Meat antioxidants

benefits, risks, challenges

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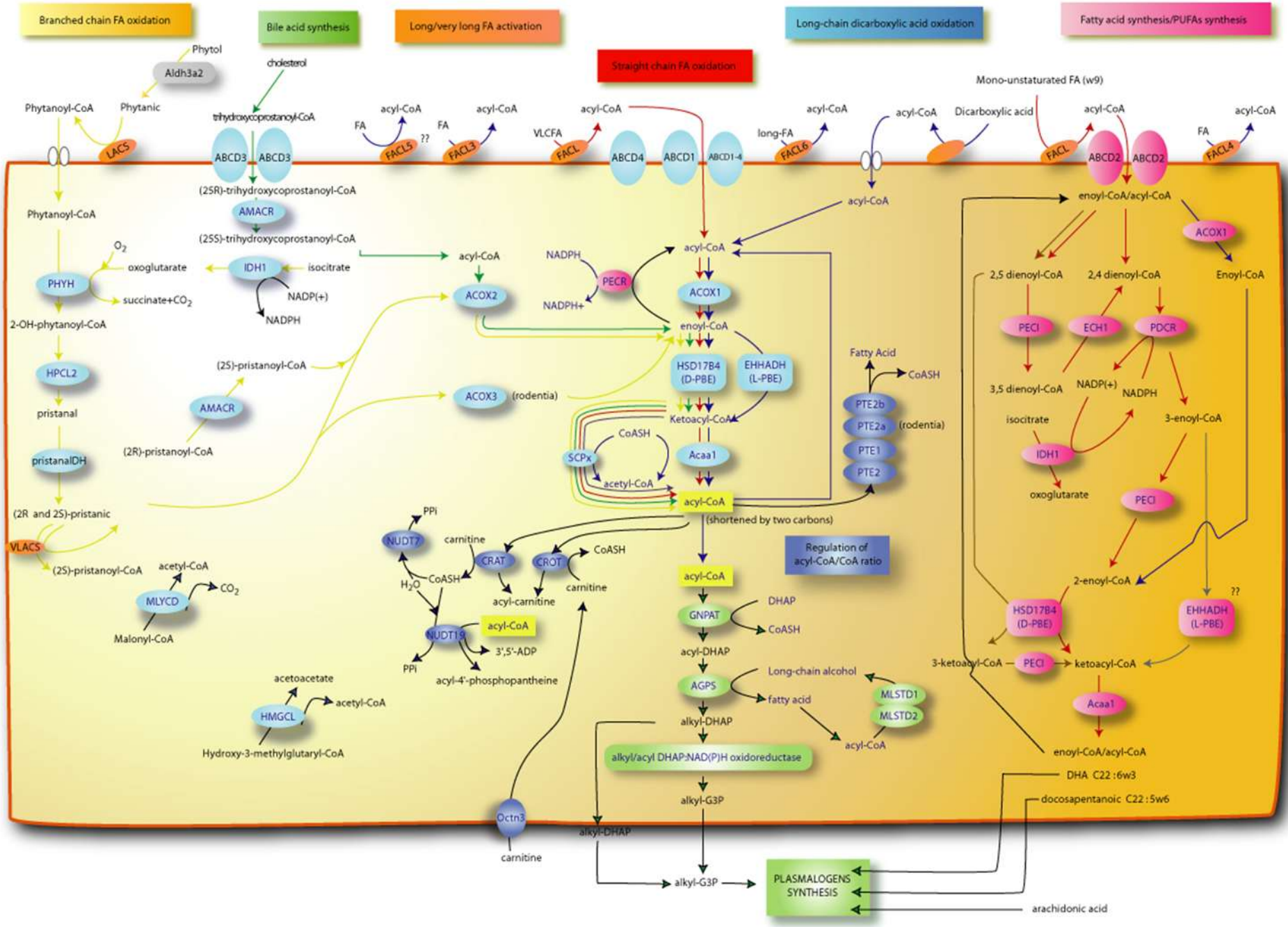

Branched chain FA oxidation
Bile acid synthesis
Long/very long FA activation
Straight chain FA oxidation
Long-chain dicarboxylic acid oxidation
Fatty acid synthesis/PUFAs synthesis
Phytol
Aldh3a2
Phytanic
Phytanoyl-CoA
LACS
cholesterol
trihydroxycoprostanoyl-CoA
ABCD3
ABCD3
(2SR)-trihydroxycoprostanoyl-CoA
AMACR
(2SS)-trihydroxycoprostanoyl-CoA
FA
acyl-CoA
FACL5
??
FACL3
VLCFA
FACL
ABCD4
ABCD1
ABCD1-4
long-FA
FACL6
Dicarboxylic acid
Mono-unstaturated FA (w9)
ABCD2
ABCD2
FACL4
Phytanoyl-CoA
PHYH
O2
oxoglutarate
succinate+CO2
2-OH-phytanoyl-CoA
HPCL2
pristanal
pristanalDH
(2R and 2S)-pristanic
VLACS
(2S)-pristanoyl-CoA
(2R)-pristanoyl-CoA
IDH1
isocitrate
NADP(+)
NADPH
ACOX2
ACOX3
(rodentia)
NADPH
NADPH+
PECR
enoyl-CoA
HSD17B4
(D-PBE)
EHHADH
(L-PBE)
Ketoacyl-CoA
SCPx
CoASH
Acaa1
acetyl-CoA
Fatty Acid
CoASH
PTE2b
PTE2a
(rodentia)
PTE1
PTE2
(shortened by two carbons)
Regulation of acyl-CoA/CoA ratio
PPi
NUDT7
carnitine
CRAT
CROT
CoASH
H2O
acyl-carnitine
carnitine
NUDT19
3',5'-ADP
PPi
acyl-4'-phosphopantheine
acetyl-CoA
MLYCD
CO2
Malonyl-CoA
acetoacetate
HMGCL
acetyl-CoA
Hydroxy-3-methylglutaryl-CoA
GNPAT
DHAP
CoASH
acyl-DHAP
AGPS
Long-chain alcohol
fatty acid
alkyl-DHAP
MLSTD1
MLSTD2
alkyl/acyl DHAP:NAD(P)H oxidoreductase
alkyl-G3P
Octn3
carnitine
alkyl-DHAP
alkyl-G3P
PLASMALOGENS SYNTHESIS
arachidonic acid
enoyl-CoA/acyl-CoA
ACOX1
2,5 dienoyl-CoA
2,4 dienoyl-CoA
Enoyl-CoA
PECI
ECH1
PDCR
3,5 dienoyl-CoA
NADP(+)
NADPH
isocitrate
IDH1
oxoglutarate
3-enoyl-CoA
PECI
2-enoyl-CoA
HSD17B4
(D-PBE)
EHHADH
(L-PBE)
??
3-ketoacyl-CoA
PECI
ketoacyl-CoA
Acaa1
enoyl-CoA/acyl-CoA
DHA C22:6w3
docosapentanoic C22:5w6

FACTORS AFFECTING OXIDATION PROCESSES

Singlet oxygen $^1O_2$

Temperature and Light

Water activity

Metal ions

iron copper, zinc, heavy metals

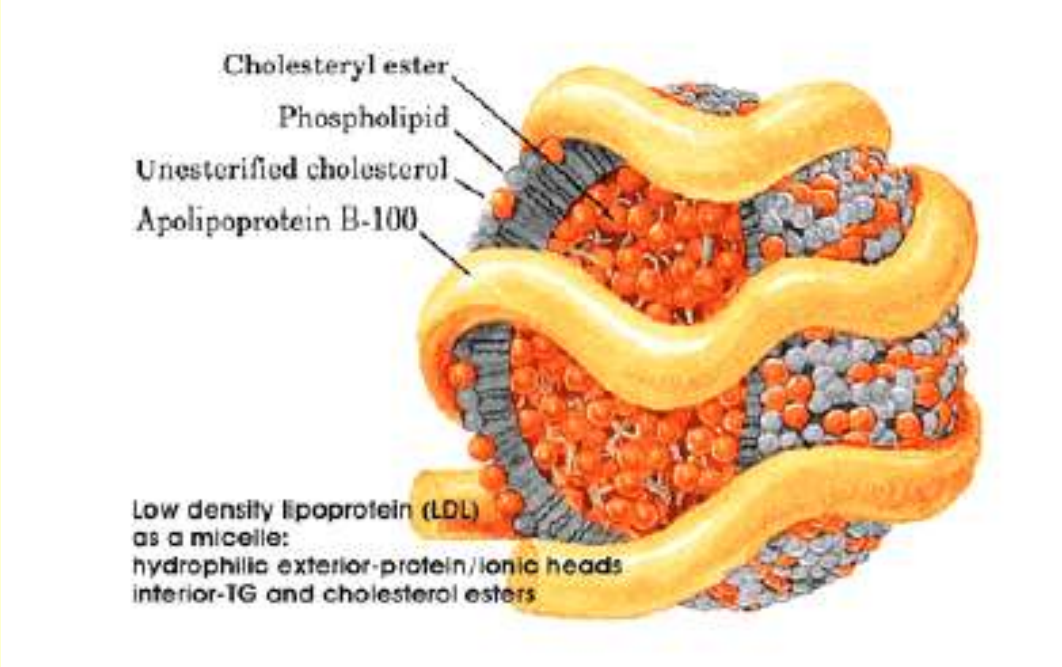
Animal's breed and species

Animal's diet

Muscle types and anatomical location

Preservative and processing techniques

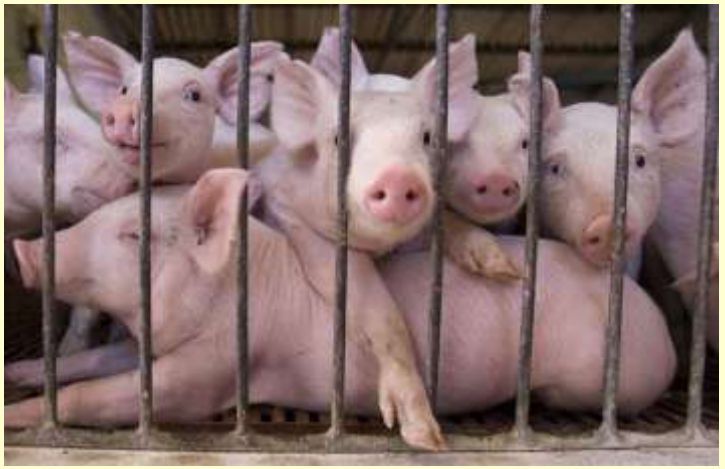
chilling, freezing, additives, cooking, irradiation, high pressure, packaging



Oxidative stress

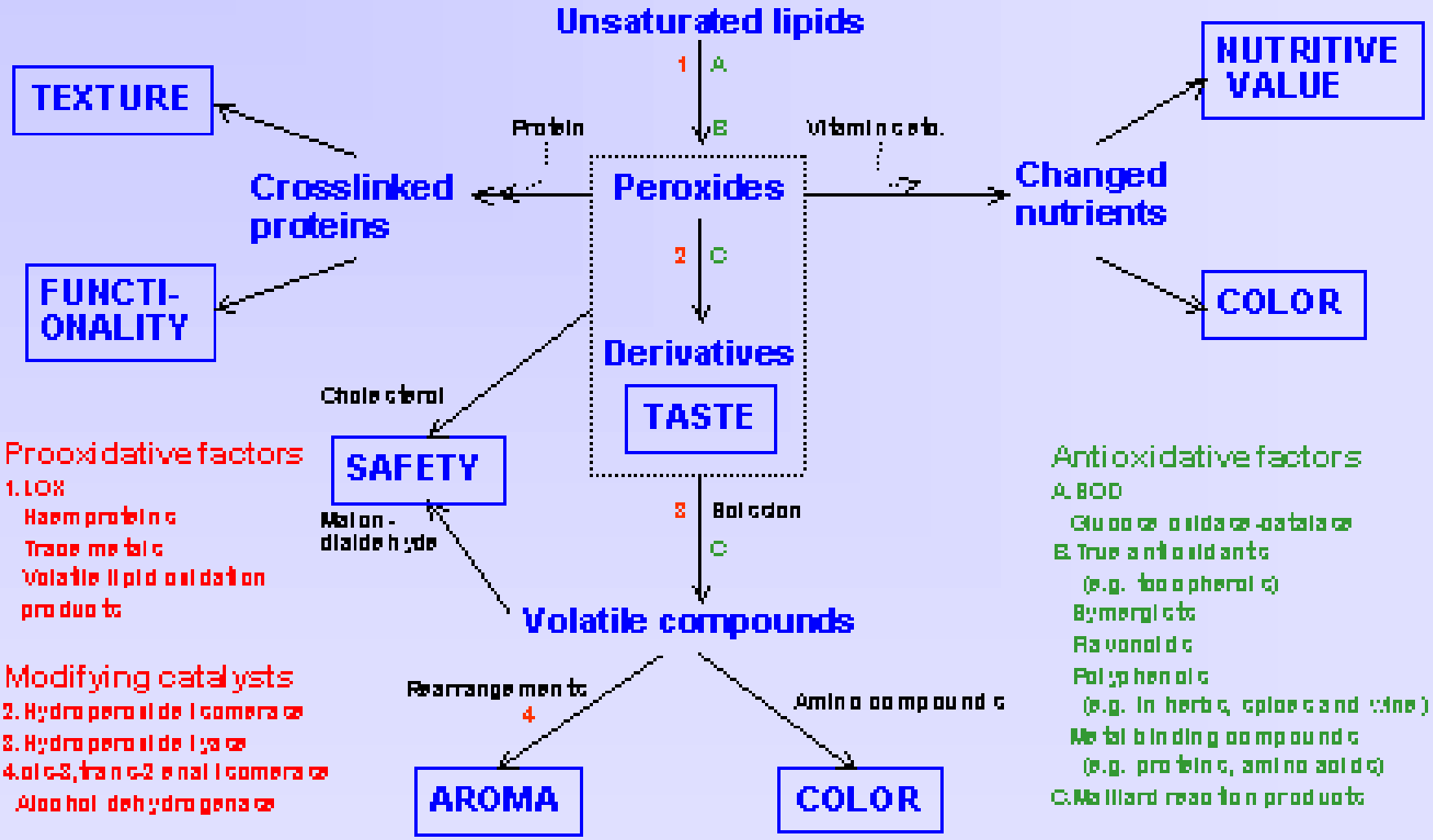
may occur due to succession of stimuli that disrupt the homeostatic condition of an animal before slaughter.

- transport, poor road conditions,
- rough handling during slaughter,
- loading or unloading,
- over-speeding and vibration of the vehicle,
- distance covered from farm to the abattoir,
- overcrowding in the vehicle,
- deprivation of food and water,
- mixing of animals with unfamiliar ones,
- aggressive behaviour,
- stunning,
- poor or high air velocity,
- harsh ambient temperature,
- relative humidity,
- lightning, and sound.




Excessive FREE RADICALS will cause the following:
Diabetes
Insomnia
Cancer
Cholesterol
Gout
Accelerated Aging
Asthma
Allergies
Uric Acid
Arthritis
Kidney Failure
ANTIOXIDANT HOT BED THERAPY
can help and prevent symtoms shown above
ecoparadise

Lipid Oxidation and Food Quality

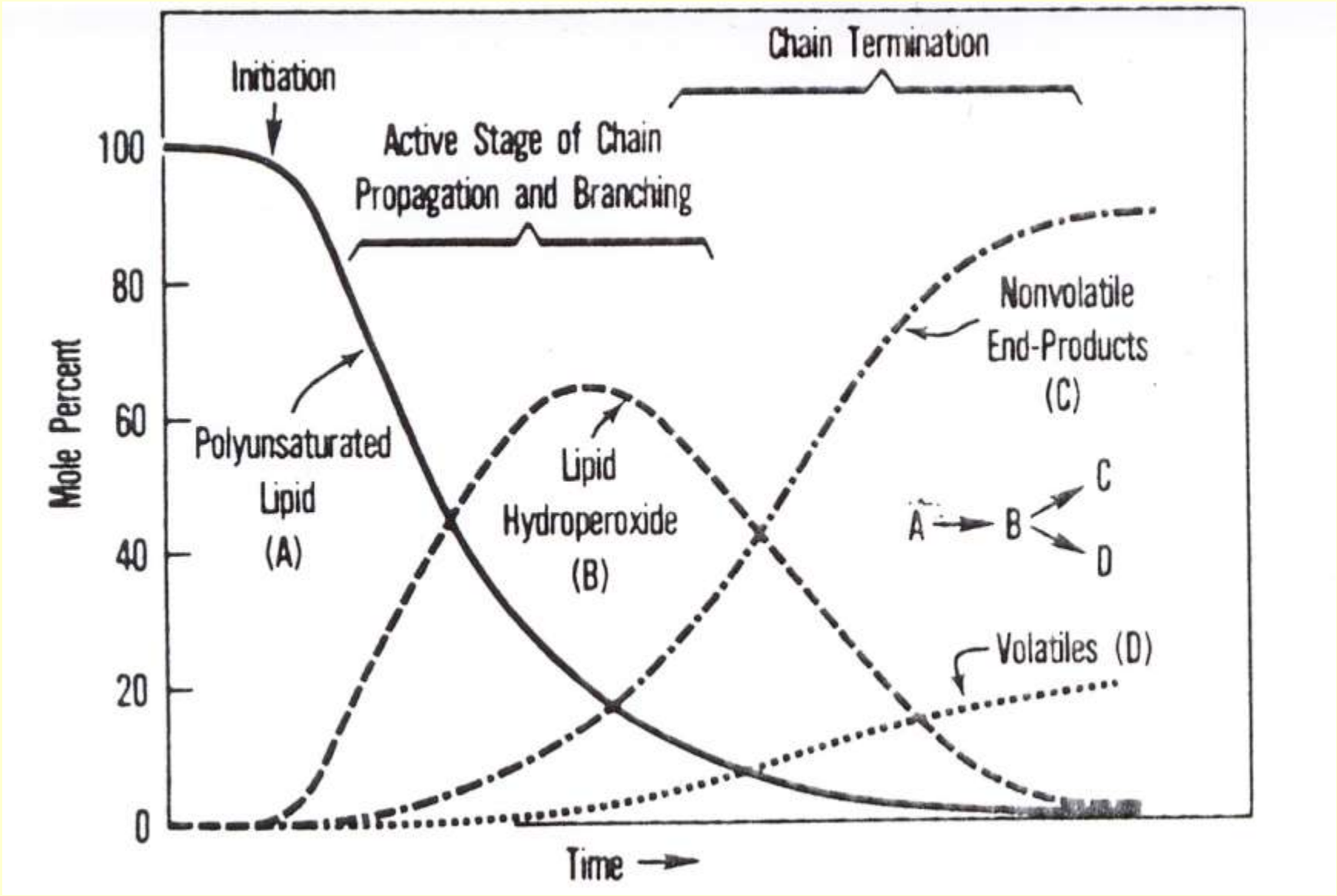


(Erikson, 1982)

Effects of oxidative stress and oxidation on meat quality

- functional and/or structural damage to muscle organelles, cells and tissues,
- degenerative damage of cellular structure of myofibrillar proteins during meat maturation and storage,
- meat defects,
- inconsistent meat tenderness,
- reduced collagen synthesis in the muscle, decreased collagen solubility and increased meat toughness,
- extended lipid and protein oxidation,
- loss of nutritional value (proteins, lipids, vitamins),
- loss of functionality,
- higher drip loss and lower water holding capacity,
- darker color (polymerisation) or discoloration (pigments oxidation)
- rancid/off flavor/WOF formation,
- decreased shelf life.

Monitoring of oxidation processes



Antioxidants

Substances that delay the onset of, or slow down the rate of oxidation.

Antioxidants are molecules, which can safely interact with free radicals and terminate the chain reaction before vital molecules are damaged (as in vitamin C), or seek out and scavenge free radicals (as in vitamin E).

„Antioxidant is every substance, which present in a low concentration in comparison with the oxidized substance, delays or inhibits significantly oxidation of this substance” (Halliwell & Gutteridge, 1995).

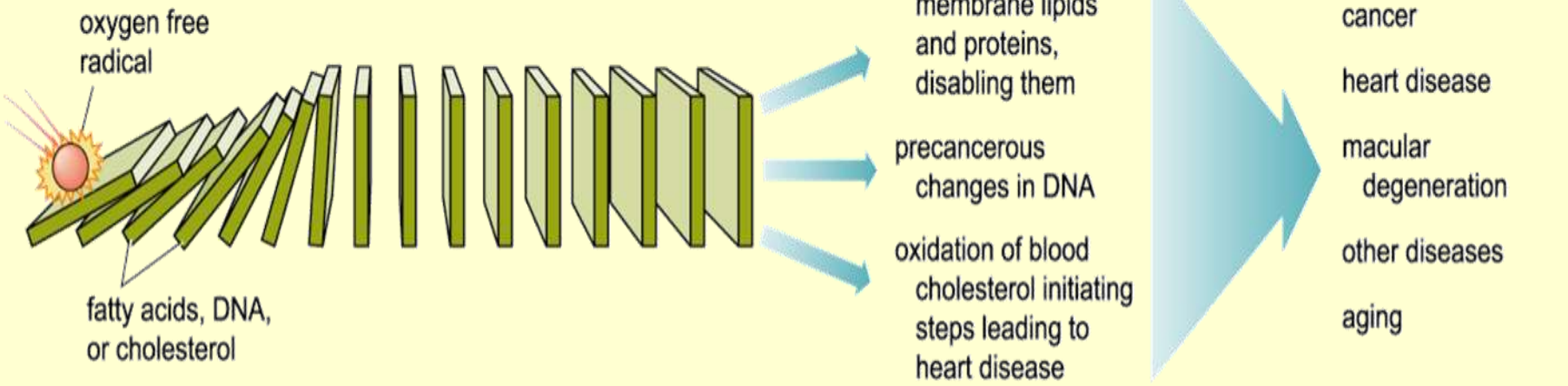
Antioxidants are compounds added to food, which are used to delay free radicals accumulation and hence strengthen its oxidative stability (Giese, 1996; Halliwell, 1995).

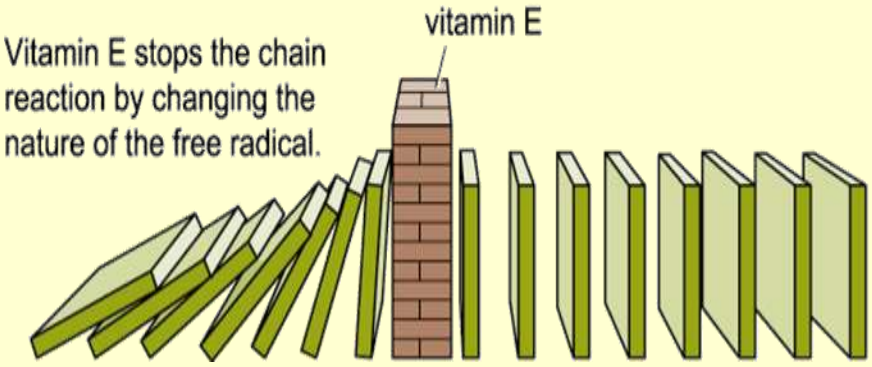
1. A chemically reactive oxygen free radical attacks fatty acid, DNA, protein, or cholesterol molecules forming other free radicals.

2. This initiates a rapid, destructive chain reaction.

3. The result is injury to tissues and the formation of more free radicals:

4. And ultimately, diseases and tissue aging:





Actions against meat components oxidation:

- ✓ Obtaining of raw material with high antioxidative potential;
- ✓ Modification of meat products composition, also by adding antioxidants;
- ✓ Optimisation of meat products processing parameters, protection of lipids;
- ✓ Optimisation of the storage conditions for fresh meat and meat products.

Antioxidants

1. primary antioxidants or donors - action depends on inactivation of peroxides by quenching free radicals of fatty acids, the antioxidant hydrogen interrupting the reaction sequence; simultaneously the antioxidant loses its activity (phenolic compounds, tocopherols);

2. secondary antioxidants or the acceptors, which protect lipids by binding air oxygen or, which delay lipid oxidation in the result of processes different from breaking of autoxidation chain reactions.

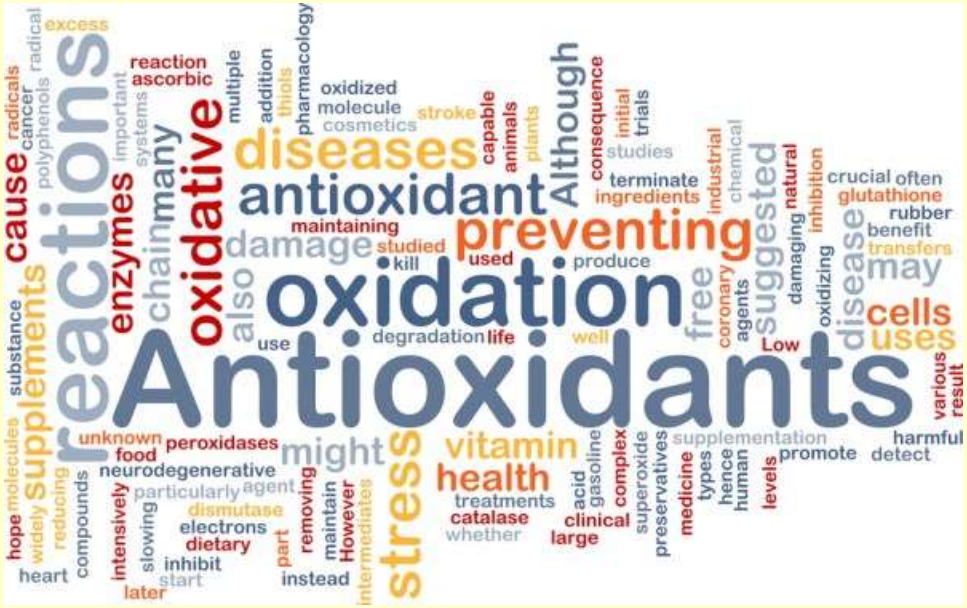
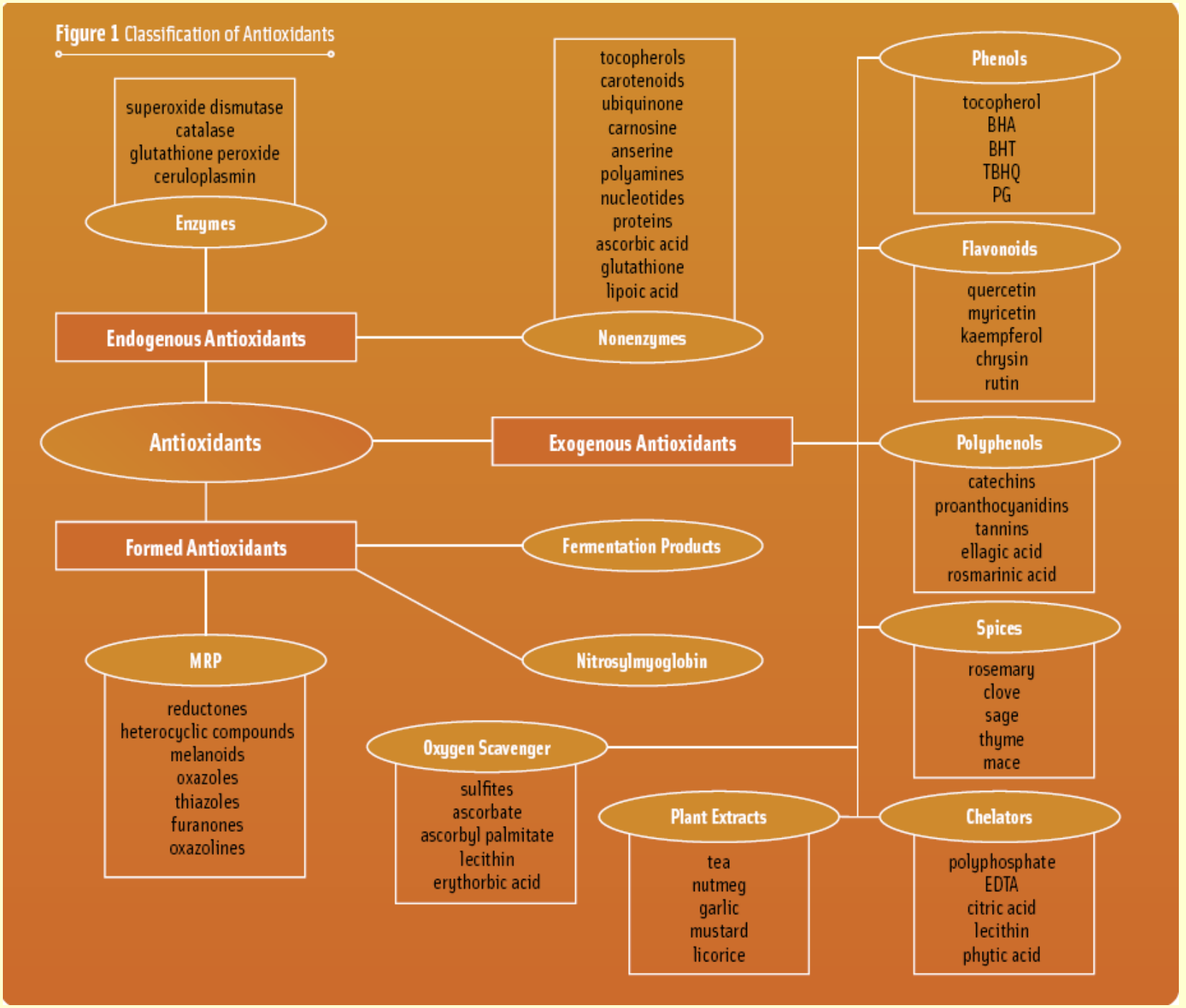
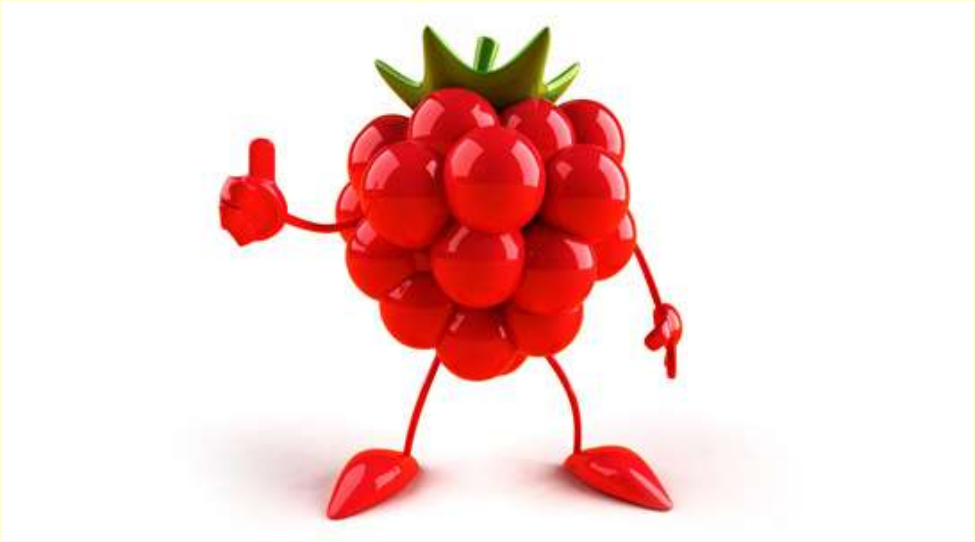


Figure 1 Classification of Antioxidants



They can act by means of:

a. complexing metal ions catalyzing autoxidation-chelators (ascorbic acid);
b. creating protective layer between oil and air surface (phospholipids);
c. partial regenerating of primarily antioxidants (ascorbic acid and thiol substances regenerating the vitamin E);
d. scavenging oxygen (ascorbic acid);
e. decomposing peroxides and nonradical products (Maillard reaction products);
f. absorbing UV radiation;
g. quenching singlet oxygen (β-carotene).



Ideal antioxidants

1. **No harmful physiological effects**

- **Pathological effect**
- **Carcinogenic potential**
- **Interactions with enzymes**
- **Effects of reproduction**
- **Nature of the metabolism rate in man**

2. No objectionable flavour, odour, colour

3. Effective in low concentration

4. Fat soluble

5. Carry-through effect

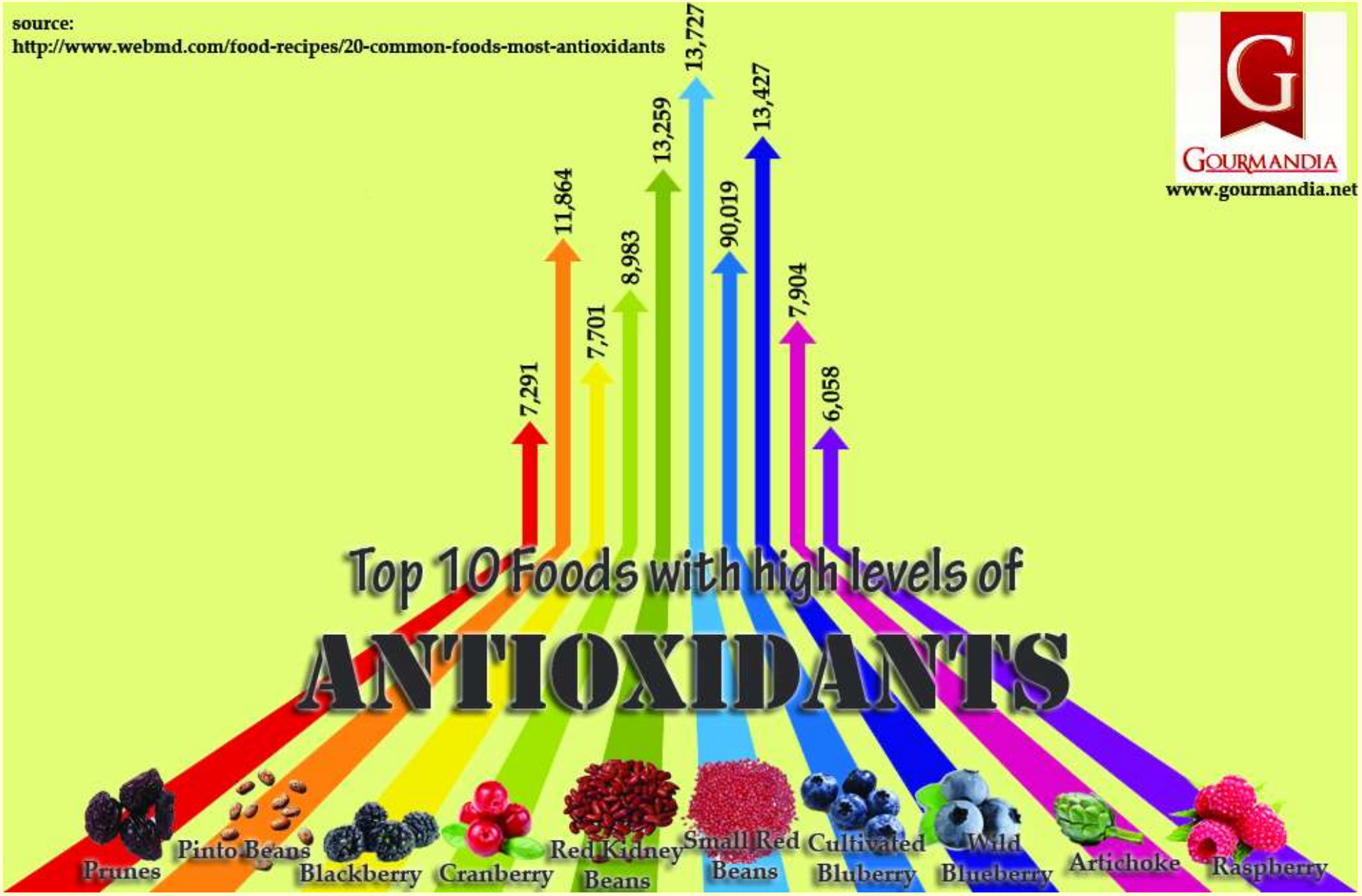
6. Readily available

7. Economical

8. Not absorable by the body

source:
http://www.webmd.com/food-recipes/20-common-foods-most-antioxidants

GOURMANDIA
www.gourmandia.net



Sources of antioxidants

Allium sulphur compounds - leeks, onions and garlic.
Anthocyanins - eggplant, grapes and berries.
Beta-carotene - pumpkin, mangoes, apricots, carrots, spinach.
Catechins - red wine and tea.
Copper - seafood, lean meat, milk and nuts.
Cryptoxanthins - red capsicum, pumpkin and mangoes.
Flavonoids - tea, green tea, citrus fruits, red wine, onion and apples.
Indoles - cruciferous vegetables such as broccoli, cabbage.
Isoflavonoids - soybeans, tofu, lentils, peas and milk.
Lignans - sesame seeds, bran, whole grains and vegetables.
Lutein - leafy greens like spinach, and corn.
Lycopene - tomatoes, pink grapefruit and watermelon.
Manganese - seafood, lean meat, milk and nuts.
Polyphenols - thyme and oregano.
Selenium - seafood, offal, lean meat and whole grains.
Vitamin C - oranges, blackcurrants, kiwi, spinach, and strawberries.
Vitamin E - vegetable oils, avocados, nuts, seeds and whole grains.
Zinc - seafood, lean meat, milk and nuts.
Zoochemicals - red meat, offal and fish.

The disease-fighting antioxidants

A diet high in antioxidants may reduce the risk of many diseases, including heart disease and certain cancers.

Antioxidants scavenge the free radicals from the body cells, and prevent or reduce the damage caused by oxidation.

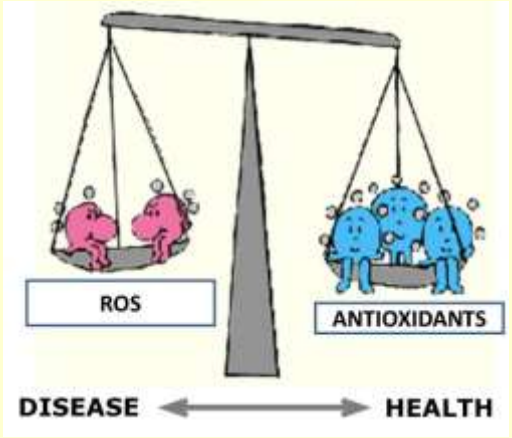
Men who eat plenty of tomatoes contining lycopene may be less likely than other men to develop prostate cancer.

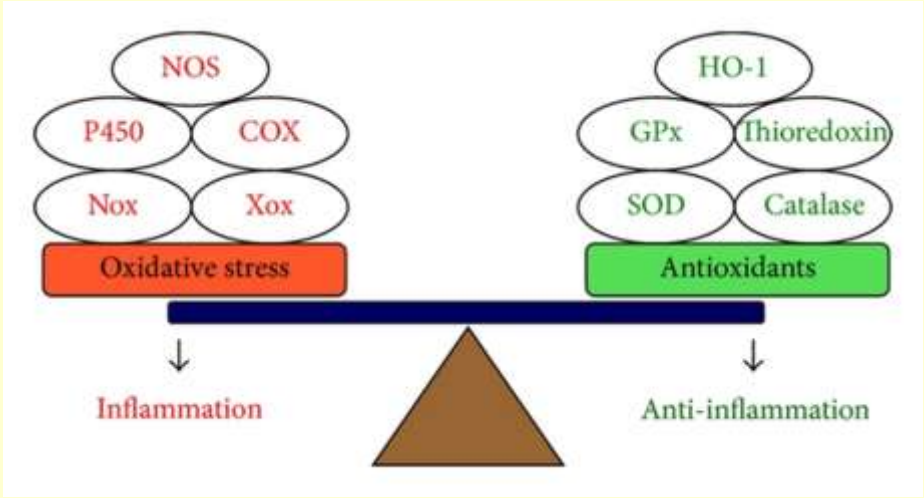
Lutein, found in spinach and corn, has been linked to a lower incidence of eye lens degeneration and associated blindness in the elderly.

Flavonoids, such as the tea catechins found in green tea, are believed to contribute to the low rates of heart disease in Japan.

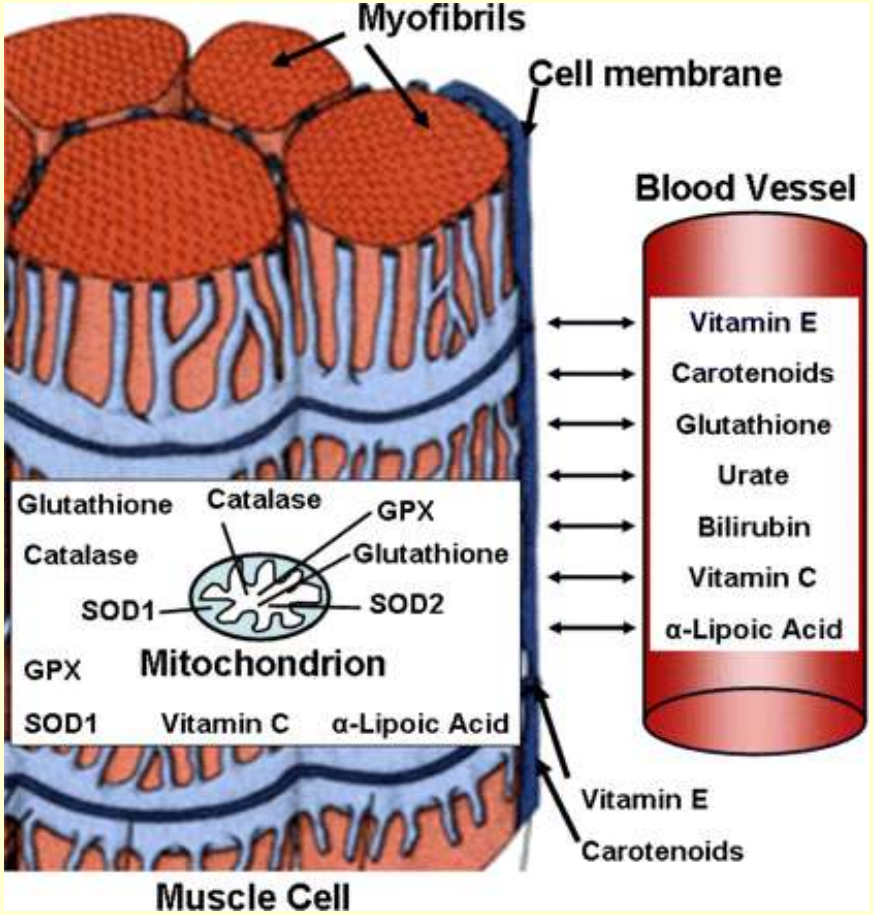
Mechanisms of defense against reactive oxygen species in meat:

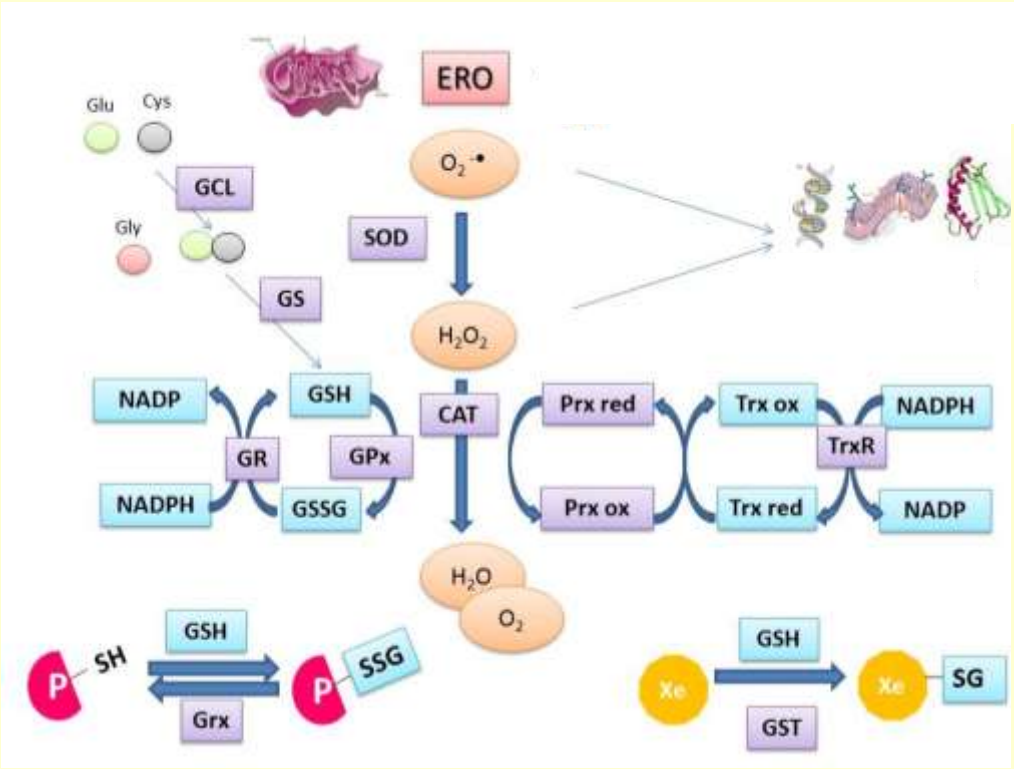
- antioxidant enzymes - glutathione peroxidase, catalase and superoxide dismutase,
- proteins and peptides able to bind prooxidative transition metal ions - carnosine, proteins with high content of thiol (cysteine) and hydroxyl (tyrosine) aminoacids ,
- hydrophilic and hydrophobic low molecular weight antioxidants that disrupt free radical chain reactions - glutathione, adenine derivatives (xantin, hipoxantin, uric acid), vitamin E, carotenoids, ubichinone (coenzyme Q),
- enzymatic system responsible for the repair or elimination of damaged macromolecules (lipids, proteins, DNA).





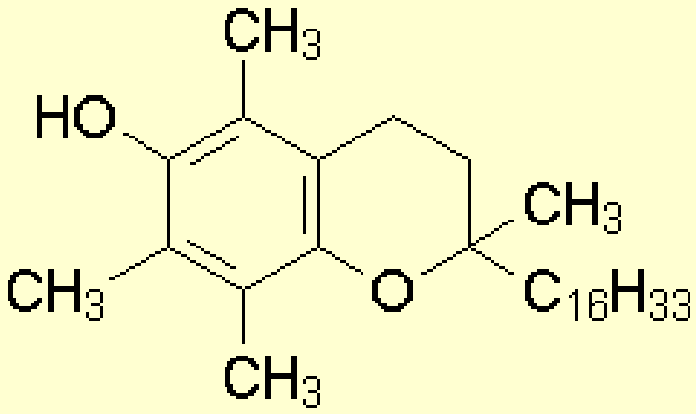
superoxide dismutase, glutathione peroxidase, catalase peroxiredoxin, glutaredoxin and thioredoxin reductase





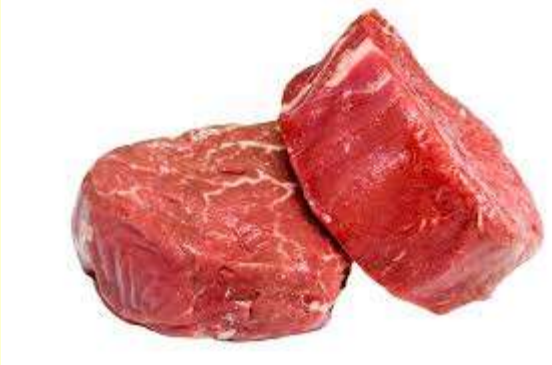
Tocopherols and tocotrienols

- vitamin E is one of the most widely distributed antioxidants in nature,
- it is the primary chain-breaking antioxidant in cell membranes,
- at least eight structural isomers are known; d-α-, d-β-, d-γ-, d-δ-tocopherols and d-α-, d-β-, d-γ-, d-δ-tocotrienols,
- α-tocopherol is the best known and possesses the highest antioxidant activity as a free radical scavenger,
- ability to regulate gene expression of proteins in cells,
- cumulated in fat tissue and liver cells,
- protect LDL, elevate HDL level, decrease total cholesterol level, decrease blood pressure.

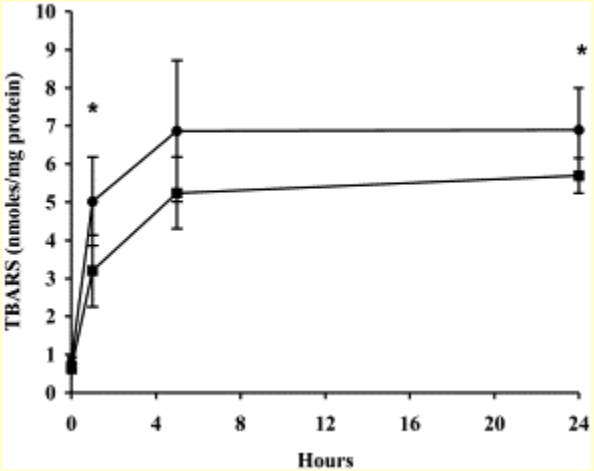


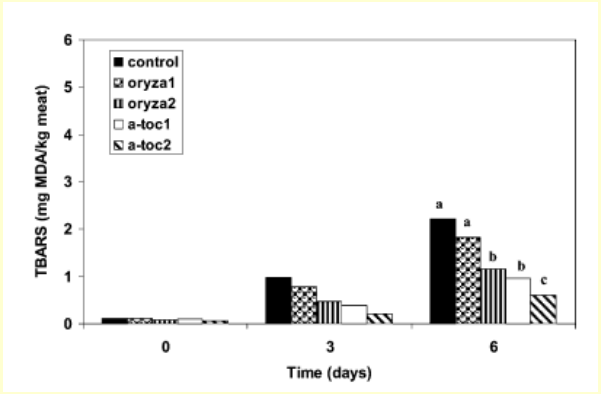
- **Improve oxidative stability of lipids and proteins in fresh and stored meat,**
- **Enhance total antioxidavite potential of meat, GSH, SOD**
- **Limit formation of methmioglobin, improve red color of meat**

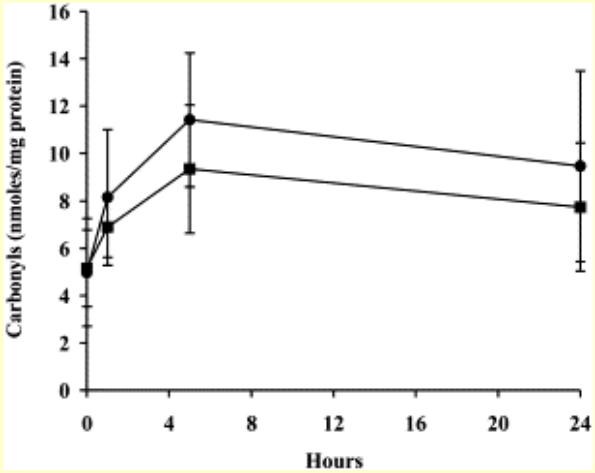
Ho et. al., (2008), Insani et al. (2007), Nam et. al., (2007), Walshe et. al., (2006), Descalzo et al. (2005), Dunne et. al., (2005), Lanari et. al., (2004), Mercier et. al., (2004), Realini et al. (2004), Sampels et. al., (2004), Botsoglou et. al., (2003), Nam et. al., (2003), Channon et. al., (2002), Djenane et. al., (2002), Okabe et. al., (2002), O'Sullivan et. al., (2002), Yang et al. (2002), Harris et. al., (2001), Malczyk, (2001), O'Grady et. al., (2001), Dineen et. al., (2000), Eikelenboom et. al., (2000), Houben et. al., (2000), Lynch et. al., (2000), Lynch et. al., (1999), Malczyk et. al., (1999), Formanek, et. al. (1998), Hamre et. al., (1998) Higgins et. al., (1998), Maraschiello et. al., (1998), Walsh et. al., (1998) Jensen et. al., (1997)



Animal feed tocopherol supplementation

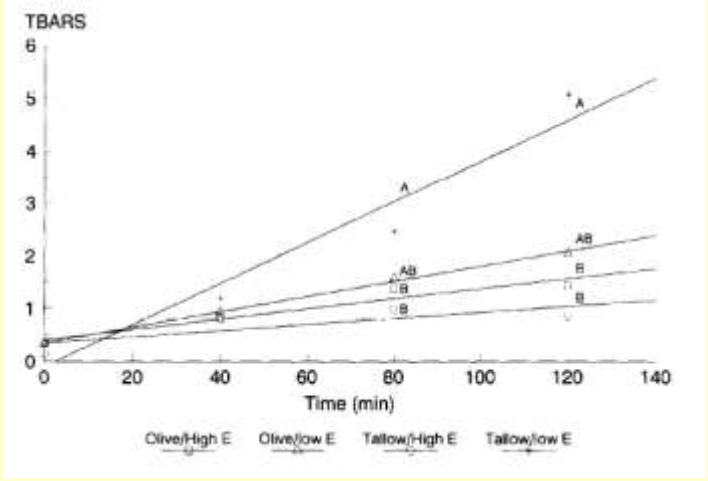


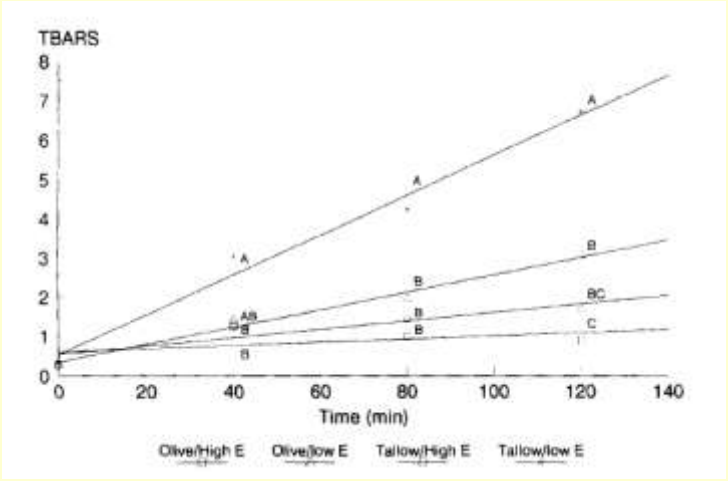




Batifoulier F., Mercier Y., Gatellier P., Renerre M. 2002. **Influence of vitamin E on lipid and protein oxidation induced by H_2O_2-activated MetMb in microsomal membranes from turkey muscle.** Meat Sci., 61, 389-395.

Lanari M. C., Hewavitharana A.K., Becu C., de Jong S. 2004. **Effect of dietary tocopherols and tocotrienols on the antioxidant status and lipid stability of chicken.** Meat Sci., 68, 155-162.

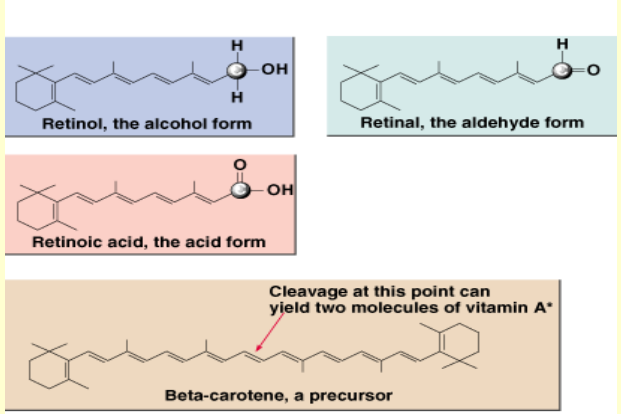




Lauridsen C., Buckley D.J., Morrissey P.A. 1997. **Influence of dietary fat and vitamin E supplementation on α-tocopherol levels and fatty acid profiles in chicken muscle membranal fractions and on susceptibility to lipid peroxidation.** Meat Sci., 46, 9-22.

Carotenoids

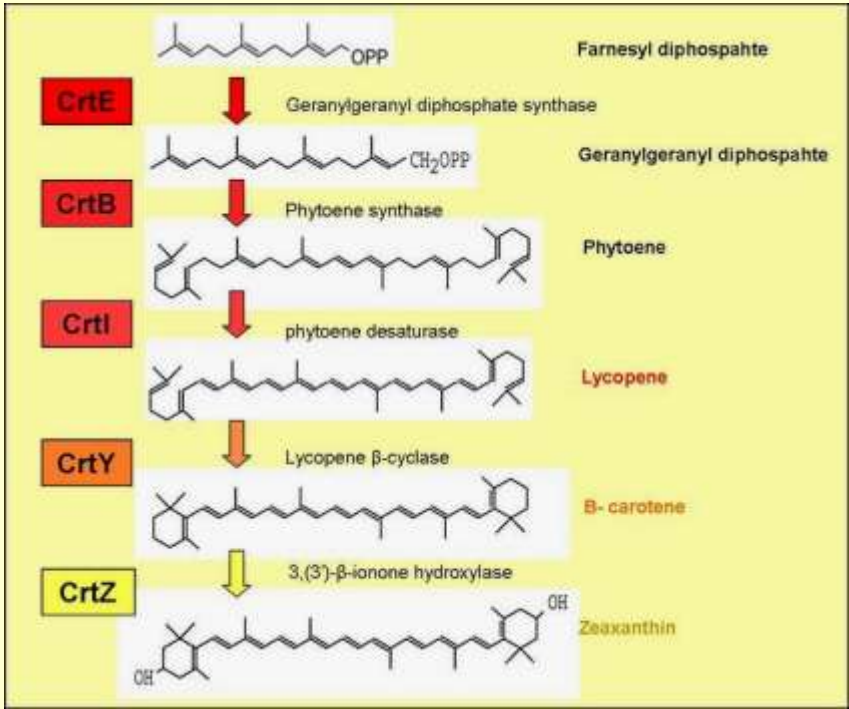
- carotenoids: carotenes e.g., α-, β-carotene, and xanthopils are lipid-soluble antioxidants located in the tissue membranes, fats and blood lipoproteins (HDL and LDL),
- natural pigments app. 600, and synthetic app. 200,
- xanthophylls, carotene and lycopene are responsible for yellow, orange and red coloring, respectively,
- structural arrangement of long chains of conjugated double bonds permits the scavenging of ROS,
- remove singlet oxygen, break the oxidation chain reaction,
- β-caroten inhibits lipids peroxidation only at small oxygen concentration,
- in organism transferred to retinol, essential to proper growth and cell differentiation,
- synergistic antioxidative effect with vitamin E via tocopherol radical regenreration.



Carotenoids

rainbow trout 6-25 mg/kg
salmon 7.5 mg/kg
astaxanthin in wild salmon 3.1 and 8.1 mg/kg

retinol beef from 0.03 µg/g (beef top round) to 0.22 µg/ g (beef brisket
total β-carotene beef 0.22-0.34 µg/g
β-carotene beef liver 8.7 µ/g and blood 2.7 µ/g
pork liver 540 µg
retinol in pork 0.09-0.23 µg/g
mutton, reindeer, venison,
and poultry contained mainly retinoids



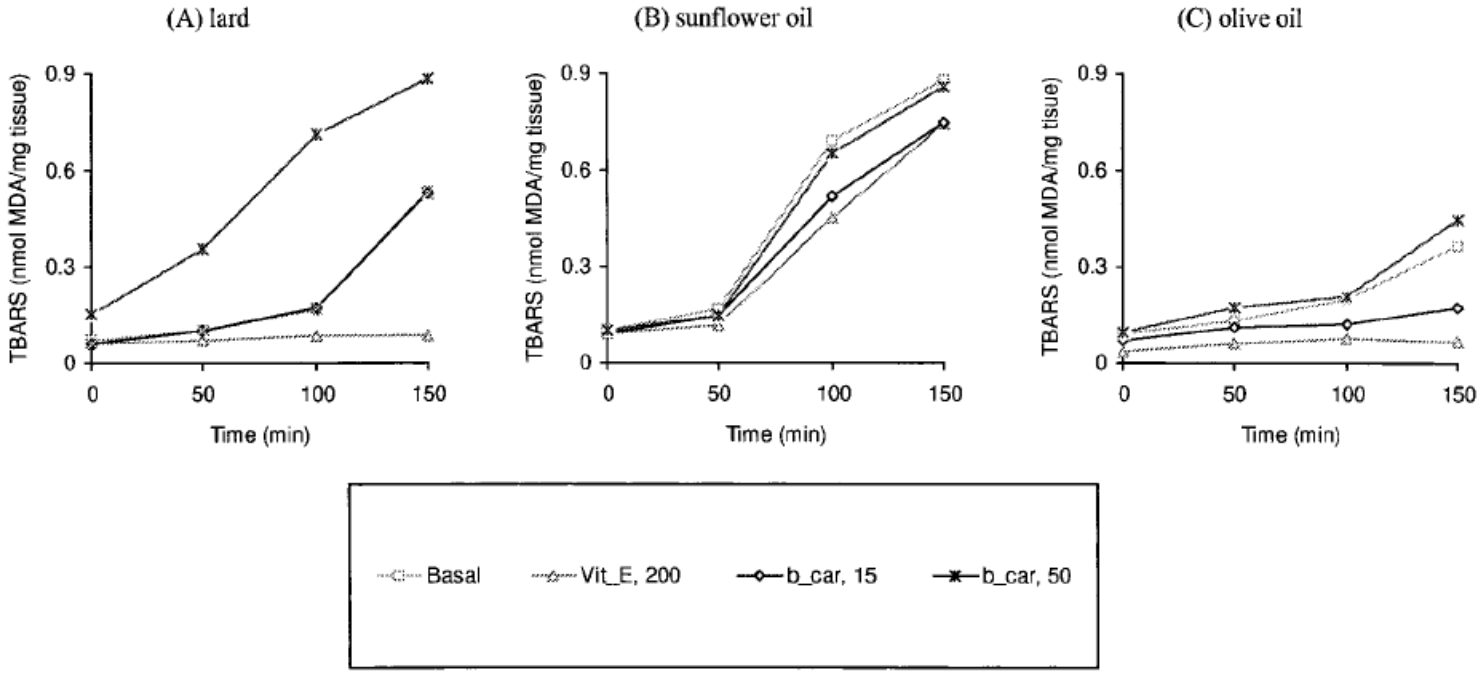
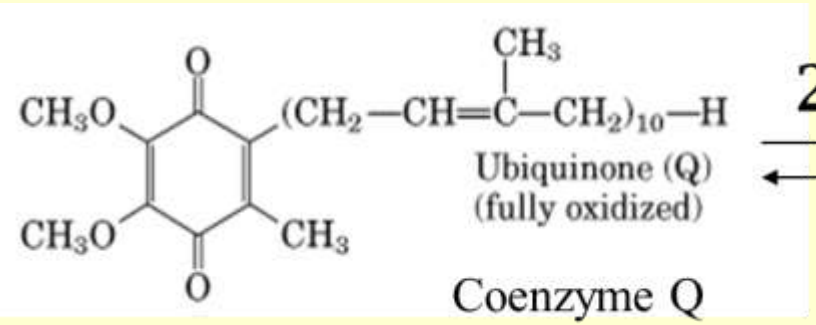


Figure 1. Iron-induced TBARS values in raw meat from broiler chickens fed diets supplemented with (A) lard, (B) SO, and (C) OO.

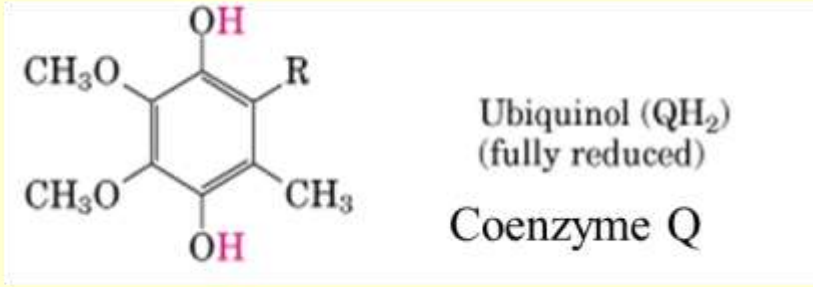
Ruiz J.A., Prez-Vendrell A.M., Esteve-Garca E. 1999. **Effect of β-carotene and vitamin E on oxidative stability in leg meat of broilers fed different supplemental fats.** *J. Agric. Food Chem*., 47, 448-454.

Conenzyme Q10 (ubiquinone)

- is synthesized in cells, is essential in mitochondrial electron transport and is also located in cell membranes,
- the only hydrophobic antioxidant located mainly in skeletal muscles and blood lipoproteins,
- can exist in three oxidation states: fully reduced ubiquinol ($CoQ_{10}H_2$), radical semiquinone intermediate ($CoQ_{10}H\cdot$), and fully oxidized ubiquinone (CoQ_{10}).
- in vitro it can function as a non-enzymatic antioxidant by scavenging ROS,· radicals and inhibiting lipid peroxidation.
- in vivio the impact of coenzyme Q10 to antioxidant defense remains uncertain.



$2H^+ + 2e$



Coenzyme Q

Can express prooxidative properties

2 mg/100 g beef and sheep meat

4.3 mg/100 g mackerel

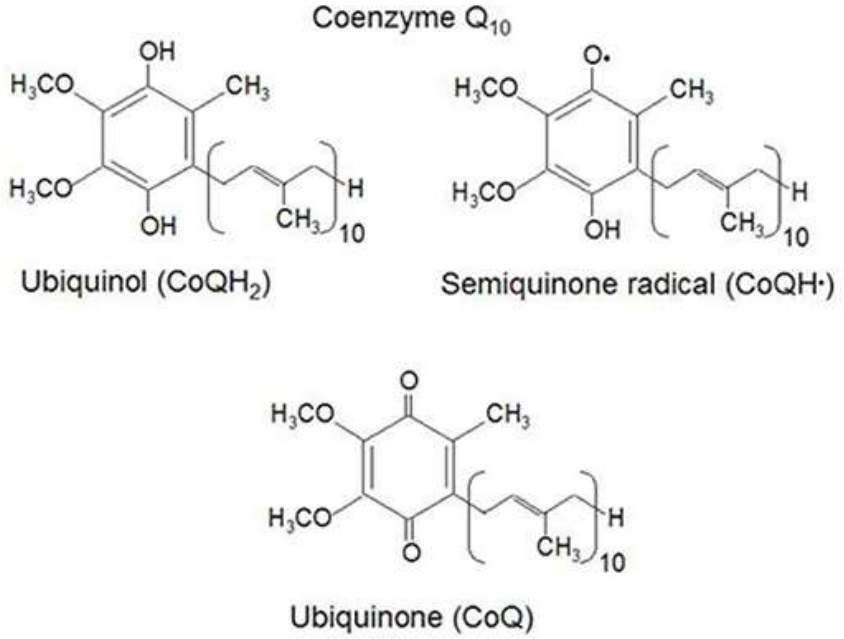
6.4 mg/100 g sardine

0.4 mg/100 g salmon

12.5 mg/100 g chicken heart

1.8 mg/100 g chicken meat

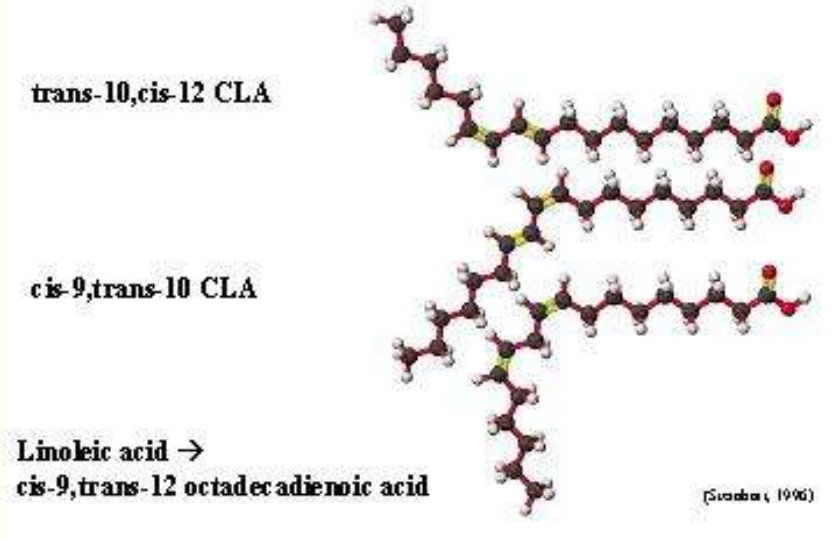
Figure 1. Chemical Structure of Coenzyme Q_{10}



Coenzyme Q can exist in three oxidation states: the fully reduced ubiquinol form ($CoQH_2$), the radical semiquinone intermediate ($CoQH\cdot$), and the fully oxidized ubiquinone form (CoQ).

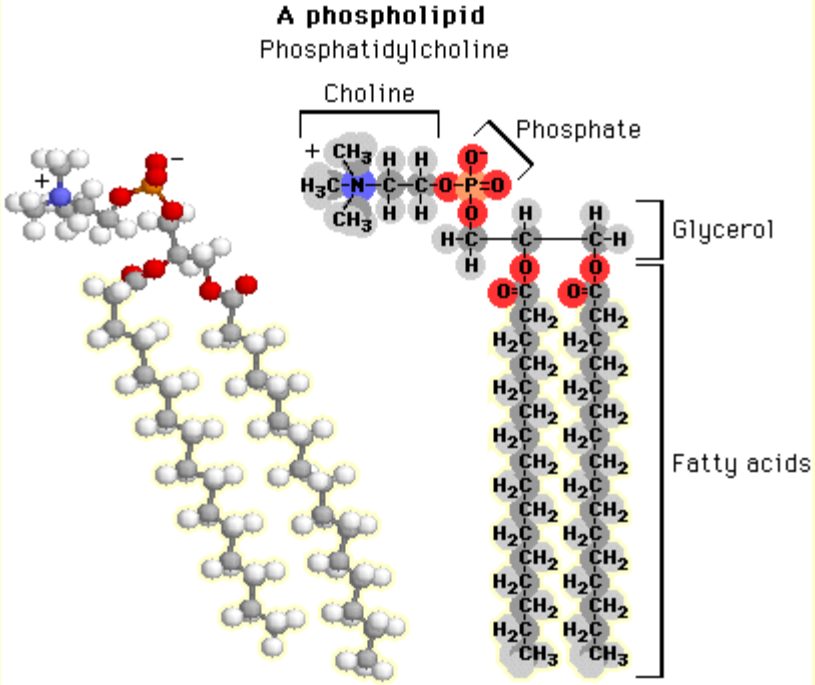
Conjugated linoleic acid (CLA)

- family of at least 28 isomers of linoleic acid,
- has antioxidant and immunomodulatory properties,
- may play a role in the control of obesity,
- in rumen bacteria convert linoleic acid to CLA, abundant in the fat of ruminant animals,
- reduced catabolism and inflammation,
- content of meat is affected by breed, age and feed composition,
- mostly present in the fat component of red meat app. **1 g/100 g**,
- in the red muscle **10-46 mg/100 g** in raw meat and **30-100 mg/100 g** in cooked red meat
- in white muscle 1.1-2.3.



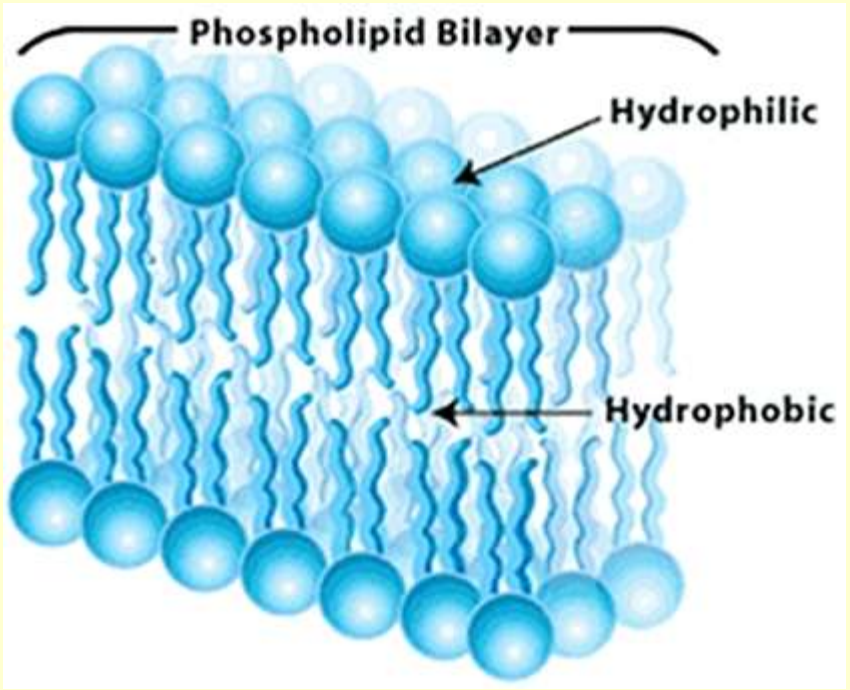
Phospholipids

- are phosphorus-containing lipids, phosphoglycerides and sphingolipids,
- phosphatidyl choline (lecitin), phosphatidyl ethanolamine (cephalin), phosphatidyl serine, phosphatidyl inositol, sphingomyelin, lysophosphatidylcholine, cardiolipin (diphosphatidyl glycerol)
- phospholipids are more polar than the other lipid classes,
- usually richer in the polyunsaturated fatty acids than the neutral lipids



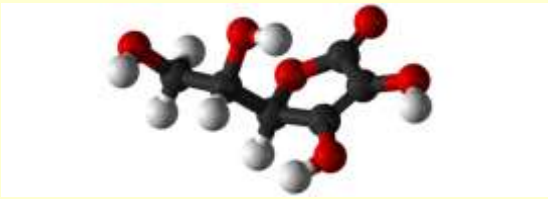
Phospholipids

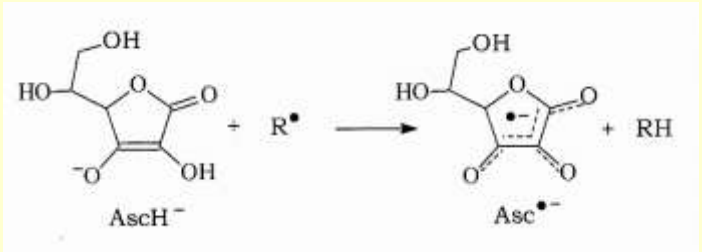
- important for function and structure of biomembranes,
- antioxidant effect is contradictory,
- have function as synergists and metal chelators and may also bring about decomposition of hydroperoxides,
- secondary antioxidant effects of phospholipids arise from the synergistic activity in mixtures with natural tocopherols and synthetic antioxidants,
- can also act as prooxidant



Ascorbates

- ascorbic acid is hydrophilic and functions better in an aqueous environment,
- widely distributed in mammalian tissues,
- can directly scavenge superoxide, hydroxyl, and lipid hydroperoxide radicals,
- able to chelate metals,
- plays an important role in the recycling of vitamin E,
- slow down lipid oxidation processes,
- enhance effectiveness of natural antioxidants,
- show higher effectiveness in combination with nitrates and phosphates,
- cofactor in hydroxylation reaction during collagen biosynthesis,
- concentration in blood app. 40 μM/1, organs and skin 100-800 μM/1, dark muscle of turkey 9 mg/kg, beef 16 mg/kg, mackarel light muscle 24 mg/kg,
- accelerate the formation of odd flavors and tastes of meat products
- in higher concentration act as prooxidant.

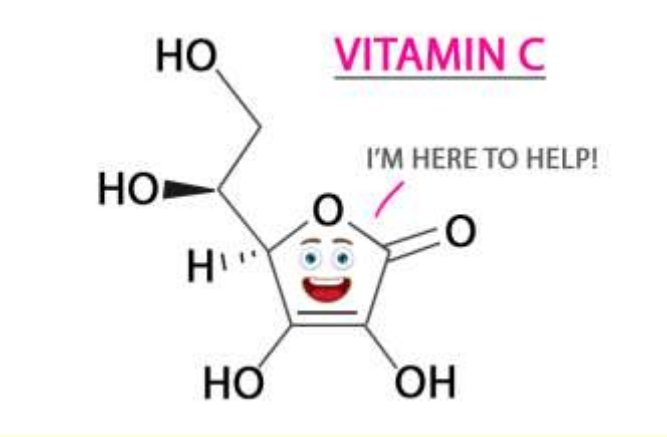




Ascorbate
is able to reduce catalytic metals such as Fe^{3+} and Cu^{2+} to their more catalytically active valence state Fe^{2+} and Cu^{+}

Low concentrations of ascorbate are required for prooxidant conditions, while high concentration is needed for antioxidant conditions

In the presence of ascorbate, catalytic metals will initiate radical chain oxidations, but when ascorbate concentration is high these radical processes will be less significant.



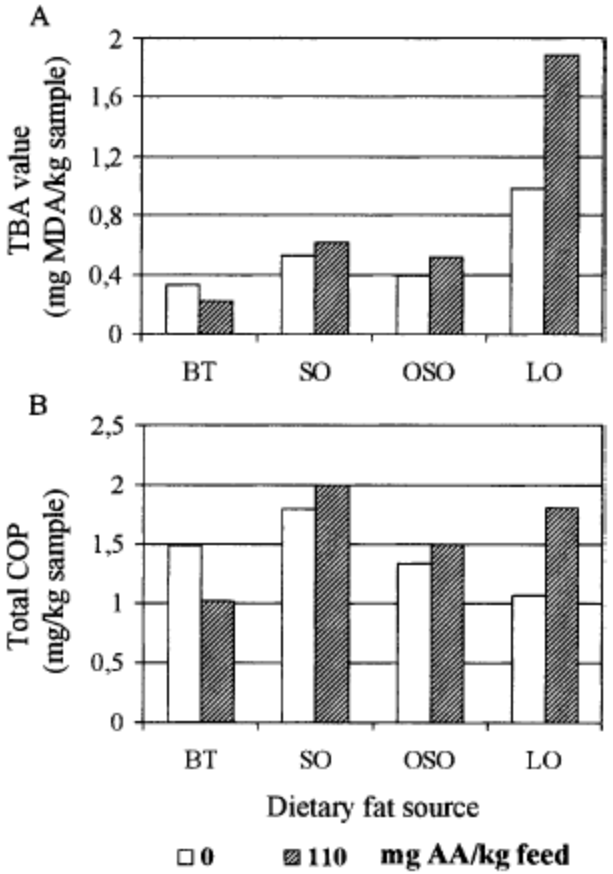


FIGURE 2. TBA values and total COP content of raw dark chicken meat samples stored at –20 C for 7 mo as affected by dietary ascorbic acid (AA) (110 mg/kg) and fat supplementation (6%). BT = beef tallow; COP = cholesterol oxidation products; LO = linseed oil; MDA = malondialdehyde; OSO = oxidized sunflower oil; SO = sunflower oil.

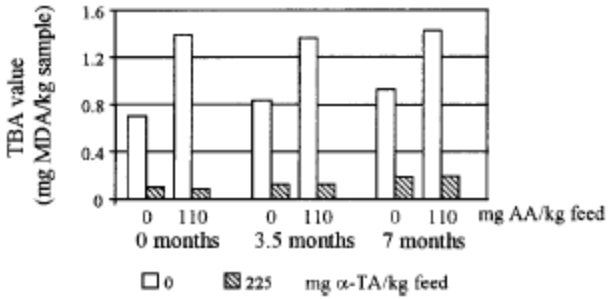


FIGURE 5. TBA values of raw dark chicken meat samples stored at –20 C for 0, 3.5, or 7 mo as affected by dietary ascorbic acid (AA) and α-tocopheryl acetate (α-TA) supplementation (110 and 225 mg/kg of feed, respectively).

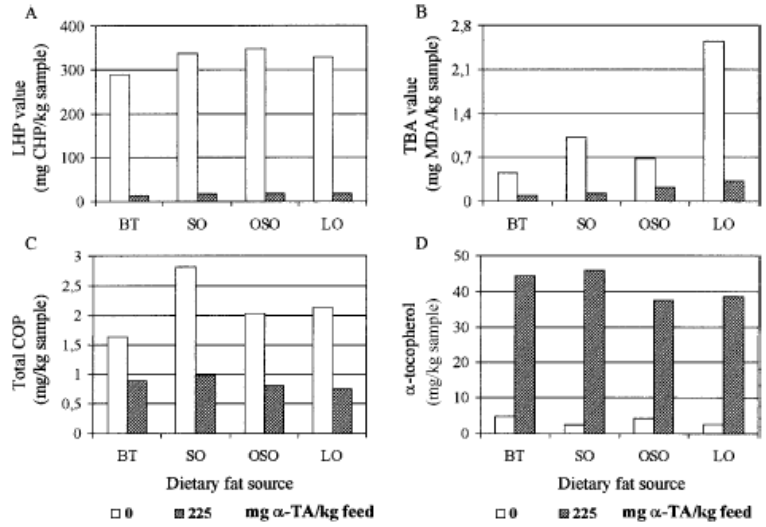


FIGURE 3. Lipid hydroperoxide (LHP) and TBA values and total cholesterol oxidation products (COP) and α-tocopherol content of raw dark chicken meat samples stored at –20 C for 7 mo as affected by dietary α-tocopherol acetate (α-TA) (225 mg/kg) and fat supplementation (6%). BT = beef tallow; CHP = cumene hydroperoxide; LO = linseed oil; MDA = malondialdehyde; OSO = oxidized sunflower oil; SO = sunflower oil.

Grau A., Guardiola F., Grimpa S., Barroeta A.C., Codony R. 2001. **Oxidative stability of dark chicken meat through frozen storage: influence of dietary fat and *α-tocopherol and ascorbic acid supplementation.*** Poultry Sci., 80, 1630-1642.

Glutathione (GSH)

- a tripeptide composed of cysteine, glutamic acid and glycine,
- synthesized in the liver and transported to tissues,
- the most abundant non-protein thiol in cells,
- exists in almost every cell of the body.

Glutathione concentration in cells varies across tissues;
in skeletal muscle fibers varies across fiber types: type I fibers (2–3 mM) ver. type IIb fibers (~0.5 mM).

GSH concentration mg/100 g

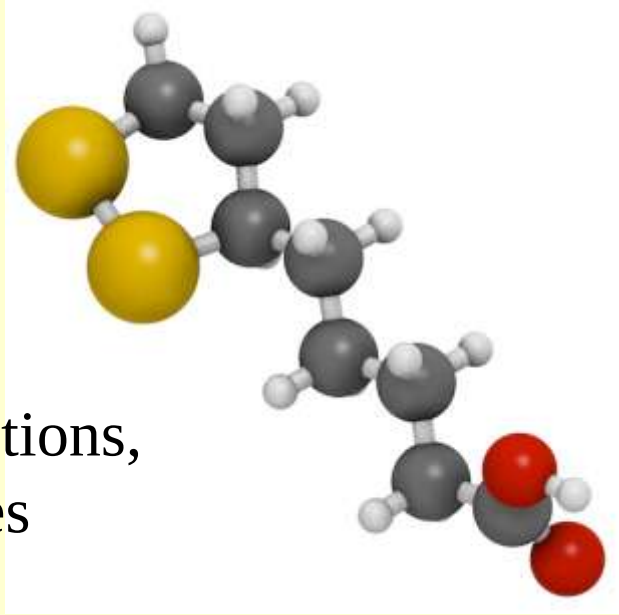
Ham (boiled)	23.3
Chicken (fresh)	6.0-13.0
Beef (fresh)	12.0-26.0
Fish (fresh)	1.2-2.6
Becon (fried)	5.0

Glutathione (GSH)

- directly acts in the neutralization of free radicals and reactive oxygen species by donating a hydrogen atom to radicals,
- serves as a substrate for glutathione peroxidase (GPx) to eliminate H_2O_2 and organic hydroperoxides,
- involved in the maintenance of endogenous antioxidants as vitamin C and E in its reduced active form,
- enhances iron absorption,
- required to maintain the normal function of the immune system, detoxify the body and reduce
- inflammation,

- take part in the modulation of the antigen presentation to lymphocytes, lymphocytes proliferation and the regulation of processes of apoptosis or programmed cell death,
- has a crucial role in DNA synthesis and reparation, protein synthesis, amino acid transport, enzymatic reactions, metabolism of sulphur, etc

α-lipoic acid

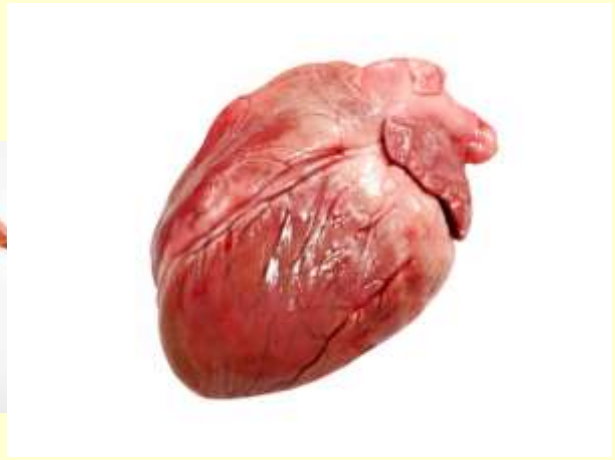


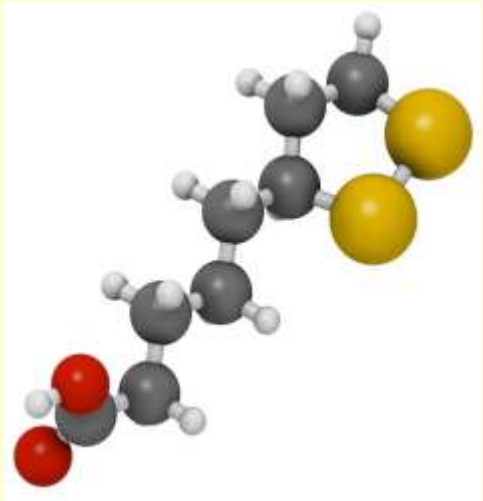
- naturally occuring vitamin-like antioxidant,
- both fat and water-soluble,
- serves as a cofactor for α-dehydrogenase complexes and participates in S-O transfer reactions,
- present in very small quantities in animal tissues and is generally bound to an enzyme complex which limits its function as an antioxidant,
- unbound and reduced α-lipoic acid (dihydrolipoic acid) and several of its metabolites are effective antioxidants,
- able to chelate iron and copper,
- able to regenerate other antioxidants back to active states, including vitamin C and E, glutathione and coenzyme Q10.

α-lipoic acid

α-lipoic acid is found in big amounts in tissues rich in mitochondria. Animal organs, such as kidney, heart and liver are good sources of alpha-lipoic acid, especially in form of lysine-bound, lipoyllysine.

~1-3 μg/g dry wt

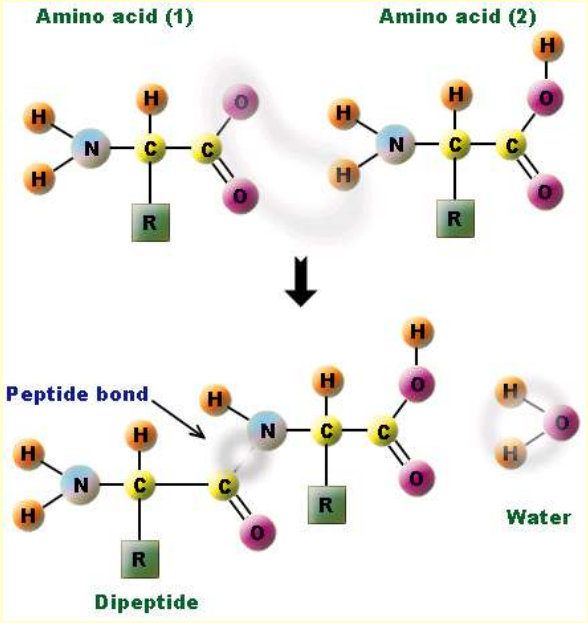




Amine compounds - aminoacids, peptides and proteins

- convert free radicals to more stable form,
- chelate metal ions,
- regeneration of primary antioxidants,
- form protective layer on the surface on air-oil phase,
- most active amine compounds contains sulphydryl groups,
- via reaction with carbonyls from oxidizing lipids they produce many non-enzymic browning reaction compounds (i.e. enaminone), which exert antioxidative properties - reducing and metal complexing.

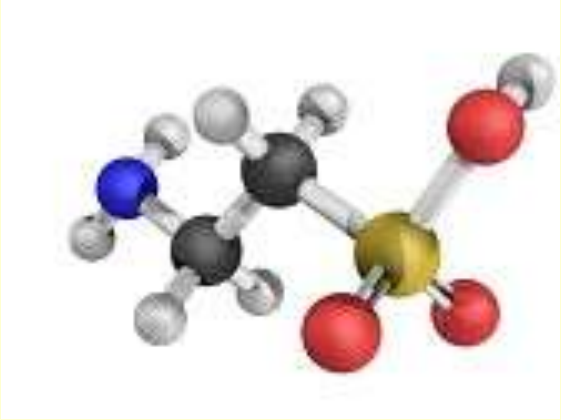
thyrosine, histidine, methionine, lysine, arginine, phenylalanine, tryptophane



Taurine

- amino acid,
- meat is the most abundant dietary source of taurine,
- derived from methionine and cysteine metabolism
- should be considered a conditionally essential amino acid during lactation, during times of immune challenge, and may offer protection against oxidative stress

Meat is rich in taurine (110mg/100g in lamb and 77mg/100g in beef, 34 mg/100 g in chicken).



Polyamines

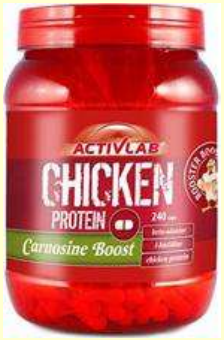
All organs of the body require polyamines for growth, renewal and metabolism due to their role in cellular metabolism and synthesis of protein, RNA and DNA.

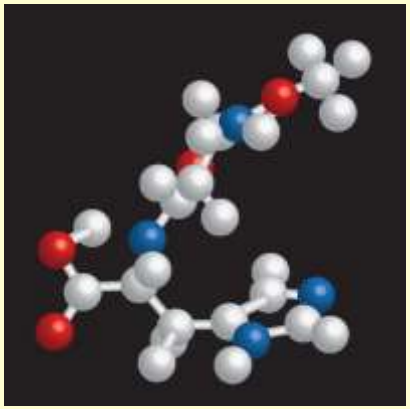
- ✓ commonly found in foods, spermidine < spermine < putrescine
- ✓ all types of food contain **putrescine** and **spermidine**, whereas **spermine**, **agmatine** and **cadaverine** may also occur naturally, and are not necessarily the result of bacterial contamination
- ✓ inhibit lipid oxidation by free radical inactivation and inhibition of iron catalyzed reactions. Antioxidant activity increases with increasing number of amine groups; **spermine > spermidine > putrescine**

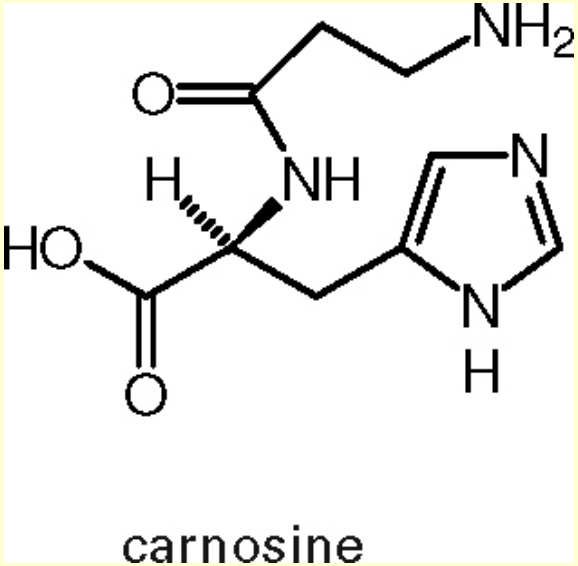
Dietary polyamines at levels normally present in foods are non-toxic, while biogenic amines, particularly histamine, are toxic at high intake levels.

Antioxidative peptides

- formed by 3-16 aminoacids, mainly proline, histydine, tyrosine in N-teminus, and valine, leucine as well as acidic aminoacids,
- can interact with linolenic acid enhancing antiooxidative activity and stimulating interaction with other antioxidants like BHA or BHT,
- tripeptides with thyrosine and tryptophan in C-terminus posses unique activity to scavenge free radicals,
- peptide content is negatively related to chromoproteins concentration in meat; high content in meat with predominant type II fibres and anaerobic metabolism.





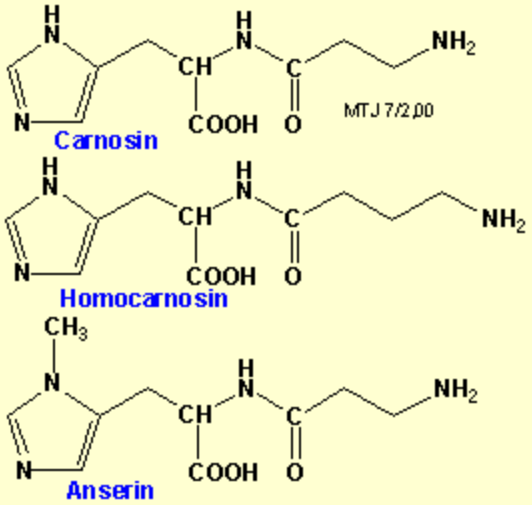


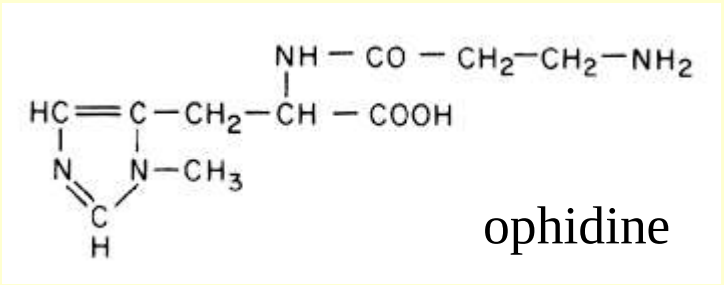
carnosine

Natural derivatives of carnosine (**CRC, carnosine related compounds**).

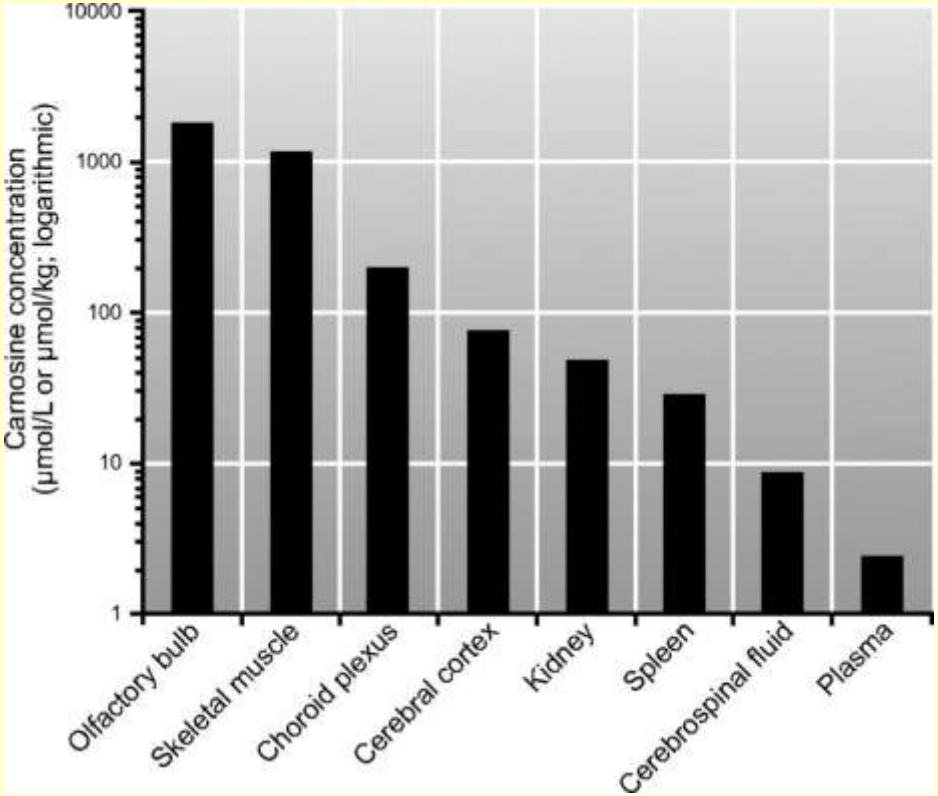
- ✓ **carnosine –** brain, kidneys, stomach, skeletal muscles, heart,
- ✓ **homocarnosine** (γ-aminobutyryl-L-histydine) **-** brain
- ✓ **N-acetyl-histydine -** brain
- ✓ **N-acetylcarnosine** – brain and heart
- ✓ **carcynine** (decarboxylation product) – brain and heart
- ✓ **anserine** N^1-methylcarnosine and **ophidine** (balenine) N^3-methylcarnosine **-** muscle tissue of birds, fish and sea vertebrates.

Especially rich in CRC are white muscles (anaerobic metabolism and predominant of type II muscle fibres (Hipkiss, 2005).





Animals	Muscles	*n*	Carnosine	Anserine	Balenine
Ox	leg	5*	26.1 ± 3.7	5.94 ± 1.75	0.103 ± 0.026
Pig	leg	6*	29.5 ± 9.6	1.42 ± 0.29	1.77 ± 0.71
Horse	leg	3**	42.6 ± 12.6	0.176 ± 0.030	0.019 ± 0.004
Deer	leg	5**	3.35 ± 0.68	13.9 ± 1.93	3.91 ± 0.74
Chicken	leg	3*	5.70 ± 1.7	17.1 ± 3.7	0.055 ± 0.028
	breast	4*	10.4 ± 1.3	32.0 ± 1.4	0.197 ± 0.031
Turkey	leg	3**	4.53 ± 0.68	20.5 ± 1.9	0.077 ± 0.009
	breast	2**	11.2 ± 1.3	46.0 ± 0.8	0.810 ± 0.023



CRC physiological effects:

- Buffering of the muslces,
- Lowering the toxicity of: - metal ions (**chelating**)
  - reactive oxygen species (**antioxidative**)
  - low molecular mass aldehydes (**antiglycemic**)

able to scavenge reducing sugar aldehydes (gliceraldehyde, dihydroxacetone), precursors for stable advanced glycosylation end products formation. This can limit late complications of diabetes.

β-alanine and histydine alone are not active
(Boldyrev i in., 2004)

Carnosine slows down ageing of cells as well as the whole body. It protects brain neurons and non-neurone cells against oxidation (thanks to SOD protection). Anserine is about 4 times less sensitive to enzyme action than carnosine.

Carnosine supplementation in the diet improve the autistic children behavior, due to their brain is damaged by oxidation procesess (McGinnis, 2004)

Lower concentration of CRC in human cells can be conected with neuropathological changes during ageing ie Alzheimer's and Parkinson's diseases (Hipkiss, 2005)

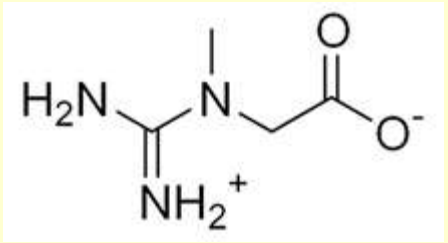
Carnitine

- L-carnitine (beta-hydroxy-gamma-trimethyl amino butyric acid) is synthesised primarily in the liver and kidneys from lysine and methionine with presence of vitamin C essential to the proces,
- it transports long chain fatty acids across the inner mitochondrial membranes to produce energy during exercise/movements,
- helps to absorb calcium and chromium to build lean muslces,
- block apoptosis and prevent muscles myopathy.

It is found in skeletal muscle and is particularly abundant in sheep muscle at up to **209 mg/100 g** and in beef at around **60 mg/100 g**.

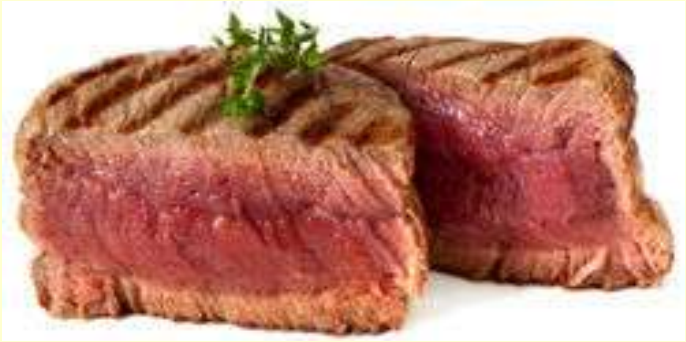
Creatine

- play an important role in muscle energy metabolism,
- is converted to creatine phosphate, assists in the resynthesis of ATP,
- is important in making energy available to sustain short time high activity,
- increased strength and fat burning properties.



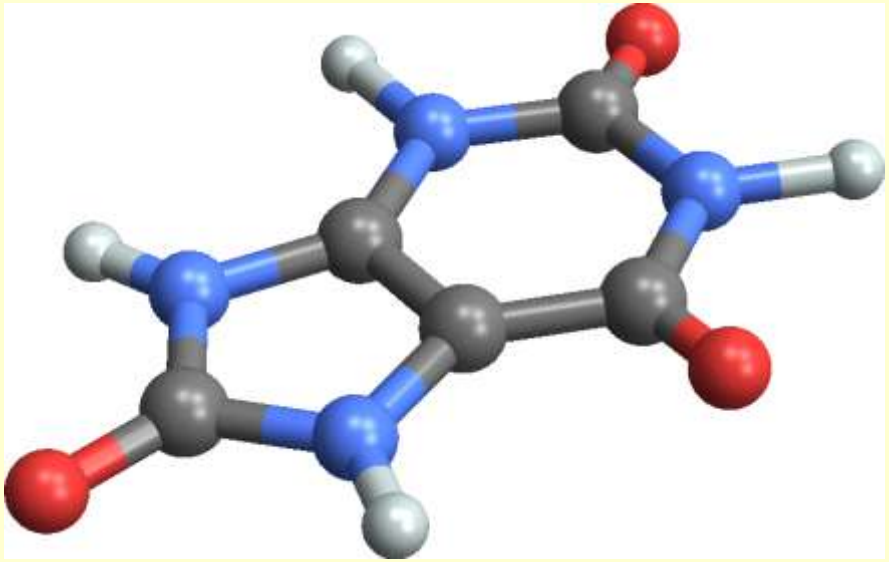
Red meat is a principal dietary source for humans.

Pork	5.0 g/kg
Beef	4.5 g/kg
Herring	6.5-10 g/kg
Salmon	4.5 g/kg
Tuna	4.0 g/kg



Uric acid

- by-product of purine metabolism,
- important low-molecular-mass antioxidant in biological fluids,
- at physiological pH, almost all uric acid is converted to urate,
- powerful scavenger of peroxyl radicals, hydroxyl radicals, and singlet oxygen,
- protect against oxidative damage by acting as an electron donor.
- chelate metal ions such as iron and copper and prevent them from catalyzing hydroxyl radicals via the Fenton reaction.

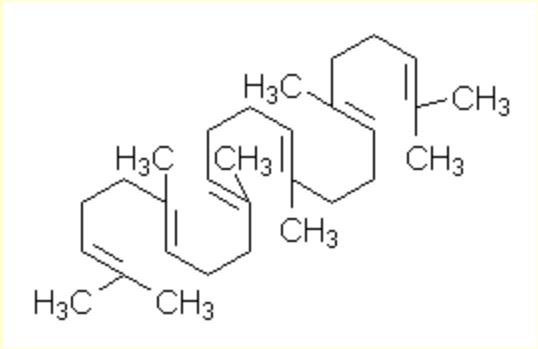


Squalene

is triterpene (30 C atoms) that is present in plants and animal tissues as a key intermediate in the biosynthetic pathway to steroids.

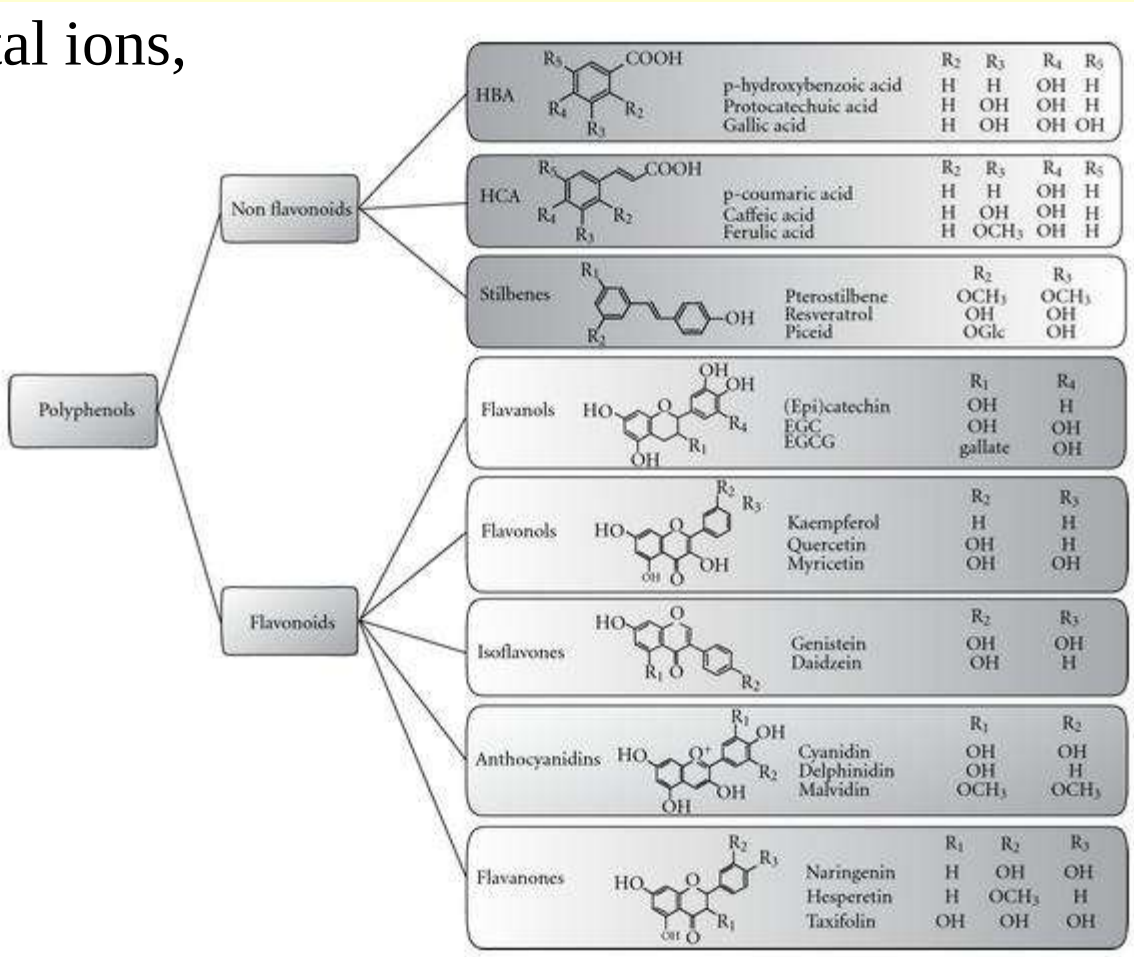
It has similar to the carotenoids conjugated double bonds and can hence build stable radicals and has been investigated as possible antioxidant.

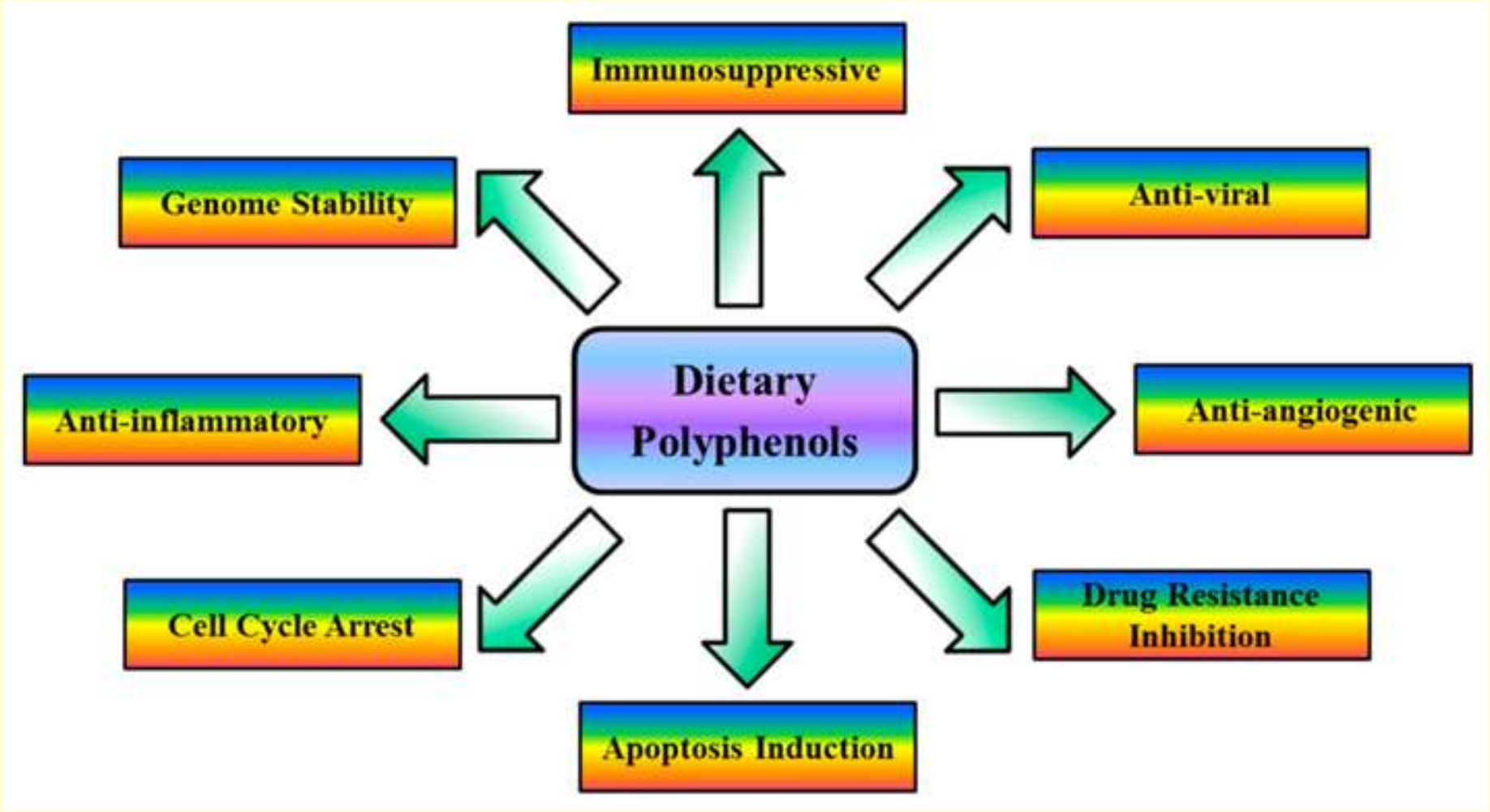
Significant amounts of squalene in plant sources are detected in e.g. olive oil, wheat germ oil, bran oil and yeast as well as in Amaranthus grain and Ecchium plants.



Polyphenols

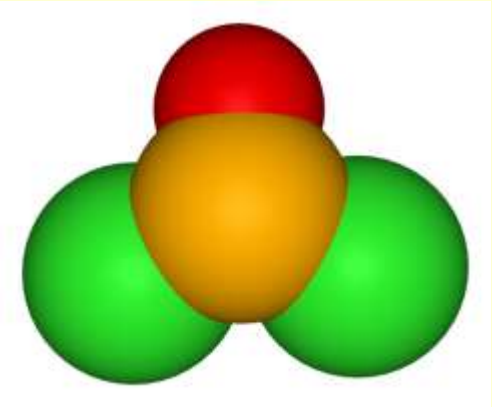
- Contain one or more hydroxyl groups with aromatic ring,
- Small amount in animal tissues,
- Inhibit lipid peroxidation,
- Eliminate reactive forms of oxygen and nitrogen,
- Form complexes with metal ions,
- Inhibit many enzymes,
- Improve animal health.




Immunosuppressive
Genome Stability
Anti-viral
Anti-inflammatory
Dietary Polyphenols
Anti-angiogenic
Cell Cycle Arrest
Drug Resistance Inhibition
Apoptosis Induction

Selenium

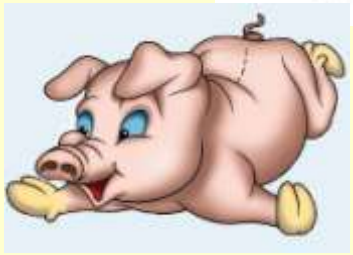
- Strong antioxidant, acts as free radical scavenging agent,
- Regulates activity of seleno-dependent glutathione peroxidase, which protects lipids peroxidation, especially due to inactivation of fatty acids peroxides,
- easily available from diet in organic forms, selenomethinine and selenocysteine,
- has some anticancer capacity,
- Is active in tyroid hormone metabolism and activation of immunological system,
- Low level of selenium led to muscle dystrophy, lower activity of immune defence system and heart problems.

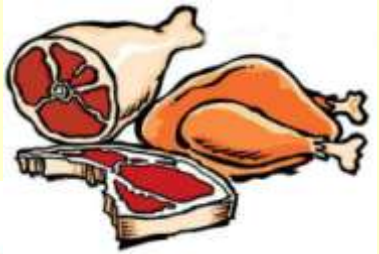


enriching animal diet

processing food

fortifying food





Is possible to increase CRC level in slaughter animals meat???

YES

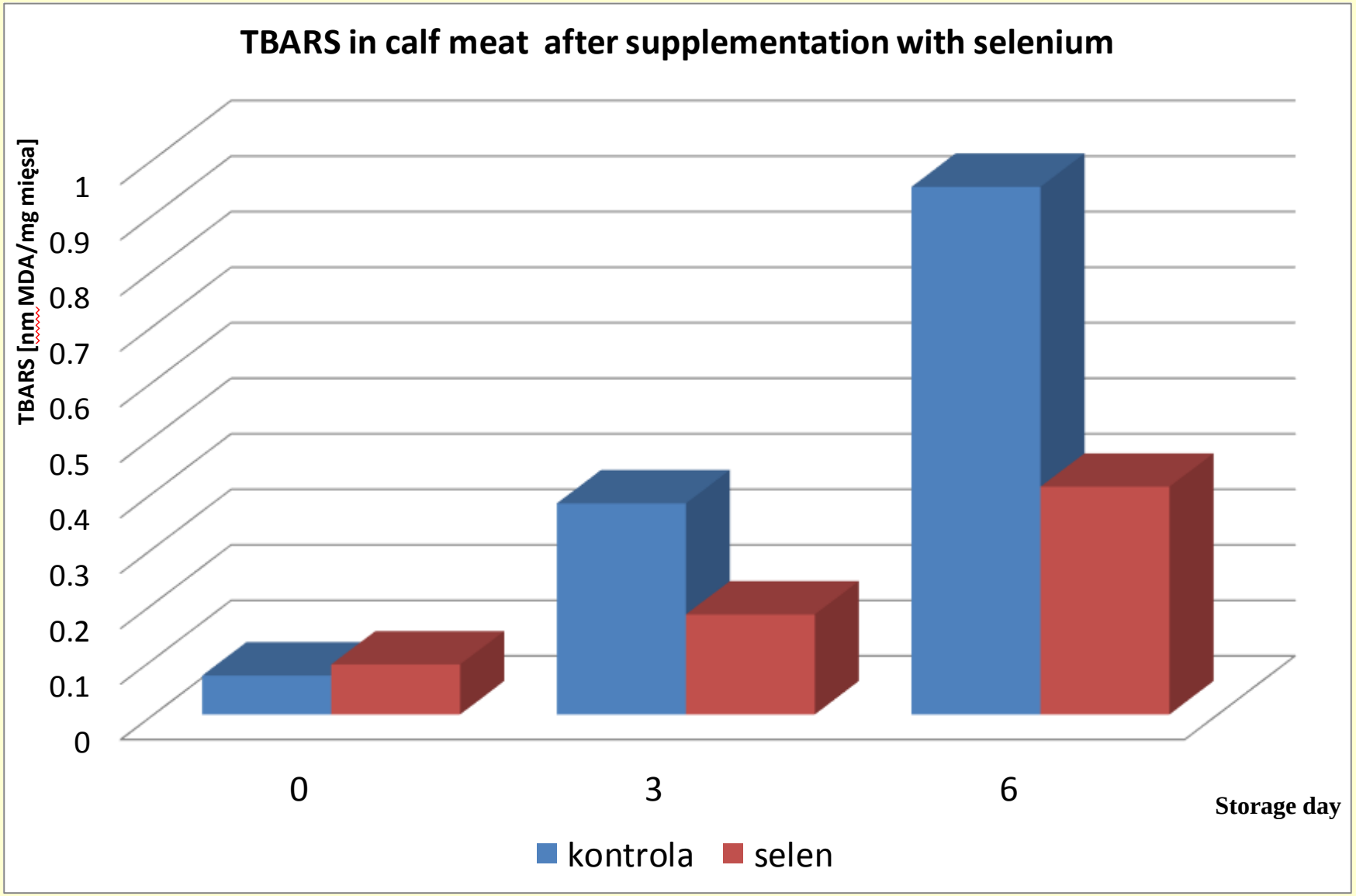
by feeding diet enriched with more than 1% of:

carnosine

histidine

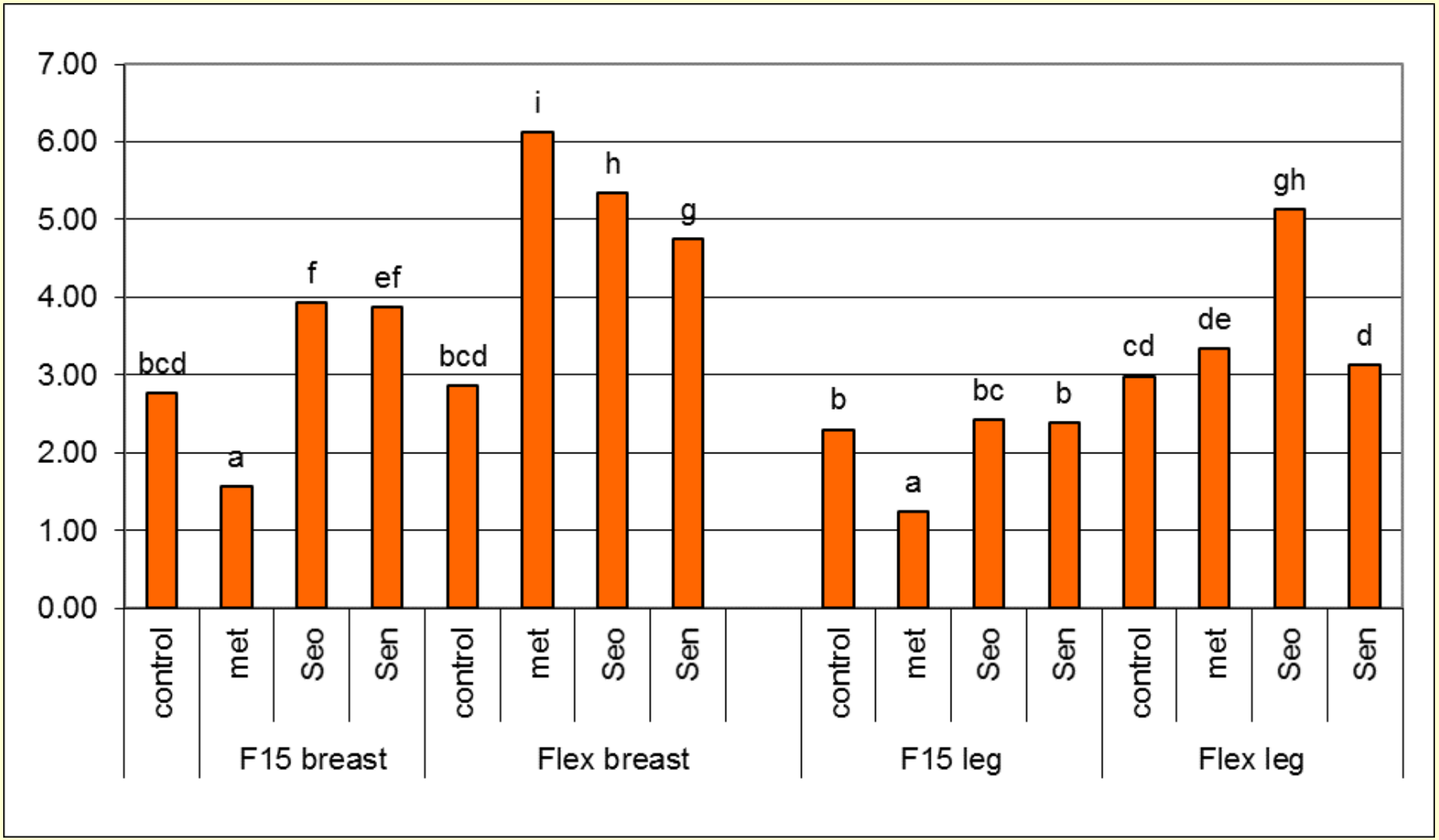
β-alanine

Concentrated poultry broth contain up to 30 times more CRC than fresh meat

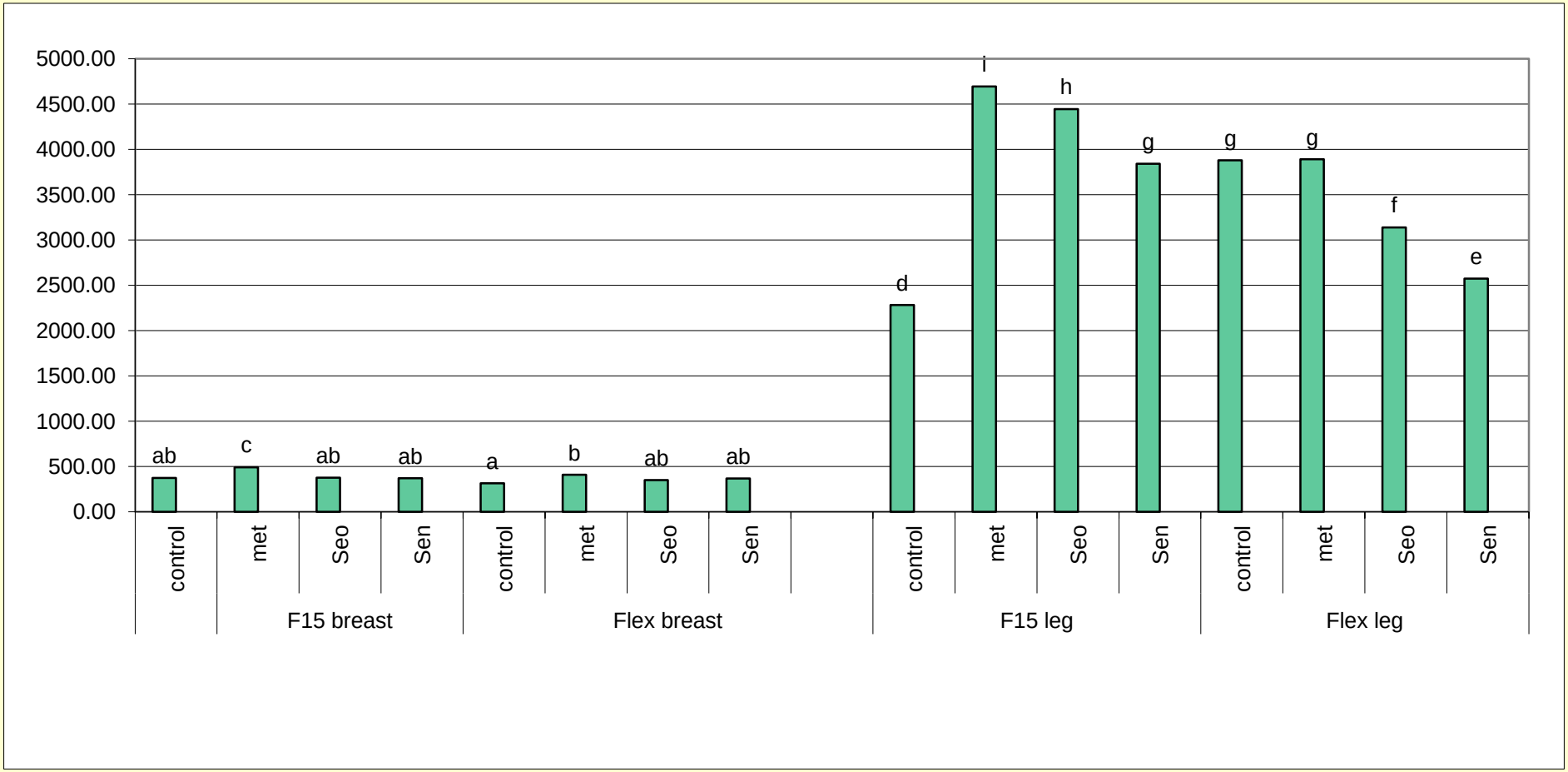


Marounek M., Skřivanová E., Skřivanová V. 2006. **Selenium content and antioxidant status in tissues of veal calves fed a diet supplemented with selenium yeast.** Slovak J. Anim. Sci., 39, 51 - 54 .

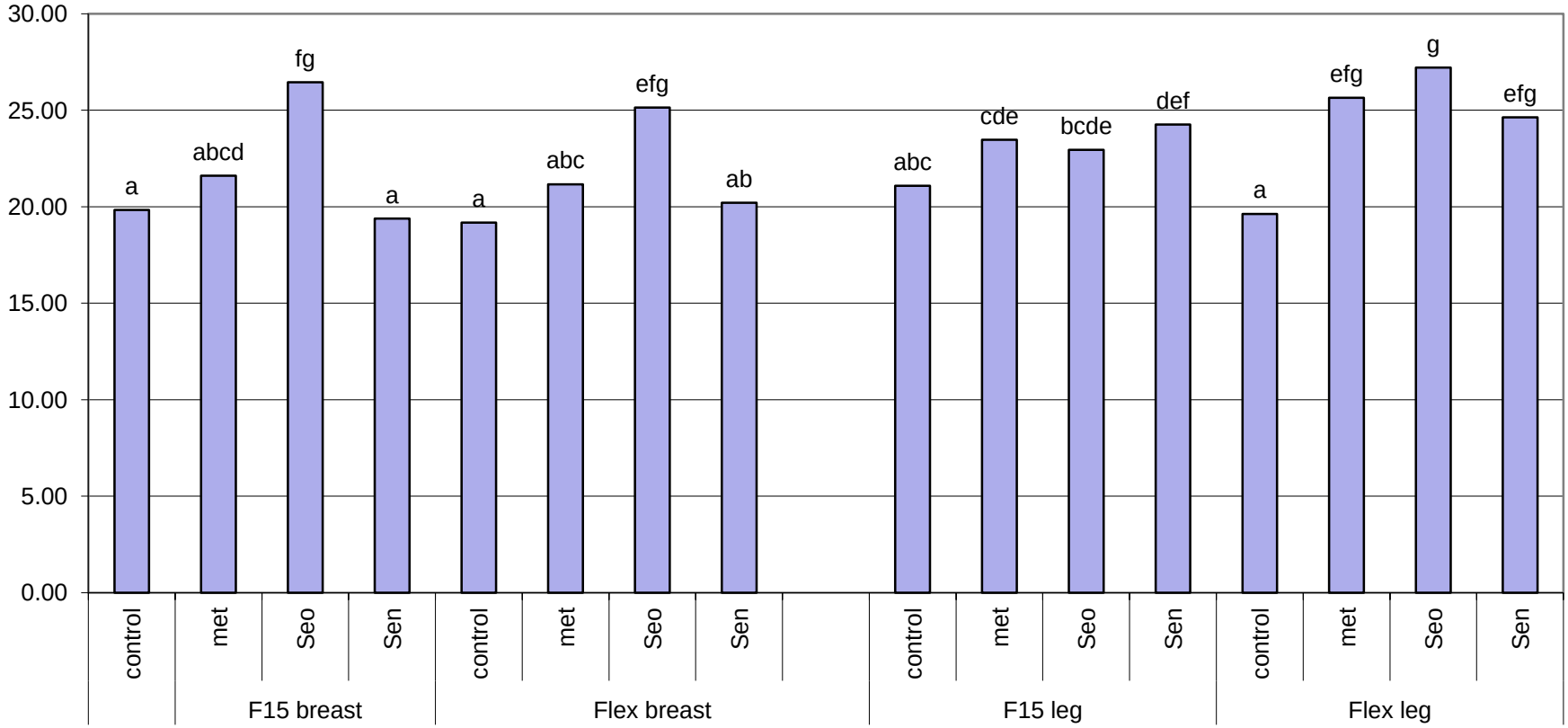
Sum of carnosine and anserine content [mg/g] in chicken breast and leg meat after dietary supplementation with selenium



Taurine content [mg/g] in chicken breast and leg meat after dietary supplementation with selenium



Ubiquinone content [mg/g] in chicken breast and leg meat after dietary supplementation with selenium



Adverse effects

Allergic reactions affecting the skin, including rashes, hives, and itching. Abdominal pain, nausea, vomiting, diarrhea, and nausea, vomiting, and vertigo, malodorous urine.

Could increase the risk of hypoglycemia in diabetic patients using insulin or oral antidiabetic agents because improves insulin-mediated glucose utilization.

Posssible competing with other components like biotin/vitamins/minerals in cell transfer due to similar chemical structure or affinity.

Reduce availability of selected substances either in animals and humans.

Prooxidative or toxic effects.

Meat

to eat

or not to eat?