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REACTIVE OXYGEN SPECIES (ROS), OXIDATIVE DAMAGE AND ANTIOXIDATIVE DEFENCE SYSTEMS WITH EMPHASIS ON HERBAL ANTIOXIDANTS AND HUMAN AND CATTLE HEALTH

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ABSTRACT – Different kinds of oxidants (free radicals) produced during aerobic metabolisms of fat, protein, carbohydrates and xenobiotics, not only create oxidative stress and damage to macromolecules but are implicated in the pathogenesis of several neurological, cardiovascular, musculoskeletal, carcinogenic and radiation related disorders, requiring their neutralization, amelioration or immunity boost up through Antioxidants- phytonutrients, dietary or endogenous protection systems. A well balanced, BMI based, low calory diet full of carbohydrates, proteins, vitamins, minerals, fibers, antioxidants and omega 3 fatty acids obtained from natural, fresh, seasonal and local fruits, coloured vegetables, pulses, sprouts, nuts and vegetable oils is preferable over non vegetarian diet of orthorexies for good health and immunity. The best fix is to have a variety of all right foods to increase i) protein intake (soya, fortified flours) ii) get coarse cereals (bajra, sorghum, oat, maize, blend of wheat and soya) iii) Increased intake of fruits and vegetables(banana, apple, pomegranate, guava, citrus, papaya, watermelon, grapes : tomato, okra, spinach, carrot, cauliflower, cabbage, lettuce, Khol khol, chillies, onion), iv) increased uptake of antioxiants (black grapes, beet root, carrot, coloured chillies,, lettuce, tomato and leafy vegetables apart from fruits and spices) v) enough omega 3 fatty acids (methi, soya, almond, walnut, flax and sesame seeds, urid, chana, chawli and leafy vegs.). Phytonutrients, dietary supplements and SOD enzymes could be used for preparing Ayurvedic medicines,herbal shampoos, creams, drinks, facials and sugar and stress free products after isolating, characterizing and purifying antioxidantive products.

Key Words : ANTIOXIDANTS, OXIDANTS

INTRODUCTION

Increased exposure to ROS or free radicals is known to cause aging, dementia, diabetes, radiation related, musculoskeltal, cardiovascular and several other diseases (Ames,1994).Antioxidative defence systems not only counter damage to macromolecules triggered by free radicals generated in aerobic metabolisms of fats, protein and carbohydrates and xenobiotic metabolism as well as multifactoral oxidative stress but are critical for preventing human diseases including cancer, atherosclerosis, stroke, rheumatoid arthritis and neurodegenerative diseases like Parkinson and Alzheimers and for maintenance of good health. For a healthy life style, well balanced, wholesome diet and antioxidants supplementation by vegetative mode is being recognized (Kumar,2009). Present communication discusses the therapeutic role of phytonutrients and dietary antioxidants (vitamin C, B, E, caritenoids and polyphenolics) as well as endogenous antioxidants (Glutathione, Lipoic acid, metalloenzymes- SOD, peroxidase and CAT) after proper isolation, purification, characterization and production of such products as supplements in ayurvedic medicinal formulations. Needless to say that antioxidantive phytotherapy is free of side effects, devoid of resistance to microbes and is less phytotoxic (Kumar, 2009).

Reactive Oxygen Species (ROS): Molecular oxygen is mainly utilized for oxidative phosphorylation and many other reactions as a substrate for metabolic activities being catalyzed by oxygenases, oxidases and hydroxylases enzymes. The ability to utilize oxygen for metabolization of fats, protein and carbohydrates for energy is at a cost of generating partially reduced oxygen species including free radicals.

Free radicals being highly reactive atom oxygen is capable of becoming part of potentially damaging prooxidants, which are electrically charged molecules, i.e. they have an unpaired electron which causes them to capture electrons from other substances in order to neutralize themselves. Free radicals attack healthy cells of the body causing them to loose their structure and function. They are produced in the body as by-products of normal cellular metabolic activities, such as: 1) prostaglandin synthesis, 2) mitochondrial electron transport, 3) endoplasmic reticulum enzyme activity, 4) oxyhaemoglobin process, 5) autooxidation, 6) phagocytosis, 7) exposure to environmental pollution, radiation, drugs,

pesticides etc 8) in hyperbaric oxygen treatment and 9) pathogenic conditions (Bhatia and Jain, 2004).

ROS species are formed because the interactions of one electron carrier with two electron carriers are rarely efficient and oxidases generate Ros in the following manner; 1) Super oxide is formed from one electron reduction of oxygen 2) Hydrogen peroxide is formed from a two electron reduction 3) Hydroxyl radical is formed via a three electron reduction of oxygen. It is particularly reactive and damages protein in many ways and damages membranes by initiating oxidation of fatty acids in membrane lipids. Lipid peroxidation (LPO) is oxidative deterioration of polyunsaturated lipids and leads to toxicity. Polysaturated fatty acids present in higher conc. in membranes in the presence of free radical initiator, such as O_2 or OH^- and oxygen may be oxidized to alkanes, aldehydes and hydrogen peroxide. This process occurs both in plants and animals. Hyroxyl radicals also damage nucleic acids both by causing double strand DNA breaks and by changing the structure of DNA bases (e.g.8-oxoguanine and thymine glycol) Hydroxyl radical is also produced in Fenton reaction

$H_2O_2 + Fe^{2+}(Cu^+) \rightarrow Fe^{3+}(Cu^{2+}) + OH + OH^-$. Hydrogen peroxide is produced by xanthine oxidase and amino acid oxidases too. 4) Nitric Oxide and peroxynitrite (Mathews *et al*, 2000) ; Superoxide has unpaired electron and combines readily with another free radical nitric oxide to form peroxynitrite also a ROS and causes LPO and Nitration of tyrosyl hydroxyl free radical .NO has been implicated in 1) Signal transduction pathways controlling neurotransmission 2) Cell proliferation platelet inhibition 3) programmed cell death and 4) host responses to infection (Wojtaszek, 2000) In plants ,NO may induce1) organogenesis 2) enhance seed germination and root growth in small conc while peroxinitrite in higher conc may induce 1) Stress 2) increase peroxidase activity (Zanardo *et al,* 2005).

Oxidative Stress : Normally a balance is maintained between the oxidative attack of free radicals and the antioxidative defence systems in the cells of our body but when the balance is tilted more towards free radicals, a condition called oxidative stress develops. At the cellular level several factors are responsible for increased oxidative stress (Table 2).

Oxidative damage to macromolecules due to induced oxidation, cleavage, crosslinking and structural and functional modifications have been implicated in the pathogenesis of over five dozen diseases (Halliwel, 1994; Percival, 1995; Sarkar *et al ,* 2008). Some of them are listed below (table 3).

Reduced glutathione (GSH) and membrane sulfhydryl (-SH) groups in erythrocytes of hypertensive patients is an indication of oxidative stress. Flavonoids like epicatechin alter Redox status (Rizvi and Kumar, 2005). In plants, induction of ascorbateguiacol specific peroxidases in metal and water shortage driven oxidative stress has been studied in rice seedlings and mulberry. Superoxide dismutase and abiotic tolerance in pea along with differential response of antioxidant enzymes under PEG- induced water stress have been reported by several authors.

Nitric oxide - a new regulator of oxidative Stress: NO first discovered in mammalian cells is a free radical and is 1) an mediator of homeostatic process and immunity 2) participant in the regulation of the oxidation/ reduction potential of various cells 3) protector/inducer of oxidative stress depending upon conc. and 4) cause of disease at high conc of Arginine (Lamattina *et al*, 2003; Neil *et al*,2003; Kopyra and Gwozdz, 2003 and Zanardo *et al*, 2005). Other nutrients that have impact on NO generation are niacin, riboflavin, folate, folic acid, Vit. B, omega-3 fatty acids and antioxidants (Hoffman, 1991)(6) No as controller of neurotransmission, cell proliferation, platelet inhibition and programmed cell death besides host response to infection (Woj taszek, 2000). With respect to plants, effect of NO have been studied in *Pisum sativum, Lupinus luteus, Glycine max,Zinnia elegans* and *Brassica napus* (Zanardoet *et al ,* 2005). Water and lipid soluble NO is mainly formed in young growing tissues and being lipophilic may diffuse through membranes acting as inter and intracellular messenger in many plant physiological processes. It may have beneficial effect on seed germination, root organogenesis, stomatal closure and defense response. When an excess of ROS occurs (Lamattina *et al,* 2003). NO affects peroxidase activity with potential knock on effect on ROS (Clark *et al,* 2000). Zanardo *et al* (2005) studied the effect of NO on seed germinating and peroxidase activity in canola and found dual effect depending upon conc. of NO donor SNP.

Antioxidative defence systems may be Exogenous or Endogenous; Enzymatic or Nonenzymatic. Vitamin C, E and Caretenoids represent the former while Superoxide dismutase SOD), Catalase and Glutathione peroxidase, co enzyme Q10, Uric acid, NADPH, glutathione, lipoic acid, N-acetyl cysteine represent the latter. In addition, Poly phenols- Flavonoids, flavonols and proanthocyanides are phytonutrients and Ferritin, albumin and lactoferrin are metal binding proteins. According to Percival (1995), Antioxidants can be classified in to following groups**;**

1. Nutrient derived antioxidant like ascorbic acid (Vitamin C), Tocopherols and Tocotroenols (Vitamin

E), Carotenoids- Beta carotene and oxycaretinoids, such as lycopene and lutein and other low molecular weight compounds such as glutathione and liopic acid.

2. Numerous other antioxidant phytonutrients present in a wide variety of plant foods.
3. Antioxidant enzymes, eg. Superoxide dimutase, glutathione peroxidase and glutathione reductase which catayse free radical quenching reactions.
4. Metal binding proteins such as ferritin, (iron) lactoferrin, albumin (copper) Metallothionein (copper), Myoglobin(iron), Transferrin(iron) and ceruplasmin (copper), that sequester free iron and copper ions that are capable of catalyzing oxidative reactions.

Endogenous Enzymatic Antioxidants : This category includes 1) Glutathione reductase 2) Glutathione peroxidase 3)Glatathione S-transferase 4) Glutamyl transpeptidase 5)Ovithiol 6) Catalase, and 7) Superoxide dismutase which function by direct or sequential removal of Ros. Methylglyoxal (MG) affects antioxidant enzymes and Glyoxalase system detoxifies them (Chaudhary *et al*, 1997; Yadav *et al,* 2005).

Glutathione- a water soluble antioxidant is thiol containing tripeptide synthesized from glycine, glutamate and cystein, plays role in homeostasis and is most abundant in most cells. It directly quenches lipid peroxides.Vit C and glutathione work interactively (Hopkins and Morgan,1945;Kumar *et al,* 2003). Glutathione present in food prevents cancer due to aflatoxin.

Glutathione reductase: Glutathione keeps cystein thiol groups in the reduced state. If two thiol group become oxidized, they can be reduced non-enzymically by glutathione. .GSSG is reduced by NADPH-dependent enzyme glutathione reductase

GSSG + NADPH + H + →2GSH + NADP +

Selenium- dependent Glutathione peroxidase: Glutathione carries out the reduction of H_2O_2 which is enzymatic reaction catalyzed by GPx, found in vacuole, cystol and extracellular space.The enzyme has substrate specifity. Peroxidases are involved in 1)Biotic and abiotic stresses 2) Lignin and suberin synthesis 3)Disease and pathogen response (Frey,1987; Chen and Schopfer, 1999)

As glutathione peroxidase contains one residue per mole of an unusual aminoacid Selenocysteine that contains selenium in place of sulfur that is why dietary supplimentation with selenium protects cancer.Peroxidases are widely distributed in plants and reduce hydrogen peroxide to water at the expense of oxidation of an organic substrate

$$2\ GSH + H_2O_2 \rightarrow GSSG + 2\ H_2O$$

Consequence of H_2O_2 accumulation in glucose-6-phosphodehydrogenase deficiency due to malarial drug primaquine results in to haemolytic anemia due to oxidative stress. In alcoholics, memory loss related to pentose-phosphate pathway based mutation in transketolase causes Wernick Korsakoff syndrome.

Glutathione S- transferases; Through the action of this widely distributed enzyme, glutathione participates in detoxification of xenobiotics or foreign organic compounds.

Ovithol found in fertilized eggs of Sea urchin, plays a role comparable to gluathione. It protects eggs against oxidative damage by peroxides. Ovithol is reduced by glutathione.

Copper/ Zinc and Manganese dependent Superoxide dismutase (SOD): It is an endogenously produced enzyme present both in prokaryotes and eukaryotes (Fridovich,1973; 95).SOD is a group of metalloenzymes with various prosthetic groups. Three main classes of them differ in their aminoacid sequence structure and metallic factors as follows;

(1) Cu-Zinc SOD in the cytoplasm with two sub units and sensitivity to cyanide and hydrogenperoxide

(2) Mn SOD in the mitochondrial matrix and in prokaryotes and is insensitive to cyanide

(3) Fe SOD, usually found in prokaryotes and in the chloroplasts of some plants. It is not sensitive to cyanide but is inhibited by hydrogen peroxide.

(4) Al SOD has recently reported (Cadmak and Horst, 1973, 95; Gregory, 1971).

Iron-dependent Catalase; H_2O_2 is also metabolized by catalase (CAD), a haem protein with an extremely high turn over rate

$$2\ H_2O_2 \rightarrow 2\ H_2O + O_2$$

SOD protect from senescence, aging, ischemic tissue damage, lipid peroxidation, protein denaturation and radiation damage. Information about SOD has been given in tables 9-12.

Dietary Antioxidants : Water soluble Vit.C, lipid soluble Vit. E and Caretenoids -Beta carotene and oxycartenoids- lycopene, zeaxanthin . and lutein are most widely studied . Antioxidants .B-carotene are precursors to Vit. A Carotenes work synergistically with Vit E which protects membrane fatty acids from lipid peroxidation and radiometric drug (Sisodia *et al,* 1991, Bhatia, 1996). Beta carotene quenches free radicals and lipid oxidants (Blot *et al,* 1995) and prevent CVD, Cancer, CNS seizures

Table1 : ROS species capable of reacting with membrane lipids, nucleic acids, proteins and enzymes.

Singlet oxygen	Superoxide anion radical	Hydrogen peroxide
Hydroxyl radical	Nitric oxide radical	Hypochlorite radical
Peroxynitrite	Peroxyl alkyl radical	

Table 2 : Accelerators of oxidative stress.

Accelerated cellular metabolism	Cigarette smoke
Strenuous exercise	Poor diet
Trauma	Alcoholism
Drugs (e.g. Primaquine)	Presence of leaky gut syndrome
Toxins (e.g. Mycotoxins)	Hypertention
Drought, water deficit,	Methylglyoxal production
Heavy metals Cold and Pollution	Deficiency of glucose-6-phosphate dehydrogenase in PPP
Illness or Infection	Alteration of Transketolase
Exposure to Allergens	Diabetes

Table 3 : Oxidative Stress-related diseases and conditions.

Accelerated cellular metabolism	Cigarette smoke
Atherosclerosis	Arthritis
Multiple sclerosis	Parkinsons disease
Ischemia and other CVD	Neonatal Lipoprotein oxidation
Hypertention	Kwashiorkar (protein energy malnutrition)
Diabetes	Drug reactions
Pancreatitis	Skin lesions
Bowel disease and Colitis	Cancer
Pulmonary dysfunction	Aging
Shock and Trauma	Renal diseases

Table 4 : ROS and Corresponding Antioxidants.

ROS	Antioxidants
Hydroxyl radical	Vit.C, glutathion, flavonoids, lipoic acid
Superoxide radical	Vit. C, glutathione, flavonoids, SOD
Hydrogen peroxide	Vit. C, glutathione, beta carotene, Vit E, Co Q10, flavonoids, lipoic acid
Lipid peroxide	Beta carotene, Vit,E, Ubiquinone, flavonoids, glutathione peroxidase

Table 5 : Fruits rich in Vitamins.

	FRUITS	SOURCE OF
1	Apple -*Pyrus malus*	Vit A, E and silicon
2	Papaya-*Carica papaya*	Vit C, B
3	Orange-*Citrullus reticulatus*	Vit C
4	Banana-*Musa paradisiaca*	Vit A, C
5	Watermelon-*Citrullus vulgaris*	Vit B, E, lylopne
6	Grapes-*Vitis nucifera*	Vit E, B
7	Pineapple-*Ananas comosus*	Vit B, E, C
8	Mentha-*Mentha pipirita*	Vit E

Table 6 : Vegetables rich in Antioxidants :

Vegetable	Common Name	Sources of
1 *Lycopericon esculentum*	Tomato	Vit A, B, B_2 and C
2 *Abelmoschus esculentum*	Okra	Vit A, C, B_1, B_2
3 *Allicum cepa*	Onion	Vit B_1, B_2, C
4 *Lactuca sativa*	Lettuce	Vit C, A
5 *Brassica oleracea*	Cauliflower	Vit A, B, C
6 *Spinacia oleracea*	Spinach	Vit A, C

Table 7 : Spices with Dietary Antioxidants:

Spices	Common Name	Sources of
1 *Curcuma domestica*	Turmeric	Vit C , riboflavin, B_1, thiamine (B_2)
2 *Capsicum annuum*	Chilli	VitA, B_2, C
3 *Cinnamomum verum*	Tejpat	Vit B_1, B_2, C, niacin
4 *Coriandrum sativum*	Coriander	VitB_1; B_2, C
5 *Carum carni*	Jira	Vit B_1, B_2, niacin
6 *Zingiber officinale*	Adrak	Vit B_1, B_2, C
7 *Trigonella foenum graceum*	Methi	Vit A& C
8 *Syzygium aromaticum*	Clove	Vit A, C, B1, B2, niacin
9 *Elattaria cardamomum*	Cardamom	Vit A, C, B1, B2
10 *Foeniculum vulgare*	Fennel	Vit C
11 *Capsicum annuum*	Chilli	Vit C, A ,B2
12 *Carum carni*	Shia jira	Vit C,A, B1, B2

Table 8 :

PLANT	SOURCE OF
Mentha piperita	Eugenol, caffeic acid, rosemaric acid and Vit E
Ocimum sanctum	Flavonoids- orientin, vicenin , b carotene, Vit C, eugenol
Andrographis paniculata	Caffeic acid, Chloregenic acid, eugnol, flavones
Phyllanthus niruri	Flavone, rutinoside, ellagic acid
Commniophora wightii	Quercetin
*Scutellania laterifol*a	Flavone, hispidin
Cassia augustifolia	Flavonols, emoden, Vit C
Aegle marmelos	Flavone glucosides, carotene
Fagopyrum esculentum	Rutin and quercetin
Ageratum conyzoids	Eugenol, flavone
Fragaria versa	Catechin
Aloe camels (sinensis)	Epicatechin
Pterocarpus marsupium	Epicatechin
Cannabinis sativum	Cannabinoids
Panex ginseng	Panaxosides, ginsenosides
Artemisia racrosum	Caffeic acid
Tephrosia purpurea	Rutin alkaloid
Podophyllum hexandrum	podophylline
Cruciferous Vegs, cabbage, broccoli and cauliflower	Iso thyocyanates, sulphoraphane & Intoles are sulphur containing phytochemicals

Table 10 : Some plants as inducers of SOD enzymes.

PLANTS	REFERENCES
Curcuma longa	Reddy *et al*,1994
Petroslinum crispum	Nielsen *et al*,1999
Emblica officinalis	Salil *et al*,2003
Momordica charantia	Naik *et al*, 2003
Glycyrrhiza glabra	"
Acacia catechu	"
Allium sativum	Saravanan *et al*, 2004
Ocimum basilicum	Das Gupta *et al*, 2004
Terminalia chebula	Naik *et al*, 2004
Bacopa monniera	Amar *et al,* 2005
Withania somnifera	Anbarasi *et al*, 2006 ;
	See Briukhanov *et al,* 2005

Table 9 : Sources of SOD Enzymes.

Escherichia coli	Keele *et al*,1970
Neurospora crassa	Hara *et al*, 1972
Streptococcus mutans	Patt *et al,* 1972
Saccharomyces cerevisiae	Hospodar *et al*,2004; Liu *et al*,2005
Chlorobium thiosulphataphilum	Hewitt *et al,*1974
Clostridium perfringens	Hewitt *et al* ,1974
Chromatium sp	Hewitt *et al*, 1974
Desulfotomaculum nigricans	Hewitt *et al*, 1974
Pleurotus olearius	Lavelle *et al*, 1975
Cordyceps mutitans	Wong *et al*, 2006
Spiriluna platensis	Lumsden *et al*, 1976
Rhodopseudomonas spheroidis	Lumsden *et al*, 1976
Photobacterium leiongnathi, Caulobacter crescentus, Brucella abortus, Haemophilus influenzae	Pavlina *et al,* 1999
Streptomyces coelicolor	
Humicola lutea	
Acenthamoeba castellanii	Dong *et al,* 1999
Actobacterium woodii	Briukhanor, 2002
SOD producing Herbs	
Pisum sativum	Swada *et al*, 1971
Nicotiana tabacum	Kurepa *et al*, 1997
Panex ginseng	Mohammad *et al,* 2005
Hordeum vulgare roots	Kim *et al,* 2005
Camella sinensis	Vyas *et al*, 2005
Lycopersicon esculentum	Dong *et al*, 2006
Allium nutans	Stajner *et al*, 2006
A. fistulosum	
A. Vineale	
A. cepa	
A. sativum	
A. flavum	
A. sphaerocephalum	Stajner *et al,* 2006
A. urisnum	Campanella *et al*, 2003
Petrosalinum crispum	Dragsted,1999
Ocimum basilicum	

Table 11 : Some fruits containing SOD enzymes

FRUIT	REFERENCES
Papaya (*Carica papaya)*	Ching *et al*, 2003
Apple (*Pyrus malus*)	Campanella *et al,* 2003
Banana (*Musa paradisiaca*)	
Cherry (*Prunus avium*)	
Watermelon (*Citrullus vulgaris*)	
Peach (*Prunus persica*)	
Pear (*Pyrus communis*)	
Plum (*Prunus domestica*)	
Pineapple (*Ananas coromus*)	
Fig (*Ficus carica*)	Campanella *et al,* 2003

Table 12 : HUMANS AND SODs.

Location	Prosthetic Group	Location in Chromosomes
SOD1 (in Cytoplasm)	Cu & Zn	Chromosome 21
SOD2 (in Mitochondria)	Mn	6
SOD3 (extracellular)	Cu & Zn	4

and is radioprotective (Bhatia and Jain, 2004) and provide protection to smokers while non beta carotene are singlet O2 quenchers. Although 600 Caretinoids are known but in Indian context Caretenoid rich plants are 1. *Aegle marmelos* (Bael) 2. *Emblica officinalis* (Amla) 3. *Ocimum sanctum* (Tulsi) 4.*Solanum nigrum* (Makoi) 5.*Spinacia oleracea*(Spinach) 6. *Lactuca sativa* (Lettuce) 7.*Daucus carota* (Carrot) 8.*Citrullus reticulata* (Orange) 9.*Amaranthus paniculatus*, which is a rich source of caretenoids,vit,C, lysine,folate and methionine. Spinach likewise is rich in vit, C, B Complex, Beta carotene, lutein, zeaxanthin, selenium and flavonoids. Fruits, vegetables and spices rich in antioxidants (Jain,1991. Singh et al, 1995) have been tabulated below;

Beans, Pumpkin, rice, peas,tomato, sweet potatoes, pomegranate and citrus fruits too are rich source of Vit C apart from guava, brahmi and Plantago ovata. Aloe vera and Alfaalfa are rich in Vit.A,C and E Vit C protects from environmental alkylating agents. Citrus fruits, other fruits, potato and sweet potato, Green and Yellow vegetables and all other fruits have 27, 13, 14, 11, 27 and 8% vit C, respectively (Behera and Panda,1989).

Vegetable oils rich in Vit E:

1, Corn 2. Soy 3.Cotton seed 4. Safflower and coloured leafy vegetables are good to heart along with omega 3 fatty acids found in flax seeds, walnuts, soya, black chana, urud and methi .

Plant derived chemicals as antioxidants: Polyphenolese.e.g. flavonoids, flavones(apigenin), flavonols(quercetin), isoflavones(orobol), isoflavonoids ferreisin) and proanthocyanides are widely distributed in plants. Phenolic acid rich plants are apples, garlic, onion. Grapes, groundnuts, cashew, coffee and corn while indoles are found in radish, cabbage, caulflower, knolkhol and carrots. These prevent from LPO. Popcorn and other whole grains, coffee and chocolate are particularly good to health because they contain surprisingly large amounts of polyphenol antioxidants and lower heart and other diseases (Joe Vinson of USA,Times of India News,2009; Krishnaswami and Raghuramulu, 1998). Phenolic compounds have anti-inflammatory, antiallergic, antiviral, antiaging and anticancerous activities (Middleton,1984).Phenolic acid rich plants include apples, garlic, onion, grapes, groundnuts, cashew coffee and corn while indoles are found in radish, cabbage, cauliflower, knolkhol and carrots,which prevent from LPO damages.Popcorn, other whole grain cereals and chocolates are good to health because they contain surprisingly large amounts of polyphenol antioxidants that lower heart and other diseases (Joe Vinson ,2009, Times of India, Feb Issue) Flavonoids (about 3000) exert protection against heart diseases through inhibition of Cyclooxygenase and lipoxylegenase activities. Flavonoids inhibit lipid peroxidation by forming less aryloxyl radicals with free radicals (Havestein, 1983; Rizvi and Kumar, 2005). They are powerful chain breaking antioxidants(Pratt, 1972) and are found in plant leaves, flowers, stems,and barks. In plants, they give protection against environmental stresses while in human they function as biological response modifiers. Plants having antioxidative phytochemicals have been given in following

Besides, *Syzygium cumin***i** and *Ginkgo biloba* too have antioxidants. Melatonin, Methyl xanthines, lycopene, Allicin, Terpene lactones, Curcumin, Chlorogenic acid are some of the Radioprotective compounds of plant origin (Abraham *et al*,1993).

Distribution of endogenous antioxidants and micronutrients in plants :

Antioxidant enzymes especially GP, CAD and SOD metabolize oxidative toxic intermediates and require micronutrients such as Cu, Mn, Fe, Zinc and Selenium for catalytic activity besides Silicon and Calcium for structural requirements. Pulses, nuts, whole grain , milk fruits and leafy vegetables are suppliers of micronutrients. Iron is found in abundance in spinach, pomegranate,

Table 13 :

	Disease / Conditions	Plants / Products Used
1.	Hypertension protection	Herbal tea (catechin,epicatechin).Beet roots, Beans, Cabbage, Carrots, Cauliflower, Onions, Pepper, Spinach, Arjun trees Bark, Garlic, Ephedra (Ephedrine),Coffea arabica.(Bhatia and Jain,2004; Rizvi and Kumar,2005)
2.	Hepatoprotection (antioxidants) Hepatoglycemic & hepatoprotective	*Andrographis paniculata,Bacopa monnieri,Terminalia chebula,Picorhiza kurroa,Embellica officinalis,Zingiber officinalis,piper nigrum,Hippophae rhamnoides,Limonium sinensis,Cucumber domestica,*Liv-52.(Kumar *et al*, 2008 ,Weiss and Landur,2003)
3.	Radioprotection	*Glycyrrhiza glabra,Tinospora cordifolia,Alliumcepa,Withania somnifera,Hernidismus* sp,*Mangifera indica,Ocimum sanctum,Aloe camell*s (green tea), *Podophyllum hexandrum,Brahm* rasayan.Phyllanthus niruri,Bauhenia purpurea Terminalia che*bula* (Ganasoundari *et al,*1997; Kumar and Goel,2000; Naik *et al*, 2004; Singh and Vats, 2006)
4.	Cardiovascular protection	Diet rich in Vitamin E is Beneficial Abana (Agarwal,1986)
4.1	Lipid Lowering	Garlic
4.2	Lipoic acid	Cabbage sprouts
4.3	Blood purifier	*Chlorophytum borivilianum*
4.4	Anticoagulant	Alfaalfa,Ginseng
4.5	Anticholesterolaemic	*Commiphora wightii,Hibiscus mulbaris*(gurhal)
4.6	Treatment of blood pressure	*Rauwolfia serpentena, Salix alba*
4.7	Athero sclerosis	S-containing cabbage,berries,mustard and neem seeds
4.8	Antithrombolytic	*Ginkgo biloba*
4.9	Omega 3 Fatty acid providers	Flax seeds,nuts (Sharma et al,1992; Daga, et al,1995; Singh & Vats,2006)
5.	Pulmonary disorders Asthma	Vitamin E & betacarotene ,Tribulus terrestris,Syzygium cumino,Solanum surattense,Portulaca oleracea,Acacia nilotica,Adhotoda zeylania,Ailanthus excisa Diet rich in Vit C,Carotenoids & Vit E.
6.	Antihistamine (Antiallergic)	Henbane
7.	Cancer (Breast,Skin, Colon & Prostate)	High Vit .C & E diet, Olive, Tomato, Beet, Taxus, Hetrotropium indicum,Gloriosa superba., Ocimum basilicum, Cannabis Sativa (Kumar et al, 1999; Albanes et al, 1995; Das Gupta et al, 2004)
8.	Ostereoporosis Bone density	Calcium rich balanced diet Vitamin K in grasses and whole grains.
9.	Arthritis and Rheumatism	*Withania somnifera,Piper nigrum*(fruit green sp.), *Abrus precatorius, Ficus benghalensis,Codonopsis* sp,*Sida alva* and Vit D.
10.	Bone fracture	*Terminalia arjuna* (bark),*Woodfordia* sp.,*Cylista scariosa,Eclipta prostata.*
11.	Neprotoxicity	Vit. C & E protect against cadmium induced nephrotoxicity (Renuga Devi *et al,*2008).
12.	Diabetes	*Acacia nilotica,Adiantum caudatum, Dillemia indica, Indigofera latetolia, Tephrosia villosa.*
13.	For Nervous system	*Cardiospermum helicabum, Cannabis sativa, Datur*a metal.
13.1	Epilepsy	*Beuncasa hispida,Datura innoxia.*
13.2	Migraine	*Ocimum cannum,Clerodendron sp.,Withania somnifera.*
13.3	Insomnia	*Biophytum reinwardii, Cannabis sativa.*
13.4	Endemetous Kwashiorkar	Vit. E, A, Zn & Fe containing food.
13.5	Alzehimers	*Coffea arabica.*
13.6	Memory enhancer	*Centella asiatica, Evolvulus alsinoides*.(Muller,1994; Trivedi,2002)
14.	Health of blood vessels & nerve tissue	Sulphur containing plants cabbage,berries,mustard seeds,onion,methi,carrot

Contuned .....

15	Gastrointestinal system (Antacids, Laxative)	Alfalfa,Garlic,Aloe,Senna
16	Endocrine system (Hormones)	Fucus, Alfalfa
17 a	Calcium (for bone)	Banana,pulses,fig,spinach,fish, soyamilk
17 b	Vit D for skeletal mass	Mushroom,Tuna,Fortified cereal with milk, Yoghurt, Sardines, Mackerel
18.	For muscles	Raisins,Apricot,Sunflower seeds,Peanuts,Almonds,Walnuts
19.	Cataract	Vit E, C and Carotene rich golden rice are good
20.	Cosmetics	*Aloe barbadenis, Citrus lemon*,Vit A for healthy skin
21.	Ageing,Skin,Hair	B-carotene,Vit E niacin,Vit B,Folate in tomato,N-acety Carnitine, Lycopene, betacarotene, Pulses, Fish, Flax seeds improve glutathione synthesis (Bhatia,1998)
22.	Role of micronutrients	Iron is needed in O_2 transport and energy product (Beets, Cheeries and Dates). Zinc affects Vit.A metabolism .Silica in Lettuce,onion,tomato Figs & Asparagus. Zn,Cu, Mn & Al (prosthetic group of SOD) in whole grains & pulses.

Table 14 : Dietary antioxidants and reproduction in cows

COMPONENT (Location in Cell)	NUTRIENT INVOLVED	FUNCTION
Superoxidase dismutase (Cytosol)	Copper and zinc	Enzyme converts SOD to hydrogen peroxide.
Superoxidase dismutase (mitochondria)	Manganese & Zinc	Enzyme converts SOD to hydrogen peroxide.
Ceruplasmin	Copper	An antioxidant protein, May prevent copper from participating in oxidation reactions.
Gluthione peroxide (Cytosol)	Selenium	Enzyme converts hydrogen peroxide to water.
Catalase Cystol	Iron	Enzyme(Liver) converts hydrogen peroxide to water.
Alpha tocopherol (membrane)	Vitamin E	Breaks fatty acid per oxidation chain reaction.
Beta Carotene (membranes)	Beta carotene	Prevents intiation of fatty acid per oxidation chain reaction.

beets,dates and jowar; Calcium occurs in plenty in pulses; Magnesium is plentiful in bajra, jowar, maize, wheat, urid, rajmah, moong, almonds, mango, plums and lotus stems. Selenium is found in nuts and silicon in lettuce, tomato, asparagus,figs and strawberries while fibres in whole grains.Supplemental biothiol, lipoic acid makes up for Vit c & E deficiency and is a universal antioxidant because dihydrolipoic acid are capable of quenching free radicals in both lipid and aqueous domains. This S containing enzyme catalyzes oxidative decarboxylation of alpha keto acids in Krebs cycle.

Antioxidative herbal supplementation in ayurvedic formulations for human health management : Ames, 1994; Kim *et al*,1995, Sardesi, 1996; Trivedi,2002; Goyal, 2004; Bhatia and Jain, 2004; Rizvi and Kumar, 2005 Singhand Vats, 2006; Sarkar *et al*, 2008;Kumar *et al,* 2008; Kumar,2009 have emphasized the role of antioxidants in the amelioration of oxidant-triggered disorders and human health maintenance as shown in Table 13.

Antioxidative properties and reproduction in cows

Inter relationship between nutrition, animal health and fertility is well established. Several minerals, vitamins and Carotenoids have a direct effect on the function of the immune system and therefore, could have a direct effect on the ability of animals to combart diseases like mastitis, abortion and placental retention(Swami, 2009). Cu and Zn effect mastitis while Selenium ,Vit. E and A affect stick ovaries. Antioxidant systems of mammalian cells have been shown in Table 14.

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