UpToDate©: Organic Foods and Children

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INTRODUCTION — Organically grown foods are foods that are grown or processed without the use of synthetic fertilizers or pesticides [1-5]. Organic farmers attempt to protect the environment by using natural matter (eg, aged manure, humus, and compost) for fertilizer and biological methods of pest control (eg, crop rotation and natural insect predators like lady bugs) [2,4,6]. Livestock and poultry used for egg, dairy, and meat production are raised on organically grown feed and without antibiotics or hormones [6].

The standards for growing and labeling organic food may vary depending upon the certifying organization or agency. The World Health Organization (WHO) and the Food and Agriculture Organization [7], as well as the Environmental Protection Agency (EPA) of the United States have adopted or proposed guidelines for the production, processing, labeling, and marketing of organic foods in an attempt to ensure that all foods that are labeled organic meet the same minimum standards.

As of October 21, 2002, food that is labeled "organic" in the United States must meet the standards of the USDA. The USDA organic seal indicates that a food is at least 95 percent organic; however, the use of this seal is voluntary. Products with less than 70 percent organic ingredients may list individual organically produced ingredients on the side panel, but may not claim to be organic on the front of the package [8].

Consumer demand for organic foods has grown steadily during the past decade [6,9]. Organic foods are available increasingly in supermarkets and chain food stores [4,6,10,11]. Although organic foods accounted for only 1.8 percent of national food sales in 2003, organic farming is one of the fastest growing segments of American agriculture. Producers, exporters, and retailers are struggling to meet consumer demand for a wide range of organic food products [6]. By 2010, sales of organic foods are estimated to rise to 3.5 percent of total retail food sales in the United States [6].

- According to the United States Department of Agriculture (USDA), the area of farmland devoted to organic crop production more than doubled between 1990 and 2005, increasing from 1 million acres to 2.3 million acres. Currently, certified organic farmland is found in all 50 states [12].

- Several large food companies (eg, Sunrise cereal from General Mills Company) have begun to market organic products.

- The value of retail sales of organic foods was approximately $10 billion in 2003. Sales of organic foods are estimated to rise to $24 billion by 2010 (approximately 20 percent annually) [6]. Fresh produce (fruits and vegetables) are the top-selling

organic category (93 percent in 2003), followed by nondairy beverages, breads and grains, packaged foods, and dairy products [4,6].

The increased demand for organically grown food can be attributed to [1,2,4-6,11,13,14]:

- Concern about the nutritional adequacy of foods grown by conventional agriculture
- Concern that pesticides and chemical fertilizers have adverse health effects
- Concern about environmental effects of pesticides and chemical fertilizers

Demand for food purity has increased despite governmental assurances that the American food supply is one of the safest in the world [11,15]. Organically grown foods are promoted and perceived by consumers to be healthier than conventionally grown foods [9,13,16].

Pediatric healthcare providers should be prepared to help the parents of their patients make informed decisions regarding the purchase and consumption of organic foods.

NUTRITION — Advocates of organic foods claim that organically grown foods are nutritionally superior to foods grown with conventional agriculture methods that use chemical fertilizers [2,11,13,17]. Many people believe that commercial fertilizers lack some nutrients that are present in "natural" organic fertilizers. They argue that "natural" fertilizers are better able to nourish plants and thus result in more nutritious foods [11].

The nutrient content of a plant is determined by several factors, including the genetic makeup, climate and soil conditions, maturity at harvest, storage, and distribution time [2,18]. Nitrogen, potassium, and phosphorous, the main soil nutrients required by crops, must be present in sufficient amounts for plants to grow [19].

Fertilization enriches soil by providing the necessary nutrients. It does not matter whether organic or synthetic fertilizers are used as long as all of the essential nutrients are provided [19]. Synthetic fertilizers are formulated to meet this requirement. Organic fertilizers may or may not. Organic fertilizers (typically manure) must be converted to soluble mineral salts by soil bacteria before they can be utilized by plants [19]. Manure breakdown cannot be synchronized with crop growth. In addition, the nutrient benefit of manure is unpredictable because its composition varies [3].

Nutrient-deficient soil affects crop yields to a greater extent than does nutritional value [18]. The nutritional value of organically and conventionally grown foods usually are similar; however, organic vegetables may have lower nitrate and protein content [1,5,20].

COST — Organically grown foods may cost 50 to 100 percent more than conventionally grown foods [6,21], the reasons for which include [3,22]:

- The smaller supply; organic farmers are fewer and crop yields and smaller
- The increased labor intensity of growing food without synthetic pesticides and chemicals

FOOD SAFETY — Three areas of food safety to consider when comparing organic and conventionally grown foods are microbial infection, natural toxins, and pesticide use.

Microbial infection — Microbial infection is the main cause of food-related illness [23]. Young children are particularly vulnerable because of the immaturity of their immune systems [24,25]. Escherichia coli (E. coli) 0157:H7, Salmonella, Listeria monocytogenese, and Campylobacter jejuni are the major pathogens of foodborne illness [25].

Foods, whether organically or conventionally grown, can become contaminated by fertilization with raw manure, irrigation of crops with contaminated water, or inadvertent contact with fecal matter during handling or processing. Illness caused by E. coli O157:H7, for example, has been linked to fresh-pressed apple juice and cider [5,26]. Pasteurization, canning, and freezing help to prevent illness caused by Salmonella, E. coli, Campylobacter, and Listeria monocytogenes contamination [27,28]. An increasing number of major food-borne disease outbreaks have been linked to consumption of fecal contamination of fresh or minimally processed produce [11,29-32].

The prevention of foodborne illness requires safe food handling practices for both organic and conventional foods. These measures include:

- Thoroughly cooking meat
- Storing foods at appropriate temperatures
- Preventing cross-contamination from meats and poultry to other foods
- Keeping hands, tools, and kitchen surfaces clean

Natural toxins — Some foods, whether organically or conventionally grown, contain naturally occurring toxins: aflatoxins in peanuts and grains, solanine in green parts of potatoes, goitrogens in some raw vegetables, and other poisons in mushrooms and herbs [11]. Most of these naturally occurring toxins are harmless when eaten in small amounts as part of a healthy diet [11]. As with pesticides, "poison" is a matter of dose [33].

Pesticides — Much of the debate about organic and conventional agriculture centers on the use of pesticides. Promoters of organic foods suggest that the pesticides used in commercial farming are detrimental to food safety and health [14]. Surveys show that individuals who purchase organic foods believe that pesticides, at any level of exposure, are hazardous to health, food safety, and the environment, and that something must be done to reduce this risk [23,34,35].

Many people are frightened by reports that lack scientific peer review. Media attention may perpetuate this misinformation. In 1989, for example, the media portrayed Alar, a growth regulator used mainly on apples, as a potent cancer-causing threat to children. As a result, apples and apple products treated with Alar were destroyed and Alar was voluntarily withdrawn from the domestic market. However, many health authorities, including the Surgeon General and the American Medical Association, issued statements that Alar poses no risk to the public's health when used in the approved, regulated fashion [23].

Organic foods contain synthetic pesticide residues, but they usually are present in smaller amounts than in conventionally grown foods [5,36,37]. Cross-contamination by wind and groundwater may account for the pesticide residues found on organically grown foods because organic farmers avoid the use of synthetic pesticides [11,15,38,39]. In addition, all plants produce toxins ("natural pesticides") that protect them from fungi, insects, and predators [11,40,41]. Plant varieties that have been developed to be naturally pest-resistant may contain increased amounts of natural pesticides and have adverse health effects [11,42].

Benefits — Careful and judicious use of pesticides permits a more abundant food supply. Pesticides increase crop yields and affordability of fruits and vegetables throughout the year. They also may prolong shelf life and retard mold growth [43].

Adverse effects — Potential adverse effects from too much exposure to a pesticide range from mild symptoms of dizziness and nausea to serious, long-term neurologic, developmental, and reproductive disorders.

Compared to adults, infants and young children have different levels of risk for adverse effects of pesticides. Several reasons are [23,44-48]:

- Children eat relatively more food (particularly fruits and vegetables) per unit of body weight than do adults.
- Children tend to eat large quantities of single foods for days or weeks on end.
- Children's behaviors, such as playing on the floor and placing hands and objects in their mouths, may increase exposures to pesticides.
- A child's developing organ systems may be more susceptible to the effects of pesticides (eg, nervous system) or less able to clear the metabolites (eg, renal).
- Infants and children may have unique exposure pathways such as through the placenta and through breast milk.

Exposure *in utero* — Effects of pesticides may depend on the developmental stage when exposure occurs [49]. There is some evidence from animal studies that *in utero* exposure to organophosphate (OP) pesticides at high doses may affect neurodevelopment and growth in the offspring [50,51]. The few studies that have focused specifically on pesticide exposure of children *in utero* indicate that OP pesticides are transferred to the developing fetus during pregnancy [52-55].

Studies about associations between maternal pesticide exposure and fetal growth have conflicting results. In one study of an urban cohort of pregnant women and newborns in Manhattan, measurements of OP pesticides (chlorpyrifos and diazinon) were inversely associated with both birth weight and length prior to 2001 [56,57]. The adverse association between OP exposure and fetal growth disappeared within a year of the EPA regulatory action to phase out these pesticides. Conversely, in a birth cohort in California, maternal organochlorine exposure was not associated with birth weight, length, or length of gestation [58].

Women living in agricultural communities appear to have higher levels of exposure to pesticides. Urinary metabolites of OP pesticides were measured during pregnancy and after delivery in 600 women residing in an agricultural community in California [53]. Metabolite levels during pregnancy and postpartum were higher in this population than in a sample of women of childbearing age in the general U.S. population. The differences were more pronounced at the post-partum measurement, when levels were 2.5 times higher than in the reference population. These findings may have implications for estimating dose of exposure during pregnancy and lactation.

There is some evidence supporting an association between OP exposure and alterations in neonatal neurobehavior [51]. In the cohort described above, neonatal neurobehavior was assessed with the Brazelton Neonatal Behavioral Assessment Scale (BNBAS), and *in utero* and early postnatal OP exposure was measured by urinary OP metabolites. The study revealed a correlation between prenatal urinary metabolite levels and abnormal reflexes in the infants. However, no detrimental assocations were found between postnatal urinary metabolite levels and any of the neurodevelopmental measures.

Exposure in childhood — Most evidence indicates that traces of pesticide residues in foods are not a problem for most people [59]. However, data are limited regarding the toxicologic consequences of exposure to pesticide residue during infancy and early childhood [60].

Children who live in agricultural settings may be exposed to higher levels of OP pesticides than their urban counterparts [61-64]. Children of farmworkers may be exposed to pesticides tracked into their homes by household members, by pesticide drift, by playing in contaminated areas, or through breastmilk from their farmworker mother [49]. Researchers in Washington State found that the median metabolite pesticide levels in 109 preschool children of agricultural workers were five times higher than in those in a reference population [65]. Studies are currently examining the effectiveness of interventions to reduce pesticide exposure to this population, including education of parents in pesticide safety and to remove contaminated shoes and clothing before entering the home, and to keep children away from pesticide-treated areas [63,66].

Pesticide regulation — Use of pesticide is regulated strictly by three federal agencies: the EPA, the Food and Drug Administration (FDA), and the USDA [67].

The EPA establishes a tolerance for all pesticides that are registered and approved for use in the United States [68]. Tolerance is defined as the legal limit of a pesticide residue allowed in or on a raw agricultural commodity and, in appropriate cases, on processed foods [60]. The pesticide tolerance for various crops or chemicals can be obtained from the EPA's Web site: www.epa.gov/pesticides/food/viewtols.htm.

The EPA uses toxicity data from animal studies that attempt to mimic human exposure (eg, continuous low-level ingestion) to determine tolerance levels. Multigenerational animal studies are used to determine the pesticide's effects on reproduction, pregnancy, and lactation [69].

If studies suggest that children may be harmed by exposure to a pesticide, the EPA does not approve the pesticide's use or requires action to reduce the potential risks. Examples for which consideration for the health of infants and children affected decisions include (pmep.cce.cornell.edu/issues/foodsafety-issues.html):

- The tolerances for the pesticide pydrin on alfalfa and sorghum were not approved. In 1985 because of concern regarding risks to children from secondary residues in milk.
- The EPA limited the use of two organophosphate pesticides, methyl parathion and azinphos methyl, in 1999.

- Another organophosphate pesticide, chlopyrifos (Dursban), was banned in 2000.

- In 2001, the EPA began to phase out diazinon, one of the most widely used organophosphate pesticides [70].

In 1993, the National Research Council (NRC) issued a report on pesticides in the diets of infants and children [60]. The report concluded that children may be exposed to relatively larger amounts of certain pesticide residues than are adults and that the exposure occurs at a vulnerable point in their development. It acknowledged the need for reassessment of pesticide tolerances that would apply specifically to infants and children and recommended the collection of data that would more accurately reflect the dietary patterns of children and the effects of pesticide exposure in infants and children [44,46,60].

The NRC report triggered passage of the Food Quality Protection Act (FQPA) in 1996. The FQPA required the EPA to review and reassess all existing pesticide tolerances to make them safer for infants and children by 2006 [71,72]. The FQPA required the EPA to apply an additional 10-fold margin of safety to its pesticide assessments to address the potential for pre- and postnatal toxicity and to compensate for gaps or inadequacies in the available database regarding potential health risks to infants and children [73-75]. The EPA is required to apply the 10-fold safety factor unless there are reliable data to support use of a different safety factor to protect infants and children [46,74,76].

As of August 3, 2006, the EPA had completed 9637, or more than 99 percent, of the planned tolerance reassessments; the remaining tolerance reassessment cases are to be completed by October 3, 2008. The tolerance reassessment process has led to EPA decisions to revoke or modify thousands of existing tolerances (3200 and 1200, respectively), and to require the establishment of many new tolerances, improving food safety and health protection. The new tolerances also ensure that pesticides used on foods meet the stringent FQPA safety standards [77].

Tolerance levels are enforced by the USDA for meat and poultry and by the FDA for all other foods. The FDA specifically analyzes for pesticide residues all foods eaten by infants and children. As an example, pesticide residues on apples, bananas, oranges, pears, grape and orange juice, and milk were monitored by the FDA between 1985 and 1991 [67,78,79]. More than 10,000 food samples were analyzed before processing and without washing or peeling. Fifty samples (0.5 percent) were in violation (0.3 percent of domestic products and 0.6 percent of imports). The majority of these violations occurred because the pesticide was not approved for use on that particular food.

The FDA monitors nutritional concerns, including pesticide exposure, through the Total Diet Study. This study examines 234 foods selected to typify the American diet. Between 1985 and 1991, analysis of these foods revealed:

- No residues were found in infant formulas
- No residues over the EPA tolerance or FDA action level were found in any of the "market basket" foods
- Low levels of malathion were found in some cereals
- Low levels of thiabendazole, a post-harvest fungicide, were found on some fruits and fruit products

The Total Diet Study findings for 2003 were consistent with previous FDA reports in that pesticide residues were below regulatory standards. An adjunct survey of baby foods also provided evidence of only small amounts of pesticide residues between 1991 and 2003 [80].

Reduction of exposure — Most pesticides begin to break down soon after application with exposure to sunlight and rain; they continue to break down after harvest [81]. Additional pesticide reduction can be achieved through washing, peeling, cooking, or processing of foodstuffs [67].

As an example, in the FDA monitoring described above, the highest residue level of the fungicide thiabendazole in raw apples was 2 parts per million (ppm), in apple juice was 0.08 ppm, and in applesauce was 0.06 ppm. The established tolerance is 10 ppm [67].

Canned or frozen fruits and vegetables are alternatives to fresh fruits and vegetables for individuals concerned about pesticide residues. Most current food preservation techniques minimize the loss of nutritive value and are safe and well standardized [82]. One comparative analysis of fresh, frozen, and canned vegetables conducted by the University of Illinois found that canned foods are nutritionally equivalent to their fresh and frozen counterparts [83].

Organic diets appear to reduce OP exposure in children. In one study of a group of 39 preschool-aged children in Washington State, children consuming a conventional diet had urinary dimethyl OP metabolites six to nine times higher than children consuming an organic diet [84]. In another study, the short-term effects of changing to an organic diet were measured in 23 school-aged children [85]. After only 24 to 48 hours of the organic diet, urinary OP metabolites (malathion and chloropyrifos) decreased to nondetectable levels. However, whether this reduction of urinary OP metabolites has any relevance to health outcomes has not been shown.

SUMMARY — "Organically grown" refers to the methods used to grow and process agricultural products (eg, fruits, vegetables, dairy, meat, and poultry) and is not related to nutritional quality or food safety [1,5,11]. Both organic and conventional farming supply nutritious foods when selected as part of a well-balanced diet [11,15,86].

Factors to consider when deciding whether to use organic products include:

- Organic foods are not free of synthetic pesticide residues, but probably contain smaller amounts than are present on conventionally grown foods. Thus, organically grown foods provide an alternative source of fruits and vegetables for individuals who are concerned about synthetic pesticides. (See "Reduction of exposure" above).

- Infants and children may be more susceptible to the adverse effects of pesticides than are adults. (See "Exposure *in utero*" above, and see "Exposure in childhood" above).

- In general, the traces of pesticide residue that are found in food pose little threat to human health. Potential adverse effects of pesticide exposure on special populations include neurologic, developmental, and reproductive disorders. (*See "Exposure in utero*" above and see "Adverse effects" above).

- Populations involved in agricultural work have higher levels of pesticide exposure, but evidence of adverse effects of such exposure levels is limited. (*See "Exposure in utero"* above and see "Exposure in childhood" above).

- Pesticides help to maintain an abundant and varied food supply. Pesticide use is regulated by the EPA and enforced by the USDA and the FDA. Efforts are being made to ensure that these regulations are appropriate for infants and children. (See "Pesticide regulation" above).

- Exposure to pesticide residue in either organic or conventionally grown food can be reduced through washing, peeling, cooking, or processing of foods. (See "Reduction of exposure" above).

- Organic food production does not eliminate the risk of foodborne illness, and "organic" should not be interpreted as meaning "safe". (See "Microbial infection" above).

- Organic farming supports smaller, family-owned farms and may be more environmentally friendly [5].

RECOMMENDATIONS — Despite the possible risks of pesticide residues, the American Academy of Pediatrics, American Dietetic Association, the American Medical Society, and the American Cancer Society recommend a diet that is rich in fruits and vegetables, with between five and nine servings of these foods daily [87-89].

Irrespective of the food production system, food safety measures are important [5]. The following steps can be taken to reduce exposure to foodborne pathogens and pesticides:

- Buy the freshest foods available. They will have the best taste and highest nutrient (ie, vitamin) content.

- Consider using frozen or canned fruits and vegetables as an alternative or supplement to fresh produce. These foods maintain most of their nutritional value and may also reduce pesticide exposure as compared to fresh produce.

- Eat a variety of foods to ensure a balanced nutritional intake and to lessen contamination from any one source.

- Select produce that is free of dirt, insect holes, mold, or decay. (See "Natural toxins" above).

- Always wash fruits and vegetables thoroughly with a dish brush.

- Do not use soap or other detergents.

- Peel fruits and vegetables before eating and throw away the outer leaves of leafy vegetables. Some nutrients and fiber may be lost when produce is peeled.

- Trim fat from meat and skin from poultry and fish because some pesticide residues are concentrated in fat.

- Make sure that apple juice and cider are pasteurized, to reduce the risk of food-borne illness such as E. coli 0157 [25,90]. (See "Microbial infection" above).

Additional information about food safety is available from the USDA and FDA Food Safety Web sites [91,92].

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