IIT KHARAGPUR

NPTEL ONLINE CERTIFICATION COURSES

NPTEL

Organic Farming for Sustainable Agricultural Production

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Lecture 35: Antioxidant Capacity of Fruits and Vegetables

What is Antioxidant Capacity?

- ✓ Antioxidant Capacity is known as Oxygen Radical Absorbance Capacity (ORAC)

- ✓ Measuring ORAC allows us to compare the capacity of individual fruits, vegetables and other antioxidant-rich foods.

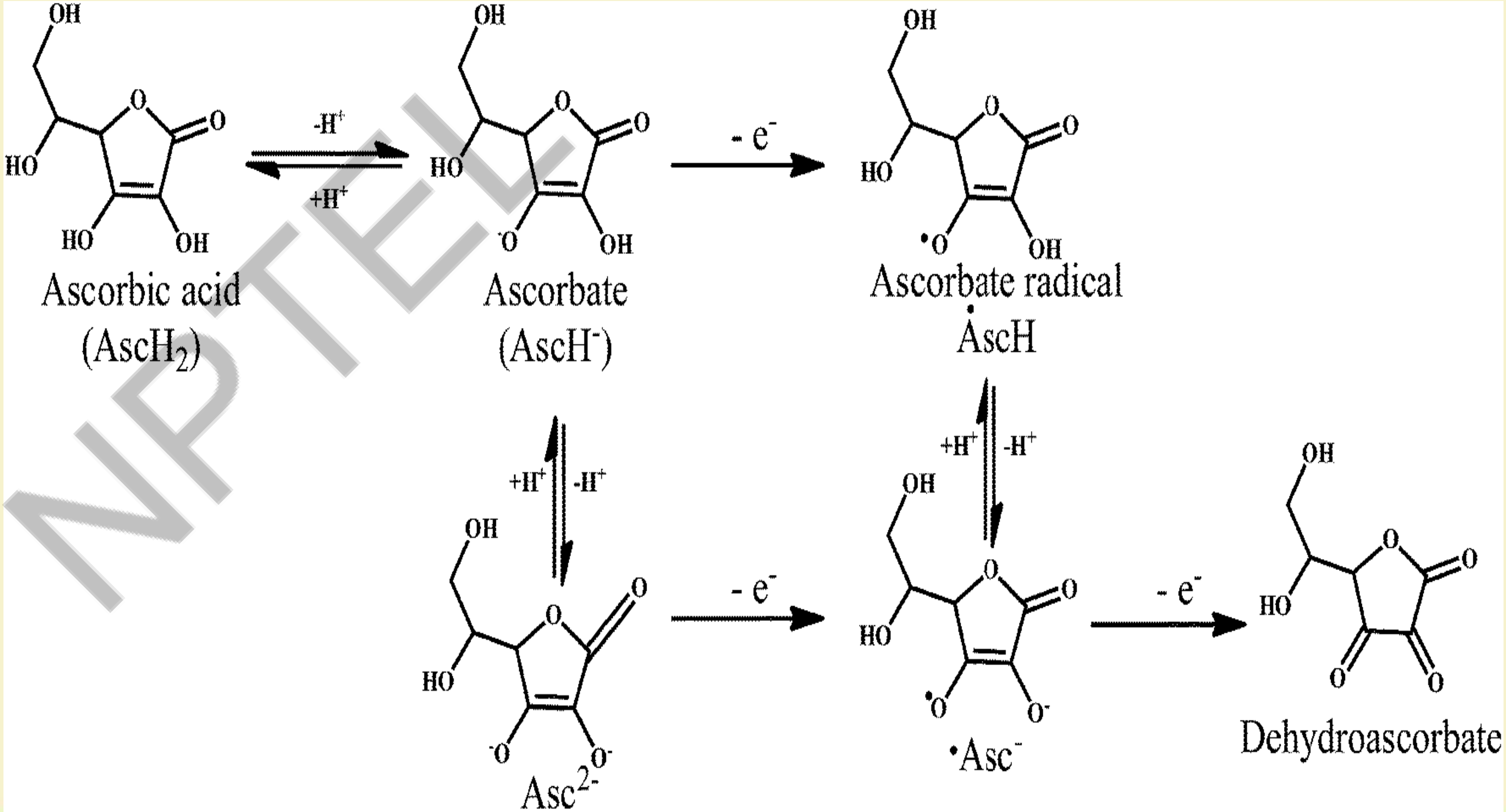
- ✓ That foods higher on the ORAC scale more effectively to neutralize free radicals

Antioxidant Function

Vitamin C (Ascorbic acid)

- It is a water soluble
- Antioxidant present in citrus fruits, potatoes, tomato and green leafy vegetables
- It is a chain breaking anti-oxidant, as a reducing agent or electron donor.
- It scavenges free radicals and inhibits lipid peroxydation.
- It also promotes the regeneration of a tocopherol

Donate 1 e^- → semi dehydroascorbate



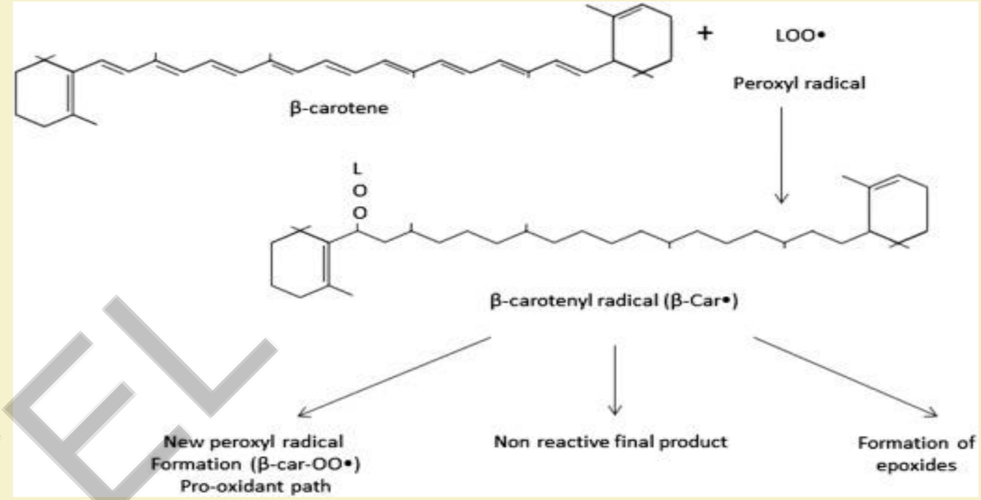
Vitamin A (β-Carrotene)

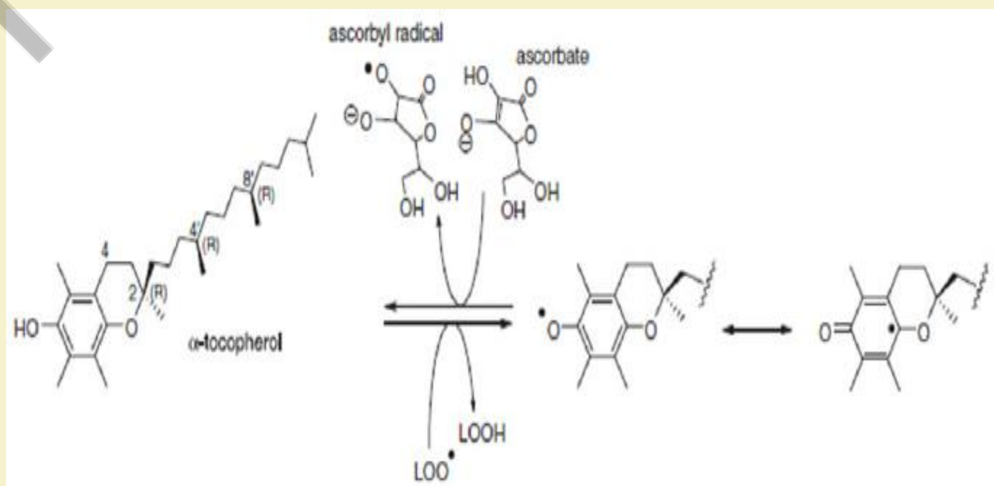
Vitamin A is a group of unsaturated nutritional organic compounds that includes retinol, retinoic acid and several pro-vitamin A carrotinoids specially beta-carrotene.

Vitamin E (Tocopherol)

- Most important and effective lipid soluble anti-oxidant
- Vital to maintain cell membrane integrity.
- Antioxidant present in unsaturated fat likes sunflower, safflower and olive oil.

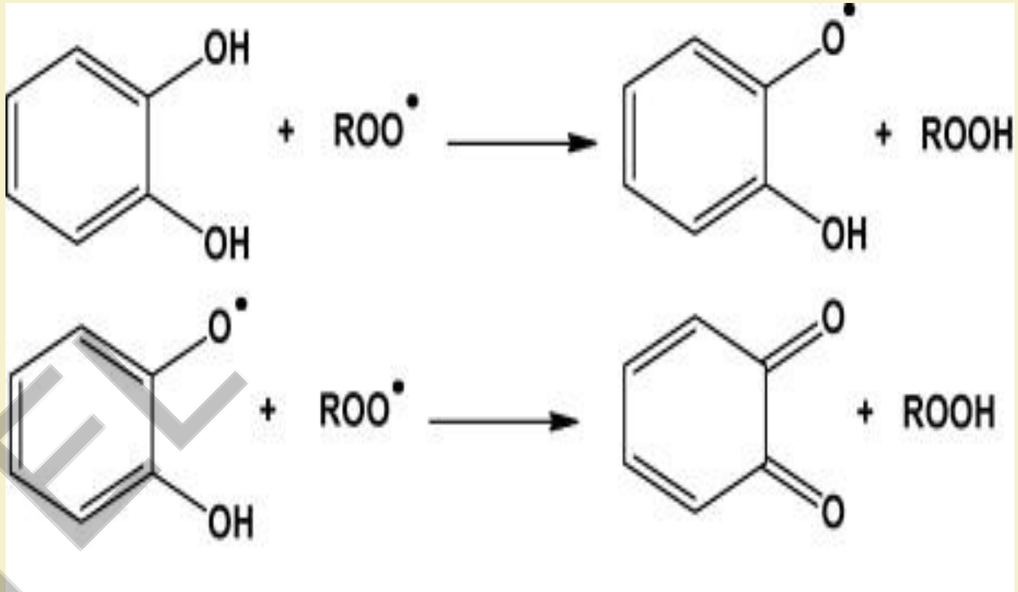
Donates double bond to prevent oxidants



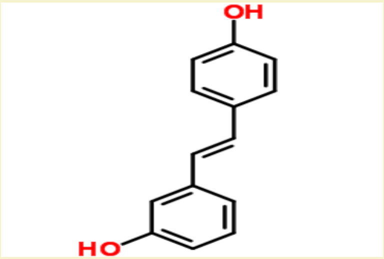


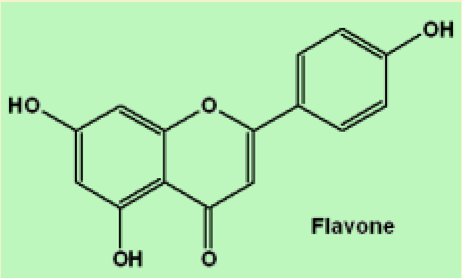
Polyphenol

- Polyphenols are group of phenolic compounds containing more than one phenol units/ molecule found.
- Polyphenol divided into two major types: Flavonoid (basic structure consisting of two benzene rings linked through a heterocyclic pyrone C ring)
- Non-flavonoid phenolics (more heterogeneous group of compounds)
- It is wide spread constituents of fruits, vegetables, cereals, olives, dry legumes, chocolate, tea, coffee and wine.



The reaction mechanism of catechol as antioxidant





Flavanoids

Determining Antioxidant Capacity

- ✓ ORAC, Oxygen Radical Absorbance Capacity
- ✓ TRAP, Total Radical-Trapping Antioxidant Parameter
- ✓ TEAC, Trolox Equivalent Antioxidant Capacity
- ✓ DPPH (Di-phenyl picryl hydrazyl)
- ✓ TOSC, Total Oxyradical Scavenging Capacity
- ✓ PSC, Peroxyl Radical Scavenging Capacity
- ✓ FRAP, Ferric Reducing/ Antioxidant Power

- ✓ ORAC Values are reported for hydrophilic-ORAC (H-ORAC), lipophilic-ORAC (L-ORAC), total-ORAC, and total phenolics (TP).
- ✓ H-ORAC, L-ORAC and total-ORAC are reported in µmol of Trolox Equivalents per 100 grams (µmolTE/100g), while TP is reported in mg gallic acid equivalents per 100 grams (mgGAE/100 g).
- ✓ When only an H-ORAC value was available for a particular food item low in fat, H-ORAC value was also utilized for the Total ORAC value.

ORAC value of Some fruits

Fruits	ORAC value	Fruits	ORAC value
Prunes	5770	Cherries	670
Raisins	2830	Kiwifruit	602
Blueberries	2400	Grapes, white	446
Black berries	2036	Banana	221
Cranberries	1750	Apple	218
Strawberries	1540	Apricots	164
Pomegranates	1245	Peach	158
Plums	949	Pear	134
Oranges	750		
Grapes, red	739		

***Source:** USDA.2005. USDA nutrient database for standard reference, Release 18. US. Dept. of Agriculture, Agricultural Research service, Washington D.C*

ORAC value of Some vegetables

Vegetables	ORAC value	Vegetables	ORAC value
Spinach	1260	Brinjal	390
Brussels sprouts	980	Cauliflower	377
Alfalfa sprouts	930	Peas, frozen	364
Spinach, streamed	909	Potatoes	313
Broccoli florets	890	Sweet potatoes	301
Beets	841	Carrots	207
Red bell pepper	713	Beans	201
Onion	450	Tomato	189
Corn	400	Yellow squash	150

Source: *USDA.2005. USDA nutrient database for standard reference, Release 18. US. Dept. of Agriculture, Agricultural Research service, Washington D.C*

Comparison between Organic and Inorganic Vegetables for Antioxidant Contents

Crops and Products	Bioactive Substances	Key results
Apple	Polyphenols	Higher in organic production
Spinach	Flavonoids, Anthrocyanin	Higher in organic production
Tomato	Lycopene, Carrotene	Similar content in both systems
Blueberry	Polyphenols	Higher in organic production
Carrot	Carrotenoids	Similar content in both systems
Cauliflower	Glucosinolates	Similar content in both systems
Strawberry	Anthocyanins	Higher in Organic systems
Broccoli	Glucosinolates, polyphenols	Higher in Organic systems
Blue berries	Flavonoids	Higher in Organic systems

Source: Aires, A. (2016). Conventional and Organic Farming—Does Organic Farming Benefit Plant Composition, Phenolic Diversity and Antioxidant Properties?. In *Organic Farming-A Promising Way of Food Production*. InTech. DOI: 10.5772/61367.

Yield and total phenol of tea grown following organic and conventional practice

Fertilizer Treatments	Made tea (kg/ha)	Phenol content mg/g in Gallic acid equivalent (GAE)	Total contents of Catechins (mg/g tea leaves)	% of increase/decrease of Catechin content over control treatments
Control (No application)	190.0	251.6	12.61	-
Chemical fertilizer	601.0	197.4	4.94	60.82% decrease
Organic fertilizer	587.0	288.3	16.48	30.7% increase

Palit, S., Ghosh, B. C., Gupta, S. D., & Swain, D. K. (2008). Studies on tea quality grown through conventional and organic management practices: Its impact on antioxidant and antidiarrhoeal activity. Transactions of the ASABE, 51(6), 2227-2238.

Mean antioxidant capacity (ORAC) in fresh eggplant grown under conventional and organic cultivation systems

Cultivation System	Soluble antioxidant Capacity (ORAC) (µmole TE/g FW)	Hydrolyzable antioxidant capacity (ORAC) (µmole TE/g FW)	Anthocyanin antioxidant capacity (ORAC) (µmole TE/g FW)
Chemical fertilizer	36.61	47.71	68.18
Organic fertilizer	50.60	75.06	68.79
LSD (0.05)	11.96	16.61	14.92

Source: *Zambrano-Moreno, E. L., Chávez-Jáuregui, R. N., Plaza, M. D. L., & Wessel-Beaver, L. (2015). Phenolic content and antioxidant capacity in organically and conventionally grown eggplant (Solanum melongena) fruits following thermal processing. Food Science and Technology, 35(3), 414-420.*

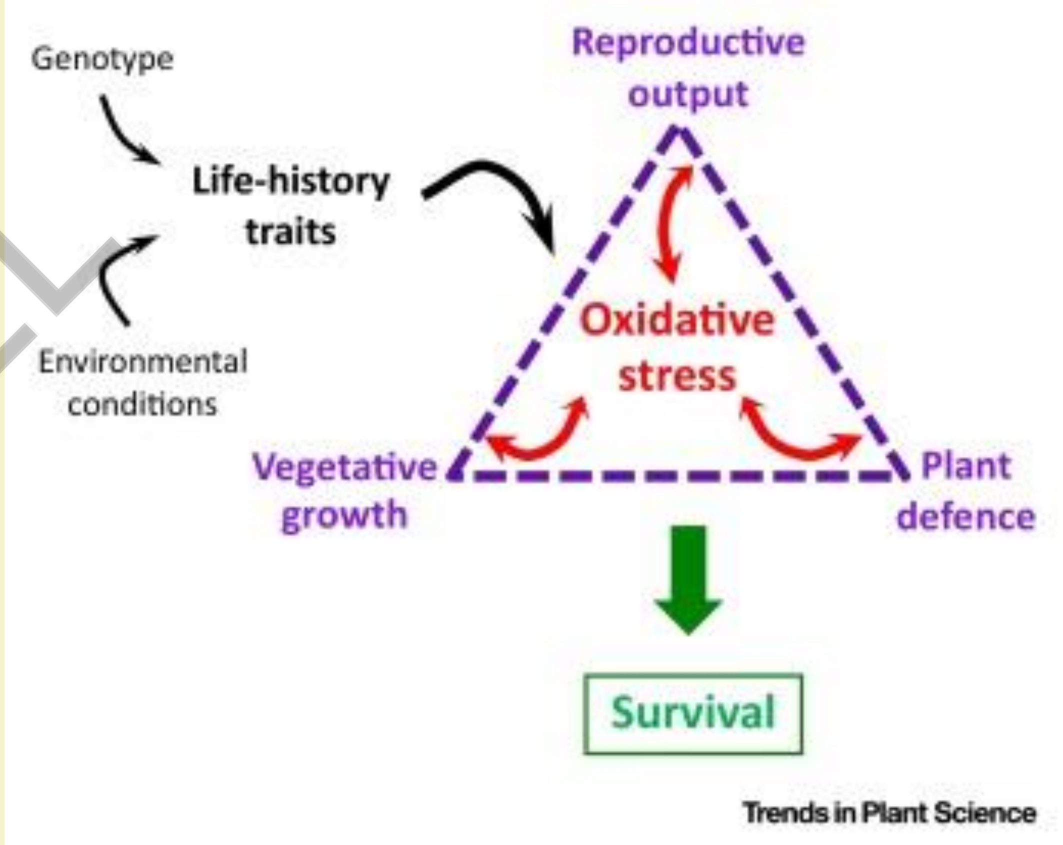
Why organic fruits and vegetables produce higher antioxidant levels than their conventional counterparts?

There are two leading theories:

1. The oxidative stress hypothesis and
2. The growth-differentiation balance hypothesis.

1. The oxidative stress hypothesis

- This stress can be caused by many environmental factors, such as herbivory by insects, low nutrient levels, etc.
- Because crops that are grown organically are not sprayed with synthetic pesticides or high levels of applied fertilizer, they experience more stress than conventional crops. Thus produce higher levels of antioxidants in response to that stress.



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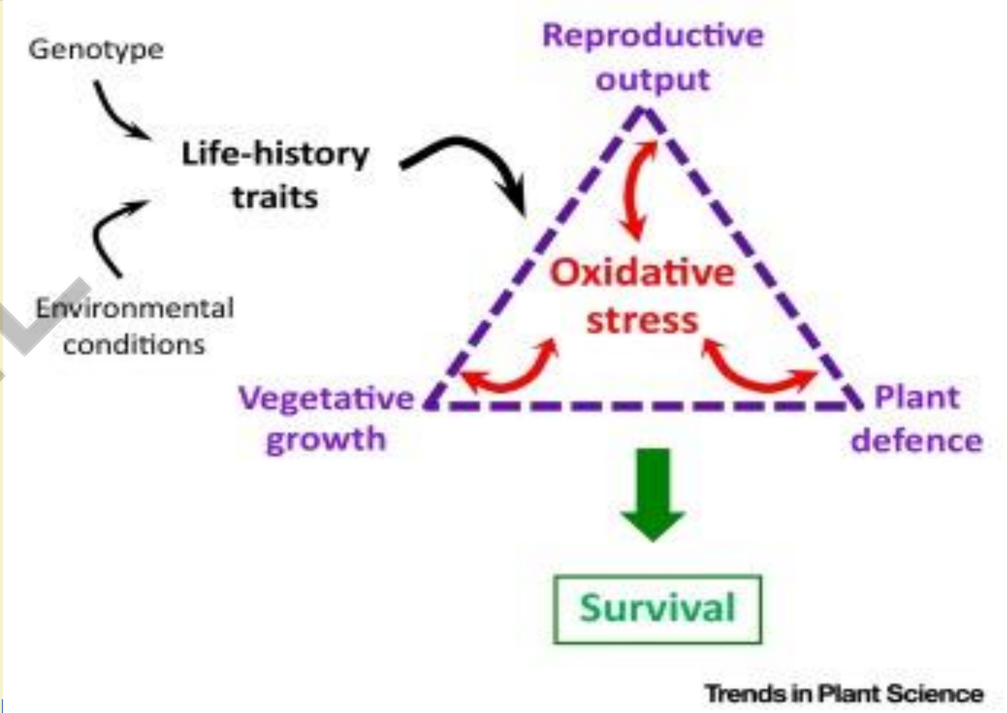
Why organic fruits and vegetables produce higher antioxidant levels than their conventional counterparts?

2.The growth-differentiation balance hypotheses

This hypothesis states that,

- In high nutrient environments (such as the conditions on conventional farms where synthetic fertilizer is used), plants will spend their resources creating new plant tissue rather than secondary metabolites.
- In less rich conditions, however, growth is limited by lack of nutrients, so more resources will be available to be spent on secondary metabolites.
- Thus, as nutrient levels decrease from high to intermediate, antioxidant levels actually increase.



Source: *Barański, M., Średnicka-Tober, D., Volakakis, N., Seal, C., Sanderson, R., Stewart, G. B., ... & Gromadzka-Ostrowska, J. (2014). Higher antioxidant and lower cadmium concentrations and lower incidence of pesticide residues in organically grown crops: a systematic literature review and meta-analyses. British Journal of Nutrition, 112(5), 794-811.*

Why organic fruits and vegetables produce higher antioxidant levels than their conventional counterparts?

- The highest levels of antioxidants are found in environments with intermediate levels of nutrients.
- Very low levels of nutrients will also result in low levels of antioxidants, because there will not be enough resources for creating secondary metabolites nor plant growth. Basically, at very low levels of nutrients you will have an unhealthy plant.
- **These intermediate nutrient** conditions are similar to those **found on organic farms**, while the **high nutrient conditions** are similar to those found on **conventional farms.**
- Thus, intermediate nutrient levels on **organic farms** should **result in crops with higher antioxidant production** than crops grown on conventional farms with high nutrient levels.