Melon (*Cucumis melo* L.) Fruit Nutritional Quality and Health Functionality

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SUMMARY. This article examines the nutritional quality and human health benefits of melons, specifically, muskmelon or cantaloupe (*Cucumis melo* L. var. *reticulatus* Naud.) and honeydew melon (*Cucumis melo* L. var. *inodorus* Naud.) types. Melons are naturally low in fat and sodium, have no cholesterol, and provide many essential nutrients such as potassium, in addition to being a rich source of *beta*-carotene and vitamin C. Although melons are an excellent source of some nutrients, they are low in others, like vitamin E, folic acid, iron, and calcium. Since the U.S. diet is already high in fat and protein content, melons should be included in everyone's diet, along with five to eight servings per day of a variety of other fruit and vegetables, to ensure adequate nutrition, promote individual health, and reduce one's risk of cancer and certain other chronic diseases.

The Cucurbitaceae family, which includes cucumbers, gourds, melons, pumpkins, and squashes, is made up of hundreds of wild species and cultivated varieties (Jeffrey, 1980, 1990). This family produces fruit with fleshy, usually edible, pericarp. This edible pericarp can be sweet, as in muskmelons (cantaloupe), honeydew melons or watermelons, or starchy, as in gourds, pumpkins, and squashes (Gebhardt et al., 1982; Haytowitz and Matthews, 1984). While cucurbit fruit are not significant sources of calories or protein, they can be important sources of dietary fiber, minerals, pro-vitamin A (*beta*-carotene), and vitamin C (Adams and Richardson, 1981). The economic value, particularly of melons, to local and corporate economies can be substantial (Taylor, 1994). The purpose of this article is to examine the nutritional quality and human health benefits of melons, specifically, muskmelon or cantaloupe (*Cucumis melo* L. var. *reticulatus* Naud.) and honeydew melon (*Cucumis melo* L. var. *inodorus* Naud.) types.

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Table 1. United States per capita consumption of fresh fruit, 1995.^{2,7}

Rank	Fruit group	Consumption (kg/capita)
1	Bananas	12.6
2	Melons ^x	11.6
3	Citrus ^w	11.4
4	Apples	8.9
5	Grapes	3.3
6	Peaches ^v	2.5
7	Strawberries	1.8
8	Pears	1.6
9	Pineapples	0.9
10	Plums ^u	0.7

^xLucier (1995a).

^vLucier (1995b).

^wIncludes muskmelon and honeydew, both western shipper and eastern fresh market (4.9 kg), and watermelon (6.7 kg).

^uIncludes oranges and tangelos (5.9 kg), grapefruit (2.8 kg), lemons (1.2 kg), tangerines and tangelos (1.0 kg), and limes (0.5 kg).

^vIncludes nectarines.

^uIncludes prunes.

Consumer preference for and nutritional benefits of melons

The two most important genera of melons, *Cucumis* (muskmelons) and *Citrullus* (watermelon), are called dessert or sweet melons. These two genera are ranked second only to bananas in total U.S. per capita consumption of fresh fruit (Table 1). The nutrient content of muskmelons and honeydew melons, based on the nutrient labeling concept of the U.S. Food and Drug Administration, may be described as relatively low in calories, fat, and sodium and are good sources of potassium and vitamin C. In addition, muskmelon is an excellent source of provitamin A or *beta*-carotene (Tables 2 and 3). It is notable that a 1-cup (236-g) serving of muskmelon fruit provides the recommended daily dietary allowance (RDA) for vitamins A and C. These RDAs are designed for

maintenance of good nutrition for all healthy individuals in the U.S. and they are calculated for 11- to 50-year-old males who, in general, have the highest individual dietary requirements (Adams and Richardson, 1981), except for pregnant and lactating women, who have values 25% and 50% higher, respectively.

Melon fruit health associated attributes

The concept that fruit and vegetables contribute to a person's well-being is as old as Hippocrates, the father of medicine, who more than 2000 years ago told his patients "Let your food be your medicine and your medicine be your food." Today this same philosophy with regard to fruit and vegetables being more than nutrition, i.e., medicine, is experiencing a revival as the recent use of the words "phytochemical," "phyto-nutrition," and "chemoprotective" would suggest.

According to the U.S. Surgeon General

Table 2. Nutrient content of orange-fleshed, netted muskmelon (cantaloupe) fruit.²

Serving size = 1 cup (236 g)		
	Amount per serving	Percentage of daily requirement (%)
Calories	71	
Calories from fat	0	
Total fat	0 g	0
Sodium	28 mg	1
Potassium	593 mg	15
Total carbohydrates	23 g	7
Dietary fiber	2 g	8
Sugars	19 g	
Protein	2 g	
Vitamin A		160
Vitamin C		130
Calcium		4
Iron		9

²Adams and Richardson (1981).

Table 3. Nutrient content of green-fleshed, honeydew melon fruit.²

Serving size = 1 cup (236 g)		
	Amount per serving	Percentage of daily requirement
Calories	78	
Calories from fat	0	
Total fat	0 g	0
Sodium	28 mg	1
Potassium	593 mg	15
Total carbohydrates	25 g	9
Dietary fiber	2 g	8
Sugars	21 g	
Protein	2 g	
Vitamin A		0
Vitamin C		90
Calcium		4
Iron		10

²Adams and Richardson (1981).

Table 5. Phytochemical chemopreventive agent trials by the U.S. National Cancer Institute.^z

Tissue cancer	Patient study group	Phytochemical agent used
Breast	Females age 45+	Beta-carotene, vitamin E (possible agents d-limonene, genistein)
Cervix	Females with dysplasia	Beta-carotene, folic acid (possible agent vitamin C)
Prostate	Men age 55+	Selenium (possible agent d-limonene)
Lung	Cigarette smokers and asbestos-exposed men	Beta-carotene, folic acid, vitamin B ₁₂
Head-Neck	Adults with previous head-neck cancer	Beta-carotene
Oral	Adults with oral leukoplakia	Beta-carotene and vitamin E
Skin	Adults with previous basal cell carcinoma	Beta-carotene
Colon	Previous colon adenomas	Beta-carotene, calcium, vitamins C and E, dietary fiber, folic acid
All cancers	Healthy male physicians	Beta-carotene

^zSondik (1995).

Table 6. Recommended daily dietary allowance (RDA)^z for beta-carotene (vitamin A value) and ascorbic acid (vitamin C) content of fruit from the 10 most consumed fruit groups in the United States.^y

Fruit	Percent RDA/236 g edible portion ^x	
	Vitamin A value	Vitamin C
Apples (with peel)	5	16
Bananas	9	39
Grapes	5	16
Muskmelons	160	131
Oranges	9	197
Peaches	35	16
Pears	1	16
Pineapples	4	67
Plums	14	0
Strawberries	3	232

^zBased on 11- to 50-year-old adult males, which have the highest RDA requirements. (Adams and Richardson, 1981).

^yTable 1., 1995 Per capita consumption of fresh fruit.

^xCalculated for edible fresh fruit weight per 1 cup.

(USSG), the most important personal consumption habits that influence health are smoking, alcohol, and diet. Among adults who do not smoke or excessively drink, the single most important personal choice influencing their long-term health is what they eat. The link between diet and the leading causes of human death in the United States is supported by research that reveals that diets high in saturated fat and cholesterol and low in fruit and vegetables greatly increases the chances of developing obesity, digestive tract disorders, cancer, and other chronic diseases (Sondik, 1995). The consensus of the USDA, the USSG, the U.S. National Cancer Institute (NCI), the American Cancer Society (ACS), and nutrition experts is that the U.S. diet contains too much fat and not enough fruit, vegetables, whole grains, and nuts.

Scientific investigations into plant substances called "phytochemicals," those compounds not presently recognized as having nutrient value, hold promise in the fight

against human diseases. In melons there are many phytochemicals that may have a vast array of potential health benefits (Table 4). Three such compounds found in melons: cucurbitacin- β , lithium, and zinc hold promise in cancer prevention, fighting depression, dandruff, and ulcers and in stimulating the immune system.

Science has a long way to go before it can be said with certainty which of the many phytochemicals act alone, which act in synergy with other phytochemicals or phytonutrients, how much is enough, how much is too much, and their bioavailability. But medical science is beginning to make progress with some phytochemicals (presumptive chemopreventative agents) through large-scale population-based prevention clinical trials using dietary modification (Sondik, 1995).

Over the past decade the NCI's emphasis on diet and nutrition research, in relationship to human cancers, has grown in size and scope. Today the overall goal of the NCI's emphasis on nutrition and cancer is to provide more definitive data for developing quantitative dietary guidance and acceptable food choices that have the potential to substantially reduce the risk of cancer in the general population. Specifically, the NCI is directing its resources to understand more fully how dietary components provide a defense against cancer or stimulate its development. This nutrition research examines phytochemicals and phytonutrients and their effect at the cellular level of the major human cancers (Table 5). The NCI's study of breast cancer, the second most common cancer among women, suggests that vitamin A (*beta*-carotene) and vitamin E play a role in the etiology of the cancer by preventing lipid oxidation and by regulating cancer cell differentiation and communication. Additionally, in cervical cancer, carotenoids (e.g., *beta*-carotene), folic acid, and vitamin C have a protective effect in

Table 4. *Cucumis melo* L. fruit chemical constituents and their human biological activities.²

Melon fruit bioactive chemicals	Human biological activity
Adenosine	Anti-aggregant, arrhythmic, endotoxic, lipolytic and tachycardic; arteriodilator; hypoglycemic; insulinic; respirastimulant; vasodilator.
Alpha-carotene	Colorant, provitamin-A.
Alpha-tocopherol (vitamin E)	Anti-mutagenic.
Aluminum	Anti-silicotic and vaginitic; candidicide; encephalopathic; pesticide.
Arsenic	Anorexic; pesticide.
Ascorbic acid (vitamin C)	Anti-Crohn's, arthritic, asthmatic, atherosclerotic, cataract, cold, decubitic, depressant, eczemic, edemic, encephalitic, gingivitic, glaucomic, hemorrhagic, hepatic, hepatotoxic, herpetic, histaminic, infertility, inflammatory, lepric, measles, migraine, mutagenic, nitrosic, obesity, orchitic, osteoarthritic, osteoporotic, oxidant, parkinson, parotitic, periodontitic, pneumonic, podriac, poliomyelitic, scorbutic, septic, shingles, ulcer and viral; antidote (aluminum, cadmium, lead and paraquat); asthma preventive; bactericide; cancer preventive; cold preventive; detoxicant; diuretic; febrifuge; fistula preventive; hypcholesterolemic; hypotensive; inteferonogenic; lithogenic; muculytic; pesticide; uricosuric; urinary acidulant; viricide; vulnerary.
Beta-carotene (provitamin A)	Allergenic; androgenic; Anti-PMS, acne, aging, asthmatic, carcinomic, coronary, hyperkeratotic, ichthyotic leukoplakic, lupus, mastitic, mutagenic, oxidant, ozenic, photophobic, pityriatic, porphyric, psoriac, radicular, stress, tumor, ulcer and xerophthalmic; cancer preventive; colorant; immunostimulant; mucogenic; phagocytotic; thymoprotective; ubiquot.
Boron	Androgenic; anti-osteoarthritic and osteoporotic; estrogenic.
Cadmium	Hypertensive; lithogenic; nephrotoxic.
Calcium	Anti-PMS, allergic, anxiety, atherosclerotic, depressant, hyperkinetic, insomniac, osteoporotic, periodontitic and tic; antidote (aluminum and lead); hypcholesterolemic; hypotensive.
Citrulline	Anti-asthenic, hepatotic and osteoporotic; diuretic.
Cobalt	Cardiomyopathogenic; erythrocytogenic.
Copper	Anti-arthritic, diabetic, inflammatory and nociceptive; contraceptive; hypcholesterolemic; schizophrenogenic.
Cucurbitacin-b	Anti-hepatotoxic and inflammatory; cancer-preventive; cytotoxic.
Cucurbitacin-e	Anti-hepatotoxic; cytotoxic.
Epsilon-carotene	Colorant.
Fiber	Anti-diabetic, obesity, tumor and ulcer; cancer-preventive; cardioprotective; hypcholesterolemic; hypotensive; laxative.
Folicin (folic acid)	Anti-spina-bifida, anemic, cervicaldysplasic, cheilitic, depressant, gingivitic glossitic, myelotoxic, neuropathic, periodontal, plaque and psychotic; hematopoietic; uricosuric; xanthine-oxidase-inhibitor.
Histamine	Anti-meniére's and migraine; bronchostimulant; gastrostimulant; histaminic antidote:adrenaline; hypotensive; myostimulant; radioprotective; secretagogue; spasmogenic; tachycardic; vasodilator.
Iron	Anti-akathic, anemic, cheilitic and menorrhagic.
Lithium	Anti-PMS, depressant, hyperthyroid, manic, psychotic and schizophrenic; deliriant; nephrotoxic.
Magnesium	Anti-PMS, aggregant, anginal, anorectic, anxiety, arrhythmic, arthritic, asthmatic, atherosclerotic, convulsant, depressant, diabetic, dysmenorrheic, epileptic, hyperkinetic, hypoglycemic, inflammatory, insomniac, lithic, mastalgic, migraine, neurotic, osteoporotic and spasmophilic; CNS depressant; Ca antagonist; hypcholesterolemic; hypotensive; myorelaxant; uterorelaxant; vasodilator.
Manganese	Anti-alcoholic, anemic, diabetic, discotic, dyskinetic, epileptic and ototic.
Mercury	Nephrotoxic.
Molybdenum	Anti-cancer (esophagus).
Myristic acid	Cancer-preventive; cosmetic.
Niacin	Anti-acrodynic, amblyopic, anginal, dermatitic, dysphagic, neuralgic, pellagic, scotomic and vertigo; cancer preventive, hepatoprotective; hypoglycemic; sedative; serotonergic; vasodilator.
Nickel	Anti-adrenalinic and cirrhotic; insulin-sparing.
Pantothenic acid	Anti-arthritic, claudificant, dermatitic, ielus, insomniac and rheumatitic; cancer-preventive.
Phosphorus	Anti osteoporotic; immunostimulant, osteogenic.
Potassium	Anti-arrhythmic, depressant, fatigue and hypertensive; cardiotoxic; spasmolytic.
Riboflavin	Anti-arabiflavinotic, cheilitic, decubitic, glossitic, keratitic, migraine, pellagic and photophobic; cancer-preventive.
Selenium	Anorexic; anti-aggregant, cirrhotic, coronary, dandruff, keshan, leuktriemic, osteoarthritic, oxidant and ulcerogenic; antidote (mercury); cancer preventive; depressant; fungicide; pesticide.
Silver	Astringent; bactericide; pesticide.
Sodium	Hypertensive.
Sulfur	Acarifuge; anti-acne, dandruff, grey, seborrheic and septic; comedogenic; keratolytic; laxative; parasiticide; pesticide; scabicide.
Thiamin	Anti-alcoholic, beriberi, cardiospasmic, colitic, decubitic, deliriant, encephalopathic, heartburn, herpetic, migraine, myocarditic, neurasthenic, neuritic and poliomyelitic; insectifuge; pesticide.
Zinc	Anti-Crohn's, acne, acrodermatitic, alopecic, anorexic, arthritic, coeliac, cold, colitic, dandruff, encephalopathic, furuncular, herpetic, impotence, insomniac, lepric, plaque, prolactin, prostatitic, rheumatic, stomatitic, ulcer and viral; antidote (cadmium); astringent; deodorant; immunostimulant; immunosuppressant; mucogenic; pesticide; trichomonicide; vulnerary.

²Beckstrom-Sternberg and Duke (1995).

preventing the progression of cervical intra-epithelial neoplasia to carcinoma. Among the proposed chemopreventative agents found in these NCI research studies, two notable phytochemicals and phytonutrients are vitamins A (*beta*-carotene) and C. Of the 10 most consumed fruit in the United States, muskmelon is the only fruit that can provide the RDA of pro-vitamin A and vitamin C (Table 6).

Recently, the NCI discontinued a trial using pharmacological levels of vitamin A as a chemopreventative agent in lung cancer, citing that vitamin A given in its purified form is not only ineffective but may hasten lung cancer (Sondik, 1995). Although research evidence supports carotenoids as potential chemopreventative agents, the epidemiologic studies do not distinguish the effectiveness of these phytochemicals and phytonutrients from the many other phytochemicals in fruit and vegetables that may contribute to the chemoprevention. Thus, many fruit and vegetables rich in *beta*-carotene also are rich in vitamins C and E. Additionally, foods rich in *beta*-carotene and vitamin C, like muskmelon, contain other phytochemicals that also exhibit suggested cancer-inhibitory activities (Table 5). It is unclear whether one, several, or all of these phytochemicals and phytonutrients are primary chemopreventative agents. It is clear, however, that consumption of fruit and vegetables that are rich in many phytochemicals and phytonutrients is wise. James A. Duke, (botanist, retired, USDA-Agricultural Research Service, Phytochemical Database, Beltsville, Md.) said it best: "I think Euclid and I would agree that the whole food is better than the sum of its

phytochemicals" (Berkstrom-Sternberg and Duke, 1995).

Regulation of *beta*-carotene content in muskmelon fruit

Muskmelon (cantaloupe) fruit, which are rich in *beta*-carotene, synthesize this compound within the fruit during ripening when chloroplasts change to chromoplasts (Goodwin and Goad, 1970). Unlike minerals and carbohydrates, *beta*-carotene is not translocated into muskmelons. Until recently, little has been known about the regulation of *beta*-carotene content. Separating muskmelons by commercial size class, (i.e., the number of fruit that fit into a 0.04 M³ shipping box) Lester and Eischen, (1996) reported that mean *beta*-carotene content increases as fruit size increases, from size class 30 to 15, then a plateau or slight increase in content occurs with size class 12 (Fig. 1). Beyond this fruit size *beta*-carotene content decreases. The explanation for this significant curvilinear regression of *beta*-carotene content with muskmelon fruit size remains to be determined. This response is not related to fruit dry weight or moisture content changes, and is similar in other cultivars (Lester and Eischen, 1996). The curvilinear response of *beta*-carotene content with increasing fruit size is not unique to muskmelon, as the same response occurs in carrot roots (Lee, 1986).

Soil type, specifically fine sandy loam and silty clay loam, influences melon *beta*-carotene content (Fig. 1). Fruit, regardless of size or cultivar, grown on silty clay loam always had significantly more *beta*-carotene content than fruit grown on fine sandy loam.

The effect of genetics on melon *beta*-carotene content is less evident than those of fruit size and soil type, but there is evidence for genetic regulation (Lester and Eischen, 1996). Contrasting different cultivars, using fruit of the same size grown on the same soil type over 2 years, Lester and Eischen (1996) showed

Fig. 1. Mean *beta*-carotene content by fruit size class averaged for Cruiser and Primo cultivars grown on two different soil types. Both linear and quadratic regressions were significant at $P \leq 0.001$. Fruit *beta*-carotene content for fine sandy loam = $4.47 + 15.5 (\text{fruit wt}) - 4.11 (\text{fruit wt})^2$, and for silty clay loam = $7.04 + 15.5 (\text{fruit wt}) - 4.11 (\text{fruit wt})^2$. $N = 80$ fruit per size class.

that some cultivars were consistently high in *beta*-carotene content each year, indicating it is likely that muskmelons rich in *beta*-carotene can be further genetically enriched, perhaps through breeding and or biotechnology. If enrichment is possible for *beta*-carotene, perhaps it will be possible for the many other health-promoting phytochemicals and phytonutrients in melons.

Eat a variety of fruit and vegetables

Melons are naturally low in fat and sodium, have no cholesterol, and provide many essential nutrients such as potassium, in addition to being a rich source of *beta*-carotene and vitamin C. Although melons are an excellent source of some nutrients, they are low in others, like vitamin E, folic acid, iron, and calcium. Since the U.S. diet is already high in fat and protein content, melons should be included in everyone's diet, along with five to eight servings per day of a variety of other fruit and vegetables, to ensure adequate nutrition, promote individual health, and reduce one's risk of cancer and certain other chronic diseases.

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