

# Using Sustainable Agriculture to Improve Human Nutrition and Health

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## ABSTRACT

The purpose of this article is twofold : 1) to provide nutrition professionals with the history of how the concept of sustainable diets was introduced to the nutrition profession and 2) to describe how different sustainable agricultural practices offer potential for improving human nutrition and health. The idea of connecting sustainable agriculture with the promotion of human nutrition and health is not new. It is a concept that was introduced to the nutrition profession more than 20 years ago. To foster healthful, sustainable diets, consumers need to choose more whole foods. From the standpoint of nutrition and health, whole foods are naturally higher in fiber and lower in fat, sodium, sugar and additives compared to highly processed foods. From the standpoint of agricultural sustainability, whole foods bypass the high-energy costs of food processing and transportation. Organic farming systems offer potential benefits to human health through reducing farmers' exposure to pesticides and by increasing the total phenolic content in selected food crops. Participation in farmers' market nutrition programs and gardening has been associated with increased fruit and vegetable intake. Gardening may also be a way to increase access to fresh produce in low-income populations that do not have access to nutritious food outlets and to increase physical activity. Further research is needed to assess the human nutrition and health benefits of other types of sustainable agriculture strategies and to investigate the links among different agricultural practices with nutrient and total phenolic content in a wider variety of important food crops. (*J Community Nutrition* 6(1) : 18~25, 2004)

KEY WORDS : sustainable agriculture · human nutrition · human health.

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## Introduction

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While various definitions for the term "sustainable agriculture" have been proposed (Padgitt and Petrzela 1994), all rest on the basic notions of balance between environmental and economic factors in agricultural systems. Sustainable agriculture was defined in the 1990 U.S. Farm Bill (Food, Agriculture, Conservation, and Trade Act of 1990 [FACTA, Public Law 101 - 624] as "an integrated system of plant and animal production practices having site-specific application, that will, over the long term :

- Satisfy human food and fiber needs
- Enhance environmental quality and the natural resource base upon which the agricultural economy depends

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- Make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls

- Sustain the economic viability of farm operations
- Enhance quality of life for farmers and society as a whole."

Consumers can support sustainable agriculture in the marketplace by purchasing organically-produced foods, shopping at farmers' markets, participating in home, school, and community gardens and participating in community supported agriculture (CSA), an innovative agriculture strategy that is designed to connect local farmers with local consumers (University of Massachusetts Extension 1999). The purpose of this article is : 1) to provide nutrition professionals with the history of how the concept of sustainable diets was introduced to the nutrition profession and 2) to describe how several different types of sustainable agricultural practices and strategies - including organic farming systems, farmers' markets nutrition programs, home, school, and community gardens, and CSA - offer potential for improving human nutrition and health.

## 1. Connecting sustainable diets with nutrition and health

The promotion of sustainable diets as an essential function of the nutrition profession is an idea that was introduced more than 20 years ago by Dr. Joan Gussow, Mary Swartz Rose Professor Emeritus of Nutrition Education, Teachers College, Columbia University and Dr. Katherine Clancy, Director of the Agriculture Policy Project at the Henry A. Wallace Institute for Sustainable Agriculture (Storper 2003). Drs. Gussow and Clancy introduced the relevance of agricultural sustainability to the nutrition profession when they explained that adherence to the U.S. Dietary Guidelines, i.e., the government's model for promotion of good nutrition and health, can also be used as a framework by which nutritionists promote sustainable diets (Gussow, Clancy 1986). According to Gussow (2001), to foster healthful, sustainable diets, consumers need to choose more "whole foods" - i.e., foods that are minimally processed and packaged. From the standpoint of nutrition and health, whole foods are naturally higher in fiber and lower in fat, sodium, sugar and additives compared to highly processed foods. From the standpoint of agricultural sustainability, whole foods bypass the high-energy costs of food processing and transportation. Furthermore, when consumers purchase foods from local farmers, more profits stay with the farmer (helping farmers to make a livable income). Finally, purchasing foods from local farmers not only helps support small farms and maintain local businesses, but ultimately it helps to promote more sustainable communities (Storper 2003).

## 2. Organic farming systems

The development of organic farming drew heavily on the analysis of farming systems as introduced by agronomist F.H. King (1927) and the composting and humus (composted plant and animal matter) research of agronomist Sir Albert Howard (1940). Organic farming systems rely on ecologically based practices, such as biological pest management and composting; virtually exclude use of synthetic chemicals, antibiotics, and hormones in crop production; and prohibit the use of antibiotics and hormones in livestock production (Greene, Kremen 2003). Under organic farming systems, the fundamental components and natural processes of ecosystems - such as soil organism activities, nutrient cycling, and species distribution and competition - are used as farm management tools. Farmers adopt these systems as a way to lower input costs, conserve non-renewable resources, cap-

ture high-value markets, and boost farm income (Greene, Kremen 2003).

A recent study that compared organic, conventional and integrated pest management apple production in Washington state over a 6 year period found that the organic system was more profitable, had similar yields, better tasting fruit, and was more environmentally friendly and energy efficient than the other two agricultural systems (Reganold et al. 2001). Another reason to support organic farming is that it reduces occupational pesticide exposure (Greene and Kremen 2003), which has been shown to be associated with acute and chronic illness in humans (Alavanja et al. 1996; Alavanja et al. 2003; Baldi et al. 2001; Calvert et al. 2003; Cooper et al. 1999; Eskenazi et al. 1999; Garry et al. 2002; Hardell and Ericsson 1999; Schreinemachers 2003), and to damage wildlife, including damage to beneficial species (Baatrup, Junge 2002; Hayes et al. 2002).

Consumer demand is rising worldwide for organically produced foods, providing new market opportunities for farmers and marketing actors in developed and developing countries. In 1991, the Codex Alimentarius Commission (CAC), a joint Food and Agriculture Organization (FAO)/World Health Organization (WHO) Food Standards Programme, began developing guidelines for the production, processing, labeling, and marketing of organically produced food. CAC guidelines on organic food take into account current regulations in several countries as well as private standards applied by producer organizations. According to the proposed Codex definition, "*organic agriculture is a holistic management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity*" (Yussefi, Willer 2003).

In the U.S., The Organic Foods Production Act of 1990 established national U.S. standards for organically produced commodities in order to facilitate domestic marketing efforts. The final U.S. organic rule went into effect in October 2002. Organic crops cannot be irradiated, genetically engineered, or fertilized with sewage sludge. Farmland used to grow organic crops is also prohibited from being treated with synthetic pesticides and herbicides for at least 3 years prior to harvest (Greene, Kremen 2003). Several U.S. states and community-based organizations are investigating ways to facilitate the production and marketing of locally-grown organic food. For example, "Sustain," which is a public interest group based in Chicago, Illinois has started an initiative to build a

regional and organic food system in 4 states including : Illinois, Wisconsin, Michigan, and Indiana (Slama 2002).

Currently, almost 23 million hectares of land are managed organically worldwide. The major part of this area is located in Australia (10.5 million hectares), Argentina (3.2 million hectares), and Italy (more than 1.2 million hectares). However, countries that have the highest total percentage of farmland under organic management include : Liechtenstein (17 percent of total farmland), Austria (11 percent), Switzerland (10 percent), Italy (8 percent), Finland (7 percent), Denmark (7 percent), and Sweden (6 percent). (Yussefi and Willer 2003). Worldwide conversion levels to organic cropland are highest in European Union (EU) countries, which have been providing consumer education and direct financial support to producers for conversion since the late 1980s to capture the environmental benefits of these systems and to support rural development. Many EU countries have set targets for organic farming adoption of 10–20 percent of agricultural land by 2010 (Lampkin 2002). Organic farming is also increasing in Africa, especially in Southern African countries, as a way to build upon indigenous knowledge and to build soil fertility on land that is threatened by degradation and erosion. Organic agricultural practices, where introduced, have reversed resource degradation and resulted in improved land productivity. More than 200,000 hectares are now managed organically in Africa (Yussefi, Willer 2003).

In most Asian countries, the total area under certified organic management is still quite low. However, the area that is 'in conversion' to organic management systems is increasing rapidly (Yussefi, Willer 2003). In 2001, locally grown organic products (fruits, vegetables, and rice) accounted for only 0.2% of total agricultural production in Korea (Brehm 2002). The demand for these products, however, is growing. In response, the Korean Ministry of Agriculture has developed a labeling program that indicates whether a product is organic, contains low or no agricultural chemicals. At present, the types of organic products that are available to consumers are fresh produce, rice, or products made with organic ingredients, such as baby food, bread, or flour (Yussefi, Willer 2003). About 55% of Korean consumers purchase organic products because of perceived health benefits. Twenty-three percent of Korean consumers purchased organic foods because they believed they tasted better or were more nutritious while only 12% stated that they were concerned with the environment (Brehm 2002).

The potential nutritional difference between conventionally- and organically- produced food has been addressed recently in two review articles. In a review of 41 published studies on organically produced fruits, vegetables, and grains, Worthington (2001) concluded that organic crops contained significantly more Vitamin C, iron, magnesium, and phosphorus and significantly less nitrates than conventional crops. This author also reported non-significant trends showing less protein but of higher quality and lower amounts of some heavy metals (lead, cadmium, mercury, and aluminum) in organic crops. In a second review article, Magkos et al. (2003) concluded there is a trend towards higher ascorbic acid content in organically grown leafy vegetables and potatoes and a lower protein concentration but of higher quality in some organic vegetables and cereal crops. However, these authors cautioned that there are only a few well-controlled studies that are capable of making valid comparisons, and, therefore, the compilation of results is difficult and generalization of conclusions regarding organically-produced versus conventionally-produced products should be made with caution (Magkos et al. 2003). Among the difficulties in obtaining comparable data on organically versus conventionally produced foods is the selection of neighboring farms and fields so that a close comparison of products grown is achieved, thus ruling out any effect of climate and soil conditions on differences observed in food properties (Carbonaro et al. 2002).

The second area of research that has evaluated differences in the nutritional and health properties of conventionally versus organically produced foods is in respect to their levels of phenolic metabolites. A growing body of evidence indicates that secondary plant metabolites, common constituents in fruits and vegetables, play a critical role in human nutrition and health (Block et al. 1992 ; Hertog et al. 1993a ; Hertog et al. 1993b). Of special interest are plant-based phenolic metabolites, which have potent antioxidant activity and a range of pharmacologic properties including : anticancer, antioxidant, and platelet aggregation inhibition activity (Frankel et al. 1993 ; Rein et al. 2000 ; Rice-Evans et al. 1996 ; Wattenberg et al. 1980 ; Waterhouse et al. 1998). There is concern that the levels of some phenolic compounds may be lower than optimal for human health in foods that are grown using conventional agricultural practices (e.g., use of chemical pesticides) (Asami 2003). This concern arises because conventional agricultural practices utilize levels of pesticides and fertilizers that can result in disruption of the natural

production of phenolic metabolites in the plant (Macheix et al. 1990).

A recent study that evaluated the differences in salicylic acid<sup>1</sup> in soups prepared from organically and non-organically grown vegetables reported that organic vegetable soups contained more salicylic acid than non-organic soups, suggesting that the vegetables and plants used to prepare them contained greater amounts of phenolic acid than the corresponding non-organic ingredients (Baxter et al. 2001). Further studies are required to establish whether these differences occur in other foodstuffs, and if consumption of organic foods results in a significantly increased dietary intake of salicylic acid (Baxter et al. 2001). In another study that aimed to assess the antioxidant profiles of conventionally- and organically-grown peaches and pears, Carbonaro et al. (2002) reported a statistically significant increase in the polyphenol content in organically grown peaches and pears when compared with conventional samples. Ascorbic and citric acids were higher in organic compared to conventional peaches whereas alpha-tocopherol was increased in the organic pear.

Asami et al. 2003, who evaluated the total phenolic and ascorbic acid content of the marionberry (a type of blackberry), strawberry, and corn using conventional, organic, and sustainable agricultural practices (use of fertilizers but no herbicides or pesticides), found significantly higher levels of total phenolic content in the organically- and sustainably-grown crops compared with the conventionally-grown crops. All agricultural commodities used in this study were grown under controlled conditions and supplied by the same farm. These authors concluded that further studies are needed to investigate the links among different agricultural practices and levels of total phenolic content in a wider variety of important food crops (Asami 2003).

### 3. Farmers' market nutrition programs

Farmers' markets can provide substantial benefits to farmers, consumers and communities. These benefits include : economic stimulation and sustainability, enhanced vitality of the local economy, reduced produce prices, and increased produce quality (Ashman et al. 1993 ; Hilchey et al. 1995 ;

Festing, H. 1998). However, several recent studies have illustrated that low-income communities may face unique barriers to accessing farmers' markets because of food access issues (e.g., lack of transportation, inconvenient hours) (Fisher 1999 ; Klotz, Steiner 2001). Based on these results, it has been recommended that in order for farmers markets to be successful in low-income communities they must : 1) be subsidized, 2) involve community organizing, 3) tailor their product mix to focus on basic foods at affordable prices, 4) hire sales staff from the local neighborhood, and 5) provide transportation (since transportation may provide to be a significant barrier for market operation) (Fisher 1999 ; Klotz, Steiner 2001).

Two federal programs have been introduced in the U.S., including the Women, Infants, and Children Farmers' Market Nutrition Program (WIC FMNP) and the Seniors Farmer' Market Nutrition Program (SFMNP), which may help address the barriers that low-income populations have in accessing farmers' markets. The WIC FMNP was established in 1992 to encourage participants in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) to include more fresh fruits and vegetables in their diets, and to shop more frequently at farmers' markets (USDA 1996). The Federal benefit under the WIC FMNP ranges from \$10 to \$20 per recipient per year, based on the State's discretion. However, state agencies may supplement the benefit level with its matching funds. Nutrition education is also provided to FMNP recipients by the State agency, often through the local WIC agency. A random survey of 2,000 participants in the California WIC FMNP showed a small but statistically significant increase in fruit and vegetable consumption among participants. Total fruit and vegetable intake was 4.50 servings in the group that used the coupons compared with 3.56 in the group that did not (Block-Joy et al. 2001). Data from the Michigan WIC FMNP also indicated that low-income populations were more likely to increased fruits and vegetable consumption when incentives, such as coupons, improved affordability. However, the maximum impact of the intervention was achieved through a combination of education and coupons (Anderson et al. 2001).

The SFMNP, which is administered by the United States Department of Agriculture (USDA) Commodity Credit Corporation, provides vouchers (coupons) to low-income seniors for farmers' markets, roadside stands, and community supported agriculture (CSA) programs. In 2003, the SFMNP ope-

<sup>1</sup>Salicylic acid, which is responsible for the anti-inflammatory action of aspirin, is present in many foods derived from plants where it functions as a chemical signal whose concentration is increased when plants become infected by pathogens. Foodstuffs produced from plants that have been reared organically may contain more Salicylic acid than conventionally reared plants (Baxter et al. 2001).

rated in 35 states, 3 Indian Tribal Organizations, Puerto Rico and the District of Columbia, with a total of \$16.7 million dollars available in grants (USDA 2003). Results from The Seattle Senior Farmers' Market Nutrition Pilot Program, which delivered bi-weekly market baskets that included a variety of fresh, locally-grown produce to 480 low-income Meals on Wheels Participants, indicated that seniors who received the produce baskets reported consuming an increase of 1.04 servings of fruits and vegetables (Johnson et al. 2004). The difference between the mean servings in the seniors who received the baskets (1.04) compared to controls (-.27) was 1.31. An evaluation of the South Carolina SFMNP found that of the 98% of respondents who used the vouchers to purchase locally-grown produce, 89% reported an intention to eat more fruits and vegetables year round because of the program. However, of the 98% of respondents who participated in the program, 83% reported not purchasing foods that they had never tried before, and the most frequently cited barriers to not wanting to attend nutrition classes were lack of transportation and poor health. Seventy-six percent of the farmers who participated in the Seattle Senior Farmers' Market Nutrition Pilot Program reported that they would be willing to set up or drive to another location and 27% said they would expand their hours of operation (Kunkel et al. 2003). Therefore, it appears that in order for the SFMNP to be successful, the program must address potential barriers to participation, including availability (lack of available market in neighborhood) and food access barriers (e.g., lack of transportation, inconvenient hours).

#### 4. Home, school, and community gardens

Recent research has demonstrated that children who participate in growing their own food through gardening have an increased preference for certain vegetables (Morris and Zidenberg-Cherr 2002), and that they are more likely to consume fruits and vegetables as a snack (Koch 2001). Results from the 1995 California Children's 5-A-Day Power Play evaluation study (n = 3,535) found that those participants who responded positively to the question, "*have you ever worked in a garden to grow fruits and vegetables?*," reported consuming significantly more servings of fruits and vegetables than those who had not gardened, 4.8 versus 3.9 for teens and 3.6 versus 2.8 for children (both significant at  $p < .001$ ) (Sugerman et al. 2003). These results are particularly significant since U.S. data indicate that fruits and vegetables are

the food groups most poorly consumed by children, and that vegetable consumption, in particular, is decreasing (Krebs-Smith et al. 1996). Since an increased consumption of fruits and vegetables is associated with decreases in development of certain chronic diseases (Terry et al. 2001), and because children develop habits that track into adulthood (Heimendinger et al. 1995; Kelder et al. 1994), exposure of children to gardening can be a powerful method of improving nutrition and health in this population. The American Dietetic Association, Society for Nutrition Education, and American School Food Service Association (2003) have identified school gardens as an integral part of a comprehensive plan to improve child nutrition and health.

Gardening may also offer nutrition and health benefits to adults and lower-income families. One research study concluded that community gardeners have greater consumption of fresh vegetables compared with non-gardeners, and lower consumption of sweet foods and drinks (Blair et al. 1991). Data from the California Dietary Practices Survey of Adults (n = 1,492) revealed that participants who reported ever working in a garden to grow fruits and vegetables consumed 4.1 versus 2.9 servings ( $p < .001$ ) (Sugerman et al. 2003). Gardening may be a particularly useful way to increase access to fresh produce in low-income populations that do not have access to nutritious food outlets (e.g., grocery stores, farmers' markets) since gardens are often located within neighborhoods and on public property (Twiss et al. 2003). Community gardens also involve characteristics that have been described as being important for health promotion including: social support, an emphasis on informal networks, and community organizing through multiple change tactics (Armstrong 2000). A study conducted in Maine found that of those lower-income families who participated in garden projects, 89% said they ate more fresh vegetables than usual, 96% planned to eat more fresh vegetables all year round, and 79% learned a new way to prepare fresh vegetables (Savoie 1998).

In adults, gardening is one of the most commonly practiced types of exercise (Crespo et al. 1996; Yusuf et al. 1996), and a recommended form of physical activity (Pate et al. 1995). Gardening has been ranked as a moderate to heavy intensity physical activity (Brooks 1988; Ford et al. 1991; Dannenberg et al. 1989). In one study, gardening was associated with a significant reduction in total cholesterol, HDL cholesterol and systolic blood pressure, after controlling for confounders.

Participants spent a greater amount of time doing gardening (225minutes/week) compared with other lead activities, such as walking (160minute/week) and bicycling (170minute/week) (Caspersen et al. 1991). It is also interesting to note that while men have reported exercising more than women (Crespo et al. 1996 ; Yusef et al. 1996), and exercising more vigorously (Crespo et al. 1996 ; Ford et al. 1991), there is evidence that women spend an equal or greater amount of time participating in gardening compared to men. In the Framingham Offspring study, women spent as much time or more in gardening and walking during the spring and summer seasons (Dannenberg et al. 1989). In another study, gardening was reported to be the leading leisure-time physical activity and was reported to be more common among women compared to men of higher socioeconomic status (25% versus 20%) while there was little difference among women and men of lower socioeconomic status (approximately 14%) (Ford et al. 1991).

### 5. Community Support Agriculture(CSA)

“Community supported agriculture” (CSA) is an innovative sustainable agriculture strategy that is designed to : 1) connect local farmers with local consumers ; 2) develop a regional food supply and strong local economy ; 3) maintain a sense of community ; 4) encourage land stewardship ; and 5) honor the knowledge and experience of local growers (University of Massachusetts Extension 1999). Members or ‘shareholders’ who join a CSA farm pay a membership fee in exchange for receiving a share of produce each week during the harvest season (Cohen, Cooley, Hall and Stoddard 1997). A major reason that people choose to become members in a CSA farm is to receive high quality organic produce (Appropriate Technology Transfer for Rural America, 1995). One study that assessed dietary patterns and food choices of CSA members versus non-members found that CSA members had higher consumption of dark green and yellow fruits and vegetables and higher dietary intake of total fiber and Vitamin A compared to non-members (Cohen, Cooley, Hall, Stoddard 1997). However, participants in this study were highly educated, mainly white, and had moderate to high incomes. Therefore, further research that includes participants from a wider range of educational, income and ethnic groups is needed to assess possible differences in dietary patterns and food choices between CSA members and non-members.

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## Summary and Conclusion

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The idea of connecting sustainable agriculture with the promotion of human nutrition and health is a concept that was introduced to the nutrition profession more than 20 years ago. In order to promote more healthful, sustainable diets, nutrition professionals should recommend that consumers purchase more whole foods and fewer highly processed foods. Nutrition professionals can also recommend to consumers specific ways in which they can support sustainable agriculture in the marketplace. These include : purchasing organically-produced foods, shopping at farmers’ markets, participating in home, school, and community garden projects and participating in CSA. Nutrition professionals can also educate the public on the potential human nutrition and health benefits of sustainable agriculture. Organic farming systems offer potential benefits to human health through reducing farmers’ exposure to pesticides and by increasing the total phenolic content in selected food crops. Participation in farmers’ market nutrition programs and home, school, and community gardens has been shown to increase consumers’ fruit and vegetable intake. Gardening may be a particularly useful way to increase access to fresh produce in low-income populations that do not have access to nutritious food outlets (e.g., grocery stores, farmers’ markets) and to increase physical activity. Further research is needed to assess the potential human nutrition and health benefits of other types of sustainable agriculture strategies, such as CSA, and to investigate the links among different agricultural practices with nutrient and total phenolic content in a wider variety of important food crops.

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