BEEF FACTS: Nutrition

Antioxidant Properties and Meat

In recent years, researchers have focused on the potential role of dietary antioxidants in promoting health and reducing the risk of heart disease, cancer, cataracts, and other degenerative diseases of aging (1). Nutrient supplement industries have rallied around the proposed benefits of antioxidant nutrients. However, recognition of the adverse health effects of high doses of antioxidant nutrients has led experts to caution against dietary supplements and recommend that such nutrients come from food sources as part of a varied diet (1,2).

How Do Antioxidants Work?

As the name implies, an antioxidant acts to prevent oxidation or oxygen damage to cells (1,3). Such damage to cells may be partly responsible for certain diseases and the effects of aging.

The normal functions of cells result in toxic molecules called "free radicals." The environment can also be a source of free radicals caused by ultraviolet radiation, smoking, and airborne pollutants. A free radical is a short-lived, highly reactive chemical that can have damaging effects on cells, particularly DNA and cell membranes. Antioxidants, both naturally occurring in the body and those from food sources, may block some of this damage by stabilizing the free radical and neutralizing the harmful effects. Although some free radical damage is repaired by the body, cell damage can accumulate and may lead to certain diseases.

Generally, the body has protective mechanisms for controlling oxidation, but at times these mechanisms can break down or become overwhelmed. Antioxidant vitamins and minerals can minimize detrimental lipid oxidation by neutralizing or scavenging free radicals (1,3).

Dietary Antioxidant Sources

Commonly cited antioxidant vitamins are: vitamins C, E and beta-carotene (provitamin A) (1,4,5). Also, several minerals such as copper, selenium, iron, manganese, and zinc have been referred to as "antioxidant minerals" because of their presence in enzyme systems which protect against free radicals and oxidant stress (6,7). For example, zinc deficiency increases sensitivity to oxidative stress (7,8). Findings of a recent study led the researchers to suggest that correction of zinc deficiency in patients with Type 2 diabetes may help to prevent the deleterious effects of oxidative stress and other diabetes-related complications (8). Also, the antioxidant properties of zinc and vitamin E may contribute to their ability to help protect against cell injury and atherosclerosis (9).

Compared to antioxidant vitamins, the optimal intake of antioxidant minerals falls within a *narrower* range (6). For example, Cu and Fe are minerals that can exhibit *both* antioxidant and prooxidant activity depending on levels of intake.

While fruits and vegetables are the predominant food sources of antioxidants, meat also contains a number of dietary components that possess antioxidant properties (4,10). The presence of antioxidants in meat such as beef can help inhibit lipid oxidation and the destructive effects of reactive oxygen species and free radicals, thereby protecting the nutritive value, flavor, and color of meat (4). For example, vitamin E delays oxidation of polyunsaturated fatty acids in tissue membranes in meat and the conversion of myoglobin (red pigment) in muscle to metmyoglobin (brown pigment) (4).

Antioxidant Properties Related to Meat Sources

Although vitamins C, E and beta-carotene have received the most attention, there are additional dietary components with antioxidant properties. Some examples in meat, other than the antioxidant minerals, include carnosine, glutathione, possibly conjugated linoleic acid (CLA) and a lipid profile less susceptible to oxidation (4).

Carnosine is a natural dipeptide (alanine and histidine) present in large amounts in skeletal muscle (4,10-

12, Table 1). In general, carnosine content is affected by muscle type, with white muscle being somewhat higher in carnosine than dark muscle.

Table 1. Carnosine Content of Skeletal Muscle.[1]

Source	Carnosine mg/100g
Beef, topside, rump	333
Pork, loin & shoulder	466
Lamb, leg	190
Chicken, breast	400
Chicken, leg	124

[1] Adapted from Chan and Decker (10).

Because carnosine is absorbed into the plasma intact, it is a potential dietary antioxidant (11). Carnosine has been found to be capable of inhibiting lipid oxidation due to iron, hemoglobin, lipoxidase and singlet oxygen *in vitro* (10,12). Because carnosine reduces oxidative rancidity, it could be used as a natural antioxidant in muscle foods. The antioxidant mechanism of carnosine has been suggested to be due to a combination of its ability to act as a metal chelator, free radical scavenger and hydrogen donor (10). Since carnosine is water soluble, it can inactivate lipid oxidation catalysts and free radicals in the water phase of muscle (10,12).

Carnosine's antioxidant effect may be influenced by vitamin E (4,13). Carnosine has been demonstrated to provide protection against oxidative damage when vitamin E is deficient (4,13). However, no improvement was noted when vitamin E was adequate. Carnosine may therefore react with secondary lipid oxidation products rather than acting as a primary free radical scavenger (4).

Glutathione (GSH), a cysteine - containing tripeptide (glutamine, cysteine, glycine) found in mammalian cells, plays an important role in detoxification and catalyzes reactions for the antioxidation of reactive oxygen species and free radicals (14). GSH is a cofactor for GSH peroxidase, a well established antioxidant enzyme which is active only in the presence of GSH (14). By supplying both GSH and selenium, beef benefits this pathway. Work continues to clarify the interrelationship among tissue GSH, nutrition and oxidative stress (14).

GSH is present in relatively large amounts in fresh meats such as beef (15, Table 2). Most meats contain approximately twice the GSH found in poultry and two to ten times more GSH than fish products. Fruits and vegetables contain moderate to high levels of GSH, while dairy products, cereals and bread are low in GSH. It is believed that GSH acts to stabilize free radicals and also combines with fat-soluble toxins to form water-soluble substances which are easily excreted in the urine.

Table 2. Glutathione Content of Meats, Poultry and Fish.[1]

Food	Glutathione mg/100g
Hamburger, pan fried	11.8
Steak, beef, pan fried	12.3
Veal cutlet, pan fried	26.3
Pork chop, lean, pan fried	18.9
Boiled ham	13.7
Chicken, roasted	7.7
Chicken breast, deep fried	6.5
Fish (cod & perch), pan fried	5.7
Shrimp, canned	1.0
Tuna fish, canned	1.1

[1] Adapted from Jones, D.P. et al. (15)

Conjugated Linoleic Acid (CLA), present in meat products such as beef, has been demonstrated to exert antioxidant-like activity *in vitro* and *in vivo* (16,17). Dietary CLA decreases the accumulation of highly unsaturated fatty acids in cell membranes (18,19). By containing lower amounts of highly unsaturated fatty acids, these membranes are less susceptible to oxidation and thus would have a lower potential of causing oxidative damage to cell components. Knowledge that oxidized derivatives of cholesterol and oxidized low density lipoprotein (LDL) have atherogenic properties have led to studies of whether CLA's possible antioxidant properties might influence atherosclerosis. In rabbits, CLA at dietary levels as low as 0.1% inhibited the establishment of atherosclerosis, and at higher levels (i.e., 1%) caused regression of established atherosclerosis (16). In hypercholesterolemic hamsters, CLA reduced the development of early aortic atherosclerosis, possibly by decreasing LDL susceptibility to oxidation (17).

Saturated Fat. Meat such as beef has a lipid profile that is less susceptible to oxidation than foods high in unsaturated fatty acids. Dietary fats which are more unsaturated (i.e., polyunsaturated fats) have been associated with increased oxidant stress in tissues (3,4). Polyunsaturated fats are also much more reactive chemically than saturated fats found in animal products. The relatively small amount of unsaturated fatty acids in meat is susceptible to lipid oxidation with generation of free radicals (4).

Selenium is a mineral which functions through selenoproteins, several of which are oxidant defense enzymes (1,6,20). For example, selenium is a constitu-

ent of the enzyme glutathione peroxidase which protects cellular membranes from oxidative damage (1,20). A deficiency of selenium increases oxidative degradation of compounds susceptible to oxidation, especially if vitamin E is low (4).

Vitamin E. Vitamin E supplementation of beef cattle, pigs, lambs and veal calves can increase color and lipid stability of fresh meat (4). Meat such as beef from animals supplemented with vitamin E to improve oxidative stability, enhance color retention, and increase retail shelf life may offer an opportunity for "value added" consumer products with enhanced nutrient value (4). In meat such as beef, vitamin E reduces lipid oxidation, which is related to the unsaturated fatty acid content of skeletal muscle lipids (4).

Recommendations and Dietary Intake

The role of antioxidant vitamins and minerals in health continues to be debated. It is encouraging that naturally occurring antioxidants in foods may offer protection against disease (1). A recent analysis of Americans' diets indicates that ground beef is a significant dietary source of vitamin E for men (21). However, questions have arisen regarding the adequacy of vitamin E levels in usual diets versus the need for supplementation. At this time, experts recommend intake of a varied and nutritionally balanced diet with antioxidants coming from natural food sources as a first priority (1). Such a diet should be able to supply recommended levels of antioxidant vitamins, minerals and other dietary components.

Future Directions

There is little controversy about the action of antioxidant compounds operating in simple systems. Less well understood is how these same nutrients interact in complex real life systems.

Meat such as beef is a natural source of many nutrients, some of which have antioxidant properties. Only recently has this value-added aspect of meat begun to be appreciated (4). Continued research may identify other dietary components with antioxidant properties in beef and other meats.

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