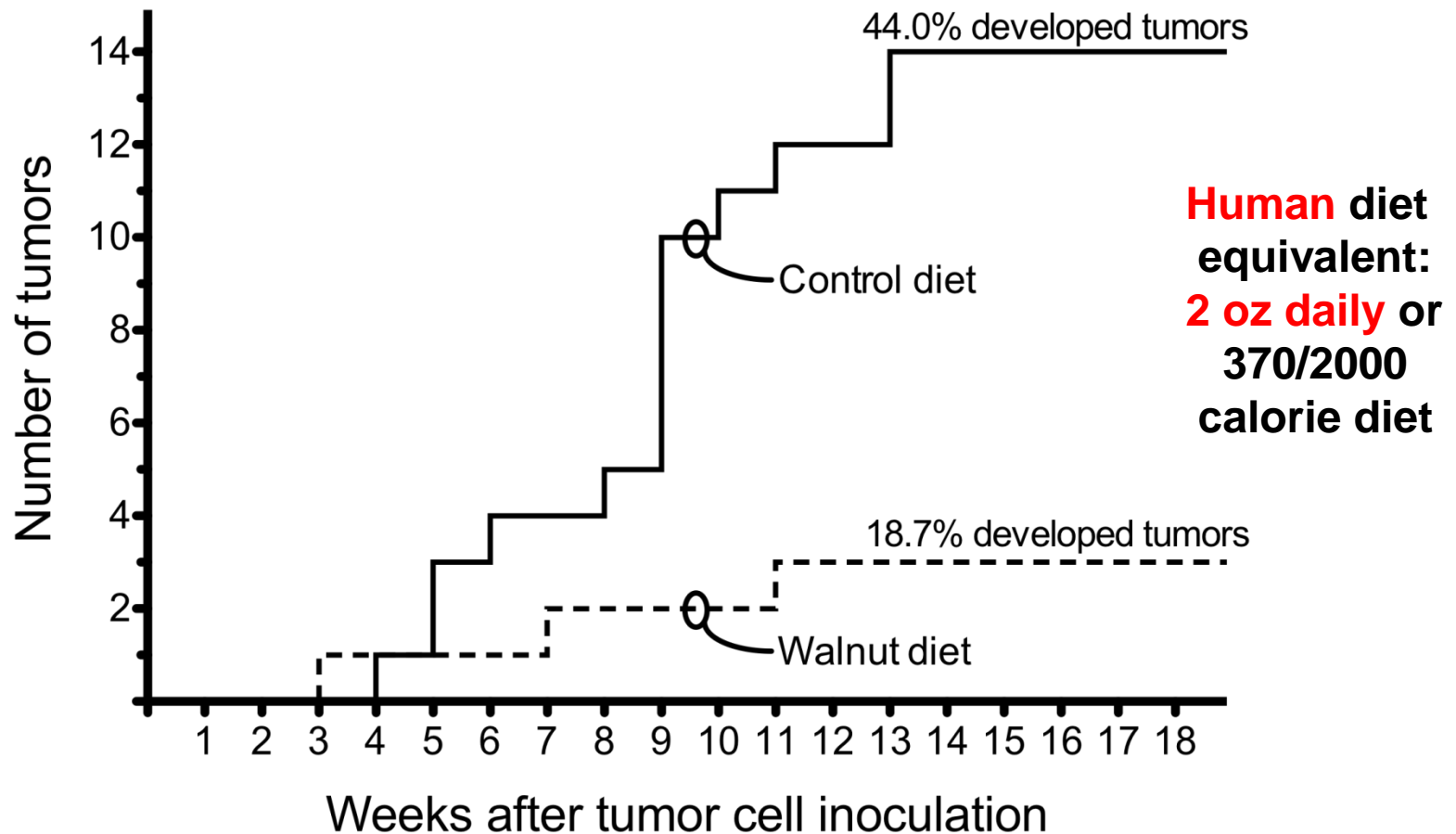
## Eating melatonin-rich foods increases the melatonin levels in serum



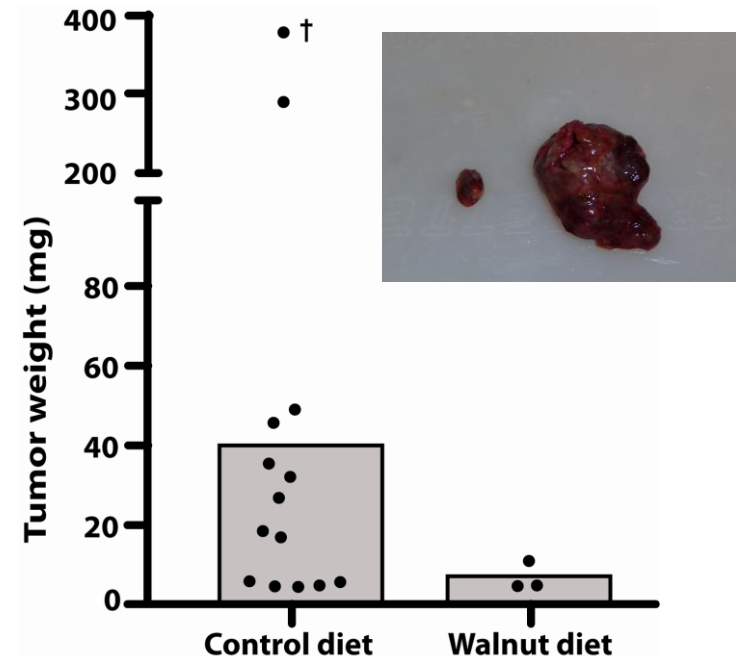
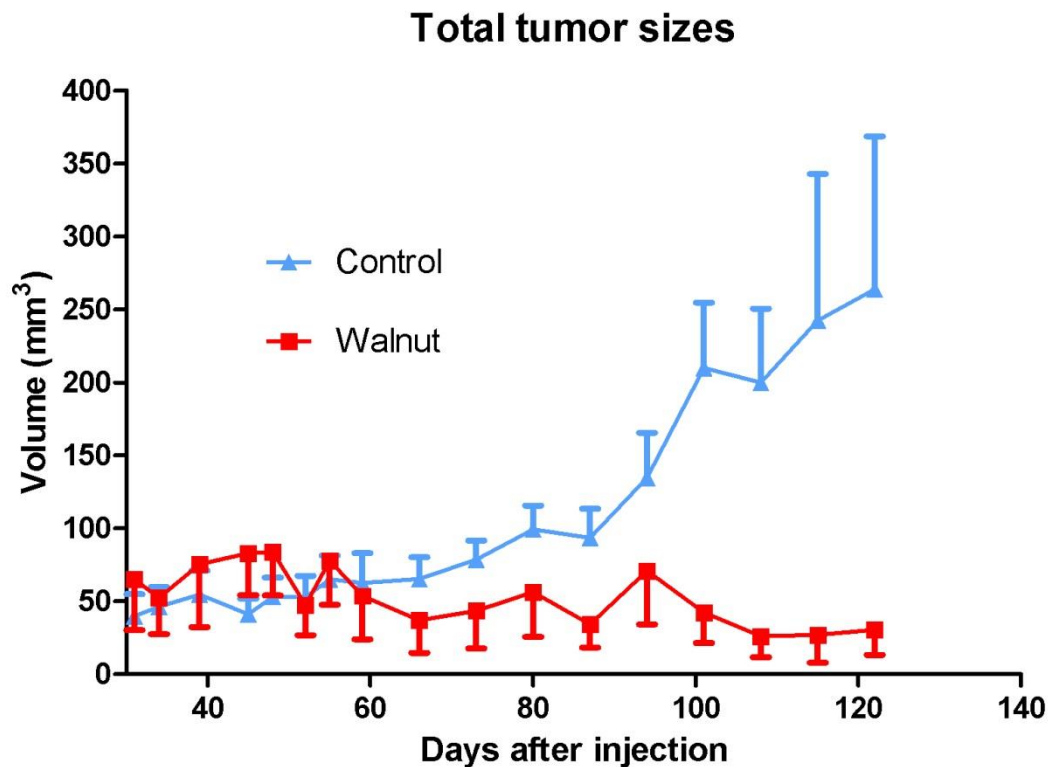
Reiter RJ et al. A walnut-enriched diet reduces the growth of LNCaP human prostate cancer xenografts in nude mice.  
**Cancer Investigation 2013; 31: 365-373.**

# Initiation of **human prostate tumors** in immune-compromized mice inoculated with LNCaP cancer cells and fed a **melatonin-containing** walnut diet

First detection of tumors

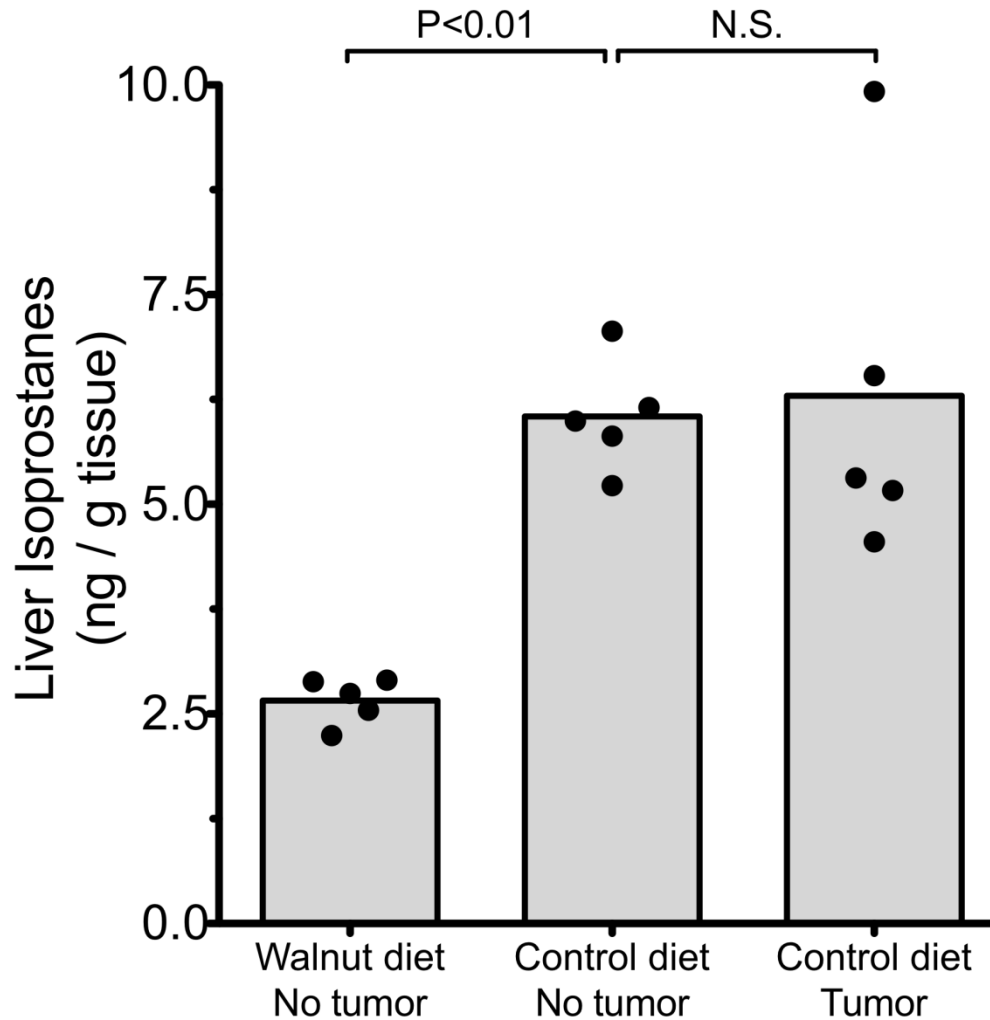


# Human prostate cancer growth rates and final tumor sizes in immune-compromized mice consuming melatonin-containing walnuts

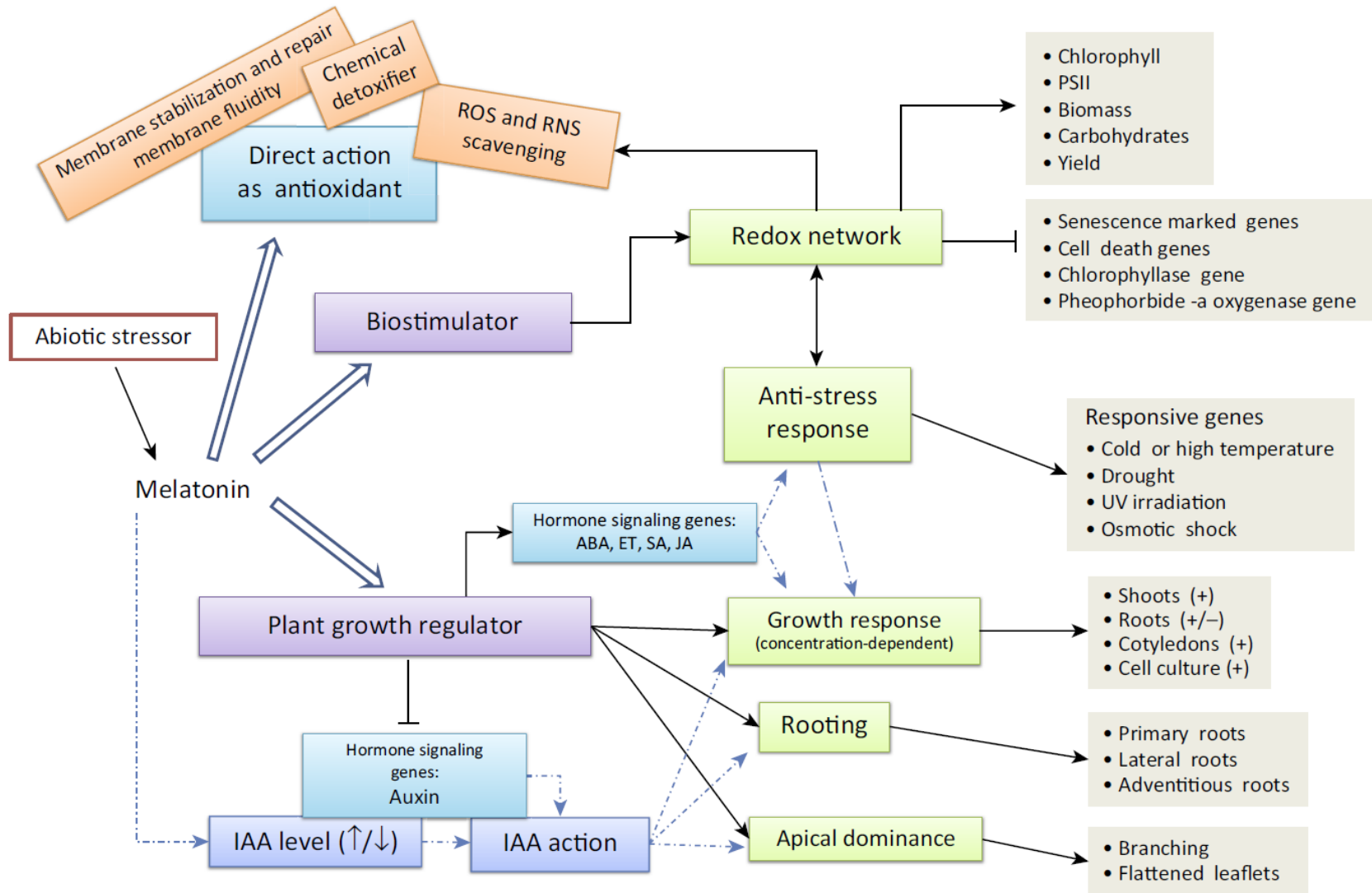


This does **not prove**, however, that **melatonin** was the walnut ingredient that **caused the inhibition** of prostate cancer growth

# Consuming a **melatonin-containing** walnut diet also **reduced lipid peroxidation** in the liver



# The multiple actions of melatonin in plants



TRENDS in Plant Science

## Genetically engineering of melatonin synthesis

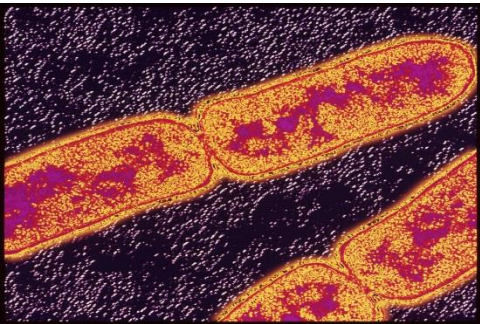
may be a primary means to improve plant tolerance and crop production



# Conclusions

1. Melatonin conserved throughout plant and animal kingdoms
2. Melatonin is a superior antioxidant in plants and animals
3. Vegetative actions that impact root and plant growth
4. Melatonin may be a prodrug in some cases
5. Mitochondria and chloroplasts may synthesize melatonin
6. Melatonin improves crop yield
7. Melatonin has critical functions in every organism

Limited number of studies under field conditions





# Numerous unanswered questions concerning melatonin in plants

Molecular mechanisms of melatonin's protection against biotic and abiotic stresses?

Do **herbivore-inducible plant volatiles** (HIPV) influence plant melatonin production?

Does melatonin influence **antiherbivore defense, insect herbivory**?

Relation of melatonin to **glutathione** and **metal toxicity**, e.g., cadmium

Are there **melatonin receptors** in plants? Function?

Mechanisms of **melatonin uptake** by **roots and leaves**?

Does melatonin protect against **soil contaminants**?

Are there **circadian and circannual rhythms** of melatonin in plants?

# Numerous unanswered questions concerning melatonin in plants (cont'd)

Does melatonin influence **nutrient uptake** by roots?

Mechanisms of **melatonin transport** in plants?

Does melatonin have a role in **vascular reunion** during grafting?

Does melatonin influence **root regrowth after cutting them** such as during transplantation of trees, shrubs or sod grass?

Does melatonin influence **half-life of flowers** after cutting?

Does melatonin influence **root regrowth** from cut shoots?

Does melatonin influence post-harvest **half life/shelf life of food stuffs**?

Does melatonin influence **fruit ripening**?

**\*Does melatonin improve crop yield?\***



