

Are Organic Foods Safer or Healthier Than Conventional Alternatives?

A Systematic Review

Crystal Smith-Spangler, MD, MS; Margaret L. Brandeau, PhD; Grace E. Hunter, BA; J. Clay Bavinger, BA; Maren Pearson, BS; Paul J. Eschbach; Vandana Sundaram, MPH; Hau Liu, MD, MS, MBA, MPH; Patricia Schirmer, MD; Christopher Stave, MLS; Ingram Olkin, PhD; and Dena M. Bravata, MD, MS

Background: The health benefits of organic foods are unclear.

Purpose: To review evidence comparing the health effects of organic and conventional foods.

Data Sources: MEDLINE (January 1966 to May 2011), EMBASE, CAB Direct, Agricola, TOXNET, Cochrane Library (January 1966 to May 2009), and bibliographies of retrieved articles.

Study Selection: English-language reports of comparisons of organically and conventionally grown food or of populations consuming these foods.

Data Extraction: 2 independent investigators extracted data on methods, health outcomes, and nutrient and contaminant levels.

Data Synthesis: 17 studies in humans and 223 studies of nutrient and contaminant levels in foods met inclusion criteria. Only 3 of the human studies examined clinical outcomes, finding no significant differences between populations by food type for allergic outcomes (eczema, wheeze, atopic sensitization) or symptomatic *Campylobacter* infection. Two studies reported significantly lower urinary pesticide levels among children consuming organic versus conventional diets, but studies of biomarker and nutrient levels in serum, urine, breast milk, and semen in adults did not identify clinically meaningful differences. All estimates of differences in nutrient and contaminant levels in foods were highly heterogeneous except for

the estimate for phosphorus; phosphorus levels were significantly higher than in conventional produce, although this difference is not clinically significant. The risk for contamination with detectable pesticide residues was lower among organic than conventional produce (risk difference, 30% [CI, -37% to -23%]), but differences in risk for exceeding maximum allowed limits were small. *Escherichia coli* contamination risk did not differ between organic and conventional produce. Bacterial contamination of retail chicken and pork was common but unrelated to farming method. However, the risk for isolating bacteria resistant to 3 or more antibiotics was higher in conventional than in organic chicken and pork (risk difference, 33% [CI, 21% to 45%]).

Limitation: Studies were heterogeneous and limited in number, and publication bias may be present.

Conclusion: The published literature lacks strong evidence that organic foods are significantly more nutritious than conventional foods. Consumption of organic foods may reduce exposure to pesticide residues and antibiotic-resistant bacteria.

Primary Funding Source: None.

Ann Intern Med. 2012;157:348-366.

For author affiliations, see end of text.

www.annals.org

Between 1997 and 2010, U.S. sales of organic foods increased from \$3.6 to \$26.7 billion (1, 2). Although prices vary, consumers can pay up to twice as much for organic than conventional foods (3–5).

Organic certification requirements and farming practices vary worldwide, but organic foods are generally grown without synthetic pesticides or fertilizers or routine use of antibiotics or growth hormones (6, 7). Organic livestock are fed organically produced feed that is free of pesticides and animal byproducts and are provided access to the outdoors, direct sunlight, fresh air, and freedom of movement (7). In addition, organic regulations typically require that organic foods are processed without irradiation or chemical food additives and are not grown from genetically modified organisms (6, 8). The International Federation of Organic Agriculture Movements endorses the principles of “health, ecology, fairness, and care” (9).

Consumers purchase organic foods for different reasons, including concerns about the effects of conventional farming practices on the environment, human health, and animal welfare and perceptions that organic foods are tastier than their conventional alternatives (2, 10–13).

The purpose of this study is to comprehensively synthesize the published literature on the health, nutritional, and safety characteristics of organic and conventional foods. Previous reviews comparing the nutritional content of organic and conventional foods have summarized studies narratively (13–18), reported differences in nutrient levels without assessing the statistical significance of those differences or weighting outcomes by sample size (19–22), or considered only harms (23).

METHODS

Data Sources and Searches

With a professional librarian, we developed search strategies for 7 databases: MEDLINE (January 1966 to May 2011), EMBASE, CAB Direct, Agricola, TOXNET, and Cochrane Library (January 1966 to May 2009) with such terms as *organic*, *vegetable*, *fruit*, and *beef* (Supple-

See also:

Web-Only
Supplements

ment 1, available at www.annals.org) and reviewed bibliographies of retrieved articles.

Study Selection

Peer-reviewed, English-language studies, regardless of design, were eligible for inclusion if they reported a comparative evaluation of populations consuming diets of foods grown organically and conventionally or a comparative evaluation of nutrient levels or bacterial, fungal, or pesticide contamination of fruits, vegetables, grains, meats, poultry, milk (including raw milk), or eggs grown organically and conventionally. We excluded studies of processed foods, those that evaluated samples from livestock feces or gastrointestinal tracts, and those that did not report information about variance or results of statistical tests (24–34). Organic practices included biodynamic farming and were defined by investigators' stated adherence. Studies merely comparing the effects of organic and nonorganic fertilization practices were ineligible unless they specified that the produce receiving organic fertilizer was grown by using organic farming practices (28, 32, 33, 35–47). Similarly, we excluded studies of such foods as recombinant bovine somatotropin-free milk and grass-fed beef unless the food production was reported to be organic.

Data Extraction and Quality Assessment

One author abstracted data on study methods (for example, design; food tested; sample size; organic standard; testing methods; harvest season; and cultivar, breed, or population studied) and end points (Supplement 2, available at www.annals.org). At least 1 additional author verified all abstracted data; discrepancies were resolved with discussion. If 2 or more studies presented the same data from a single population or the same farm experiment, we included these data only once in our analyses.

We defined quality criteria a priori and evaluated the extent to which included human population studies specified the organic standard used, evaluated the amount of organic foods consumed in diets, linked reported outcomes with health outcomes, obtained institutional review board approval and participant consent, and were not funded by an organization with a financial interest in the study outcome. For the studies that directly evaluated the study foods, we evaluated the extent to which each study specified the organic standard used, used the same harvesting or processing method for both groups, reported sample size, used equal sample size in both groups, and were not funded by organizations with a financial interest in the study outcome. We also evaluated the extent to which the organic–conventional comparison pairs were of the same cultivar or breed, grown on neighboring farms, and harvested during the same season.

Data Synthesis and Analysis

We calculated summary effect sizes by using random-effects models for outcomes with at least 3 studies reporting data: summary risk differences (RDs) and summary prevalence rates for studies reporting the number of sam-

ples contaminated and summary standardized mean differences (SMDs) for studies reporting mean nutrient or harm levels. Differences were calculated as organic minus conventional (for example, a positive number indicates more contamination in organic). All RDs are absolute RDs.

We performed tests of homogeneity (Q statistic and I^2 statistic) on all summary effect sizes. Homogeneity was indicated if I^2 was less than 25% and P value for the Q statistic was greater than 0.010. If the 2 tests agreed, we report only the I^2 statistic; otherwise, we report results for both. We used funnel plots to assess publication bias (48). We qualitatively summarized studies not reporting information on variance and excluded studies not reporting any information on variance or statistical testing. All analyses were completed by using Comprehensive Meta-analysis, version 2 (Biostat, Englewood, New Jersey). Because of the large number of comparisons (22 for produce and 31 for meat, poultry, milk, and eggs), we report adjusted P values for summary estimates using the Sidak formula for multiple comparisons. For each reported summary effect size, we omitted 1 study at a time to assess the influence of each individual study on summary effects and omitted outliers that were more than 1 order of magnitude larger or smaller than others. We explored heterogeneity by conducting subgroup analyses by food type, organic standard used, testing method, and study design when at least 3 studies examined these subgroups.

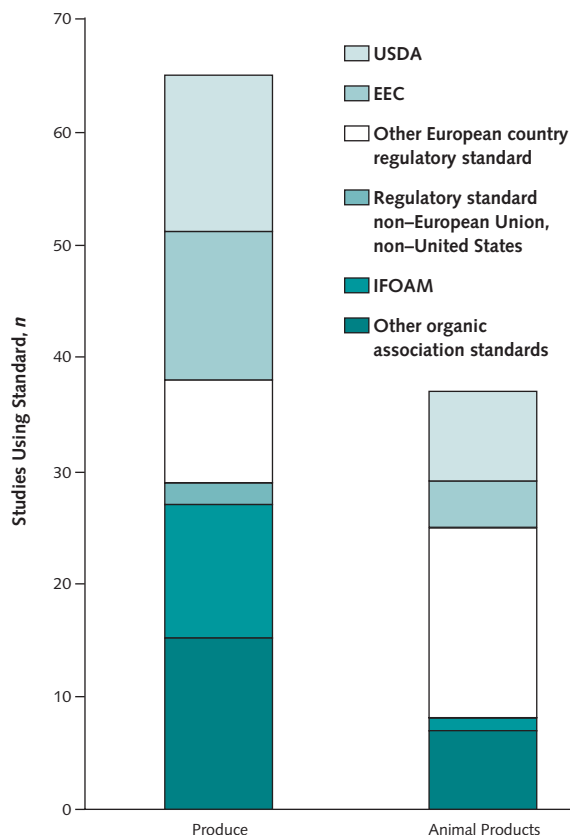
We limited our analyses of bacterial contamination to foodborne pathogens monitored by the Centers for Disease Control and Prevention's FoodNet (49) (for example, *Campylobacter*, *Listeria*, *Salmonella*, and *Escherichia coli*). However, given the potential for transfer of antibiotic resistance between species, we included all human pathogens (for example, *Staphylococcus aureus*) in the analyses of antibiotic resistance.

Studies frequently reported several results per outcome (for example, mean vitamin C level in years 1 and 2). To include such studies only once in our analyses, we combined the results within each study by using random-effects models and used this study-level summary effect in our overall summary calculation.

Similarly, several studies (50–53) reported multiple results for resistance to the same antibiotic by examining different bacteria (for example, *Salmonella* and *Campylobacter*). To include these studies only once in each effect size calculation, we used results for pathogens in the *Enterobacteriaceae* family (for example, *Salmonella*) for the main analyses and the alternate species (for example, *Campylobacter*) in sensitivity analysis.

Among the produce studies, several studies that otherwise could have been included in summary effect size calculations did not report sample sizes. To avoid discarding them, we assumed that they had a sample size of 3 (a common sample size among the smaller studies). In sensitivity analyses, we varied this to 10, the median sample size among studies. This alternate assumption did not change

Figure 1. Organic standards used for studies of produce and animal products.



Sixty-five produce studies and 37 studies of animal products reported the organic standard applied. EEC = European Economic Community; IFOAM = International Federation of Organic Agriculture Movements; USDA = U.S. Department of Agriculture.

conclusions, so we report the outcomes using a sample size of 3.

Role of the Funding Source

This study did not receive external funding.

RESULTS

Searches identified 5908 potentially relevant articles (Appendix Figure 1, available at www.annals.org). Two hundred thirty-seven studies met inclusion criteria: 17 evaluated health outcomes among human populations consuming organic and conventional foods (54–70); 223 compared organic and conventional fruits, vegetables, grains, meats, poultry, milk, or eggs directly (50–53, 57, 65, 69, 71–286) (3 reported on both human and food outcomes). Supplement 2 lists all studies reporting each outcome and studies included in each subgroup analysis.

Studies in Humans Consuming Organic and Conventional Foods

Seventeen articles describing 14 unique populations (13 806 participants) met inclusion criteria (Supplement

3, available at www.annals.org). Study designs varied: 6 randomized, controlled trials (56, 57, 62, 65, 66, 69), 2 prospective cohort studies (54, 61), 3 cross-sectional studies (55, 64, 68), 4 crossover studies (describing 2 populations) (59, 60, 63, 67), and 1 case–control study (70). Only 3 studies (61, 64, 70) examined clinical outcomes (for example, wheezing, allergic symptoms, or reported *Campylobacter* infections), and the remaining studies examined health markers (for example, serum lipid or vitamin levels).

In general, the included studies were of fair quality (Appendix Figure 2 [top panel], available at www.annals.org). Only 6 studies specified the organic standard used. Only 5 studies (54, 61, 64, 65, 68) evaluated participants who consumed a predominately organic diet; participants in the remaining studies consumed only certain organic foods (for example, apples [62], carrots [69], or meat or dairy products [68]). The sample sizes ranged from 6 to 6630, and duration ranged from 2 days to 2 years. Four studies were from the United States (55, 59, 60, 63), and all others were from Europe.

Studies in Pregnant Women and Children

One prospective cohort study (61) and 1 cross-sectional study (64) of pregnant women and their children reported no association between diet type and the development of eczema, wheezing, serum IgE levels, or other atopic outcomes among children. Exploratory subgroup analyses found that children who consumed dairy products of which more than 90% were organically produced had a lower risk for eczema at age 2 years than children who consumed dairy products of which less than 50% were organically produced (odds ratio, 0.64 [95% CI, 0.44 to 0.93]) (61).

Three other studies examined markers of pesticide or insecticide exposure in children. One cross-sectional study (55) and 1 crossover study (59) examined urinary organophosphate pesticide metabolites, finding significantly lower levels among children on organic diets than those on conventional diets. Although these studies suggest that consumption of organic fruits and vegetables may significantly reduce pesticide exposure in children, they were not designed to assess the link between the observed urinary pesticide levels and clinical harm. One crossover study comparing urinary insecticide levels among children spending 5 days on a conventional diet followed by 5 days on an organic diet found household use of insecticides—but not diet—to be a significant predictor of urinary insecticide levels (60).

Studies in Nonpregnant Adults

Eleven reports of 10 populations examined differences between adults consuming organic and conventional diets. Only 1 reported clinical outcomes: An exploratory case–control study (70) found consumption of organic meat in

Table 1. Summary of Benefits: SMD of Nutrient Levels Found in Organic Versus Conventional Fruits, Vegetables, and Grains*

Nutrient	Summary of All Identified Studies				Results of Meta-analysis						
	Studies, n	Comparisons, n	Comparisons Favor Organic, n†	Comparisons Favor Conventional, n‡	Studies, n§	Studies Describing Sample Size, n	Organic Sample Size, n	Conventional Sample Size, n	SMD (95% CI)	P Value¶	Heterogeneous (I ² Statistic)
Ascorbic acid	Foods studied: banana, berries, broccoli, cabbage, carrots, celery, eggplant, grapes, leafy greens, lettuce, oranges, peaches, pears, peppers, plums, potatoes, strawberries, and tomatoes										
	41	113	23	12	31	28	1141	1306	0.50 (0.05 to 0.95)	0.48	Yes (80%)
β-Carotene	Foods studied: eggplant, plums, carrots, tomatoes, sweet peppers, kale, and orange										
	16	23	6	3	12	6	114	114	1.14 (−0.13 to 2.42)	0.83	Yes (91%)
α-Tocopherol	Foods studied: peaches, pears, plums, corn, cabbage, carrots, and olive oil										
	8	19	3	2	5	5	60	60	−0.09 (−0.70 to 0.53)	1.00	Yes (26%)
Potassium	Foods studied: carrots, celery, corn, oranges, grapes, potatoes, peppers, plums, onions, strawberries, and wheat										
	37	108	18	18	14	9	300	315	0.45 (−0.30 to 1.20)	1.00	Yes (87%)
Calcium	Foods studied: carrots, celery, corn, oranges, peppers, plums, strawberries, onions, potatoes, and wheat										
	36	105	18	7	15	11	484	500	0.61 (0.01 to 1.22)	0.68	Yes (84%)
Phosphorus	Foods studied: carrots, celery, corn, plums, onions, and potatoes										
	30	82	24	12	7	6	353	374	0.82 (0.44 to 1.20)	<0.001	No (0%)
Magnesium	Foods studied: potato, plums, onions, peas, carrots, celery, corn, cabbage, strawberries, peppers, tomato, orange, and wheat										
	34	86	23	6	13	10	352	362	0.65 (0.01 to 1.30)	0.66	Yes (81%)
Iron	Foods studied: potato, plums, onions, peas, corn, cabbage, carrots, strawberries, peppers, wheat, oats, and tomatoes										
	24	77	10	12	12	9	350	300	0.30 (−0.47 to 1.08)	1.00	Yes (90%)
Protein	Foods studied: wheat, banana, plum, tomato, soybeans, grape juice, and eggplant										
	27	63	7	34	14	8	93	108	−1.27 (−3.20 to 0.62)	1.00	Yes (83%)
Fiber	Foods studied: banana, eggplant, plums, wheat, grape juice, and oranges										
	8	11	2	5	7	3	73	90	−0.79 (−1.87 to 0.29)	0.97	Yes (83%)
Quercetin	Foods studied: plums, tomatoes, bell peppers, grapes, grape leaves, lettuce, strawberries, and black currants										
	13	50	16	2	11	6	156	156	2.45 (0.20 to 4.69)	0.52	Yes (94%)
Kaempferol	Foods studied: plums, black currants, grapes, lettuce, bok choy, collard greens, tomatoes, bell peppers, strawberries, and tomatoes										
	9	18	6	2	9	5	96	96	2.64 (0.41 to 4.86)	0.36	Yes (93%)
Total flavanols	Foods studied: apples, grape leaves, strawberries, chicory, and black currants										
	5	22	7	6	5	3	96	96	−0.19 (−1.68 to 1.31)	1.00	Yes (59%)
Total phenols	Foods studied: apples, peaches, pears, plums, bell peppers, berries, tomatoes, chicory, olive oil, grape leaves, oranges, strawberries, bok choy, lettuce, leafy greens, tomatoes, and wheat										
	34	102	36	12	22	19	401	401	1.03 (0.47 to 1.59)	0.007	Yes (67%)

SMD = standardized mean difference.

* All summary effect measures reported are results of random-effects models. Among studies examining nutritional content, studies with null findings tended to report results incompletely (hence, they were excluded from syntheses). The exception to this rule was among studies reporting on protein content of organic vs. conventional grain: Studies insufficiently reporting results (hence, they were excluded from summary effect calculation) tended to find significantly higher levels of protein in conventional vs. organic grains. In calculation of summary effect sizes, sensitivity analyses were performed, in which studies not reporting sample size were removed, and subgroup analyses were done by fresh vs. dry weight. Findings did not substantially change with the sensitivity analyses.

† The number of comparisons in which a statistically significant difference was identified with higher levels in the organic group.

‡ The number of comparisons with a statistically significant difference with higher levels in the conventional group.

§ Supplement 2 (available at www.annals.org) lists the studies included for each statistical analysis.

|| The difference between mean nutrient level in organic minus that in conventional divided by the pooled SD; thus, a positive (negative) number indicates higher (lower) nutrient levels in organic.

¶ All summary *P* values are adjusted *P* values.

the winter (but not organic meat in general) to be a risk factor for illness due to *Campylobacter* infection (odds ratio, 6.86 [CI, 1.49 to 31.69]).

The remaining studies examined differences in the serum, urine, breast milk, and semen of persons consuming organic and conventional diets. We found no studies comparing pesticide levels among adult consumers of organic versus conventional foods. Seven studies evaluated serum and urine antioxidant levels or immune system markers; 6 of these found no consistent differences in plasma or urine carotenoids, polyphenols, vitamins E and C content, low-density lipoprotein cholesterol, antioxidant activity, ability to protect against DNA damage, immune system markers, or semen quality between participants consuming organic and conventional diets (54, 57, 62, 65, 66, 69). All were randomized, controlled trials except the study of semen quality (a prospective cohort study) (54). One prospective

crossover study reported a statistically significant reduction in serum total homocysteine levels, phosphorus levels, and fat mass after 2 weeks on an organic Mediterranean diet compared with a conventional Mediterranean diet but did not describe the magnitude or clinical significance of these reductions (67). Another crossover study found that organic diets were associated with higher urinary excretion of quercetin and kaempferol but not other polyphenols and found no difference in 7 of 8 serum markers of antioxidation (56).

Two cross-sectional studies examined the breast milk of women from the Dutch KOALA (Child, Parent, and Health: Lifestyle and Genetic Constitution) Birth Cohort consuming predominantly organic versus conventional meat and dairy products (58, 68). They found no difference in the amount of total fatty acids in the breast milk of mothers who consumed meat and dairy products of which

Table 2. Summary of Harms: RD or SMD in Harms in Organic Versus Conventional Fruits, Vegetables, and Grains*

Harm	Summary of All Identified Studies			
	Studies, <i>n</i>	Comparisons, <i>n</i>	Comparisons Favor Organic, <i>n</i> †	Comparisons Favor Conventional, <i>n</i> ‡
Any detectable pesticide residue contamination**	22	NA		
<i>E. coli</i> contamination	5	NA		
DON contamination	9	NA		
OTA contamination	7	NA		
Cadmium level	15	77	21	1
Lead level	11	49	9	7
Mercury level	3	34	0	0
Arsenic level	2	16	0	0
DON level	10	29	9	0
OTA level	4	15	3	2

E. coli = *Escherichia coli*; DON = deoxynivalenol; NA = not applicable; OTA = ochratoxin A; RD = risk difference; SMD = standardized mean difference.

* All summary effect measures reported are results of random-effects models.

† The number of comparisons in which a statistically significant difference between organic and conventional was identified with lower levels in the organic group.

‡ The number of comparisons with a statistically significant difference with lower levels in the conventional group.

§ Supplement 2 (available at www.annals.org) lists the studies included for each statistical analysis.

|| RD is calculated as the risk for contamination in the organic group minus that in the conventional group; thus, a positive (negative) number indicates more (less) contamination in organic. All RDs are absolute RDs. SMD is the difference between mean contaminant level in organic minus that in conventional divided by the pooled SD; thus, a positive (negative) number indicates more (less) contamination in organic.

¶ All summary *P* values are adjusted *P* values.

** One of the studies included in the pesticide synthesis includes a data set (U.S. Department of Agriculture's Pesticide Data Program) that oversamples products from sources with a history of violations. Hence, prevalence estimates may overstate prevalence of pesticide contamination in both organic and conventional products.

†† Result not robust to removal of 1 study at a time. Removal of 1 study (225) rendered results significant, suggesting higher contamination among organic produce (RD, 5.1% [95% CI, 2.92% to 7.18%]; *P* < 0.001; *I*² = 0%).

‡‡ For cadmium, lead, mercury, arsenic, DON, and OTA levels, these are the sample sizes instead of the number of contaminated samples divided by the total number of samples.

more than 90% were organically produced versus mothers who consumed meat and dairy products of which less than 50% were organically produced (58, 68). In subanalyses, they found higher levels of 2 beneficial fatty acids (conjugated linoleic acid and trans-vaccenic acid) in the breast milk of mothers consuming predominantly organic dairy and meat products versus mothers consuming conventional alternatives (58).

Studies of Nutrient and Contaminant Levels in Organic Versus Conventional Foods

Two hundred twenty-three studies of foods met inclusion criteria: 153 studies of fruits, vegetables, and grains and 71 studies of meats, poultry, milk, and eggs (1 study reported on both types of foods [189]) (Supplement 4, available at www.annals.org). Seventy percent (157 studies) were from Europe, and 21% (47 studies) were from the United States or Canada. Study methods varied: Among produce studies, 52% (80 studies) were on experimental farms in which potential confounders (for example, weather, geography, or plant cultivar) of the relationship between method of cultivation and nutrient levels were

controlled and 29% (44 studies) sampled food grown on commercial farms. Among animal product studies, 11% (8 studies) were conducted on experimental farms and 56% (40 studies) surveyed farms. Of the 37 milk studies included, 7 examined pasteurized milk and 30 examined raw milk (Supplement 4).

Forty-six percent (102 studies) of included studies specified the organic cultivation standard used (Appendix Figure 2 [bottom panel]). The most common standards were European Union or other European country-specific standards (43 studies), International Federation of Organic Agriculture Movements or other association standards (34 studies), and U.S. Department of Agriculture standards (22 studies). The most common standards among produce studies were from organic associations; country-specific European regulatory standards were most common among animal product studies (Figure 1).

Sixty-eight percent (151 studies) reported that harvesting or processing methods were the same for both groups; the remaining studies largely did not describe harvesting or processing methods (such as in studies that examined retail

Table 2—Continued

Results of Meta-analysis						
Studies, n§	Studies Describing Sample Size, n	Contaminated/Total Organic, n/N	Contaminated/Total Conventional, n/N	Difference (95% CI)	P Value¶	Heterogeneous (I ² Statistic)
Foods studied: variety of fruits and vegetables 9	9	253/3041	45 184/106 755	RD, -30% (-37% to -23%)	<0.001	Yes (94%)
Foods studied: apples, bell peppers, berries, bok choy, broccoli, cabbages, carrots, cucumber, leafy greens, lettuces, spring mix, scallions, spinach, summer squash, tomatoes, and zucchini 5	5	63/803	39/1454	RD, 2.4% (-1.5% to 6.3%)††	1.00	Yes (58%)
Foods studied: barley, buckwheat, corn, mixed grains, rice, rye, and wheat 9	9	267/393	310/347	RD, -23% (-37% to -8%)	0.043	Yes (89%)
Foods studied: baby multicereal, baby rice cereal, baby semolina, barley, buckwheat, corn, maize/tapioca, oats, rice, rye, spelt, and wheat 7	7	384/713	791/1641	RD, 11% (-3% to 24%)	0.93	Yes (92%)
Foods studied: beet, bell peppers, cucumber, greens, green beans, lentil, oats, potatoes, purple 11	9	568††	470††	amaranth, strawberries, tomatoes, and wheat SMD, -0.14 (-0.74 to 0.46)	1.00	Yes (87%)
Foods studied: cucumber, greens, potato, strawberries, tomato, and wheat 8	7	207††	354††	SMD, 0.38 (-0.16 to 0.92)	0.98	Yes (75%)
Foods studied: results not synthesized 0	NA	NA	NA	NA	NA	NA
Foods studied: results not synthesized 0	NA	NA	NA	NA	NA	NA
Foods studied: oats and wheat 8	8	278††	275††	SMD, -0.82 (-1.19 to -0.45)	<0.001	Yes (69%)
Foods studied: corn and wheat 4	4	198††	214††	SMD, -0.21 (-0.13 to 0.54)	1.00	Yes (62%)

samples). Eighty-seven percent (194 studies) reported sample size; however, definitions of a sample varied (for example, 1 sample is 10 apples from 1 tree vs. 10 apples from 1 row of trees). Sixty-five percent (146 studies) had equal sample sizes in both groups, and 91% (204 studies) were not funded by an organization with an overt interest in the outcome. Eighty-six percent (61 studies) of animal product studies sampled animal products from the same season. Among produce studies, 59% (90 studies) and 65% (100 studies) compared food pairs from neighboring farms or the same cultivar, respectively.

Vitamin and Nutrient Levels by Food Origin

Vitamins

We did not find significant differences in the vitamin content of organic and conventional plant or animal products (Supplement 5 [available at www.annals.org] and Table 1). Produce studies reported on ascorbic acid (31 studies), β -carotene (12 studies), and α -tocopherol (5 studies) content; milk studies reported on β -carotene (4 studies) and α -tocopherol levels (4 studies). Differences were heterogeneous and not significant. Few studies examined vitamin content in meats, but these found no difference in β -carotene in beef (272), α -tocopherol in pork (149) or beef (272), or vitamin A (retinol) in beef (272).

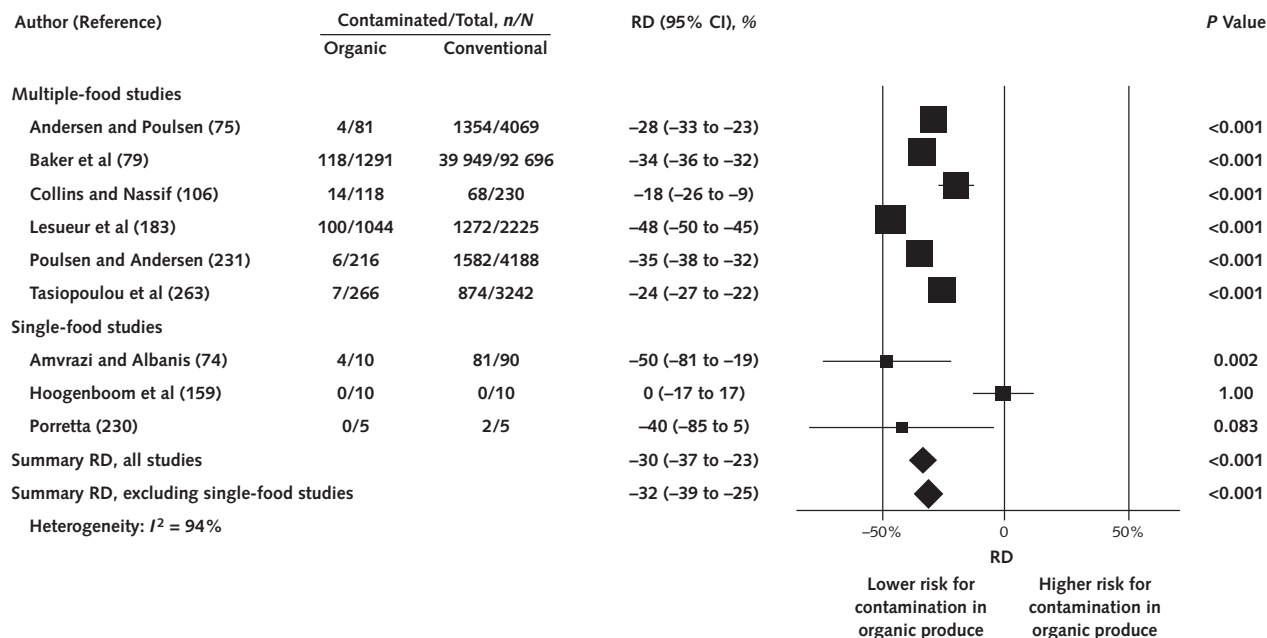
Nutrients

Summary SMDs were calculated for 11 other nutrients reported in studies of produce (Table 1). Only 2 nutrients were significantly higher in organic than conventional produce: phosphorus (SMD, 0.82 [CI, 0.44 to 1.20]; $P < 0.001$; 7 studies; median difference, 0.15

mg/kg [minimum difference, -18 mg/kg; maximum difference, 530 mg/kg]) and total phenols (SMD, 1.03 [CI, 0.47 to 1.59]; $P = 0.007$; 22 studies; median difference, 31.6 mg/kg [minimum difference, -1700 mg/kg; maximum difference, 10 480 mg/kg]). The result for phosphorus was homogenous ($I^2 = 0\%$), but removal of 1 study (227) reduced the summary effect size and rendered the effect size statistically insignificant (SMD, 0.63; $P = 0.064$). The finding for total phenols was heterogeneous ($I^2 = 67\%$) and became statistically insignificant when studies not reporting sample size (95, 175) were removed ($P = 0.064$). Too few studies of animal products reported on other nutrients for effect sizes to be calculated.

Few studies examined fatty acids in milk (Supplement 6, available at www.annals.org). These studies suggest that organic milk may contain significantly more beneficial ω -3 fatty acids (SMD, 11.17 [CI, 5.93 to 16.41]; $P < 0.001$; $I^2 = 98\%$; 5 studies; median difference, 0.5 g/100 g [minimum difference, 0.23 g/100 g; maximum difference, 4.5 g/100 g]) and vaccenic acid than conventional milk (SMD, 2.62 [CI, 1.04 to 4.19]; $P = 0.031$; $I^2 = 97\%$; 5 studies; median difference, 0.26 g/100 g [minimum difference, 0.11 g/100 g; maximum difference, 3.1 g/100 g]). All but 1 of these studies (212) tested raw milk samples. Results were robust to removal of 1 study at a time. Similarly, organic chicken contained higher levels of ω -3 fatty acids than conventional chicken (SMD, 5.48 [CI, 2.19 to 8.76]; $P = 0.031$; $I^2 = 90\%$; 3 studies; median difference, 1.99 g/100 g [minimum difference, 0.94 g/100 g; maximum difference, 17.9 g/100 g]). The differences between the remaining fatty acids examined in chicken and milk (Sup-

Figure 2. RD of detecting any pesticide residues in organic and conventional fruits, vegetables, and grains.



All studies sampled food from retail or wholesale settings except Hoogenboom and colleagues (159), which sampled directly from farms. Tasiopoulou and colleagues (263) did not specify the study design, but because the testing was part of a governmental monitoring program, we assume that samples were obtained from retail or wholesale settings, similar to the other government monitoring programs (75, 79, 231). We used a continuity correction of 0.5 (half a sample contaminated) for studies with 0 counts to allow RDs to be calculated. Removal of studies with 0 cells did not change results (see Appendix, available at www.annals.org). All RDs are absolute RDs. Summary *P* values are adjusted *P* values. Funnel plots did not suggest publication bias, and results were robust to removal of 1 study at a time. RD = risk difference.

plement 6) were heterogeneous and statistically insignificant. Several included studies reported that the season of sampling and brand of milk affected fatty acid levels at least as much as the farming method (93, 94, 123, 125).

We found no difference in the protein or fat content of organic and conventional milk (Supplement 5). Results were robust to removal of 1 study at a time. Too few studies examined the protein and fat content of meats to calculate summary effect sizes.

Contaminants

Pesticide Contamination

Detectable pesticide residues were found in 7% of organic produce samples (CI, 4% to 10%; 3041 samples) and 38% of conventional produce samples (CI, 32% to 45%; 106 755 samples) (9 studies) (Table 2). Studies of meats, poultry, eggs, and milk did not assess pesticide levels. Organic produce had 30% lower risk for contamination with any detectable pesticide residue than conventional produce (RD, -30% [CI, -37% to -23%]; $P < 0.001$; $I^2 = 94\%$; 9 studies) (Figure 2). This result was statistically heterogeneous, potentially because of the variable level of detection used among these studies.

Only 3 studies reported the prevalence of contamination exceeding maximum allowed limits; all were from the European Union (159, 183, 263). One study was small (10 samples per group) and did not detect any pesticide resi-

dues exceeding maximum allowed limits in either group (159). Differences in prevalence of contamination exceeding maximum allowed limits were small among the other 2 studies (6% [60 of 1048 studies] for organic vs. 2% [179 of 2237 studies] for conventional [183], and 1% [1 of 266 studies] for organic vs. 1% [36 of 324 studies] for conventional [263]).

Bacterial Contamination

Prevalence of *E. coli* contamination was 7% in organic produce (CI, 4% to 11%; 826 samples) and 6% in conventional produce (CI, 2% to 9%; 1454 samples)—not a statistically significant difference (Figure 3) (RD, 2.4% [CI, -1.5% to 6.2%]; $P = 1.00$; $I^2 = 58\%$), although only 5 studies examined this outcome. Four of these 5 studies found higher risk for contamination among organic produce. In sensitivity analyses, when we removed the 1 study (of lettuce) that found higher contamination among conventional produce, we found that organic produce had a 5% greater risk for contamination than conventional alternatives (RD, 5.1% [CI, 2.92% to 7.18%]; $P < 0.001$; $I^2 = 0\%$). No study detected *Salmonella* (90, 159, 205, 206, 214), enterohemorrhagic *E. coli* (90, 159, 205, 206, 214), or *Listeria* (214, 226) among produce samples.

Bacterial contamination is common among both organic and conventional animal products; however, differ-

ences in the prevalence of bacterial contamination between organic and conventional animal products were statistically insignificant (**Figure 4**). For chicken, 67% (CI, 42% to 93%) of organic samples and 64% (CI, 40% to 90%) of conventional samples were contaminated with *Campylobacter* and 35% (CI, 8% to 63%) of organic samples and 34% (CI, 16% to 52%) of conventional samples were contaminated with *Salmonella* (3 studies). Pork was commonly contaminated with *E. coli* (65% of organic and 49% of conventional samples) (201), *Salmonella* (median, 5.1%; range, 0% to 39%) (282), and *Listeria monocytogenes* (3% of organic and 4% of conventional samples) (152). No studies compared the contamination of organic and conventional beef with human pathogens.

Antibiotic Resistance

The risk for isolating bacteria resistant to 3 or more antibiotics was 33% higher among conventional chicken and pork than organic alternatives (CI, 21% to 45%; $P < 0.001$; $I^2 = 62\%$; 5 studies) (**Figure 5 [top panel]** and **Supplement 7**, available at www.annals.org). Results were robust to removal of 1 study at a time. Bacteria isolated from retail samples of organic chicken and pork had 35% lower risk for resistance to ampicillin (RD, -34.9% [CI, -56.2% to -13.6%]; $P = 0.031$; $I^2 = 90\%$; 5 studies) (**Figure 5 [bottom panel]**), although removal of 1 study rendered results statistically insignificant. Although comparisons for most of the remaining antibiotics suggest greater resistance among bacteria isolated from conventional compared with organic products, differences were statistically insignificant (**Supplement 8**, available at www.annals.org). Few studies examined resistance to the same antibiotic on the same animal product, and effect sizes were heterogeneous.

Fungal Toxin and Heavy Metal Contamination

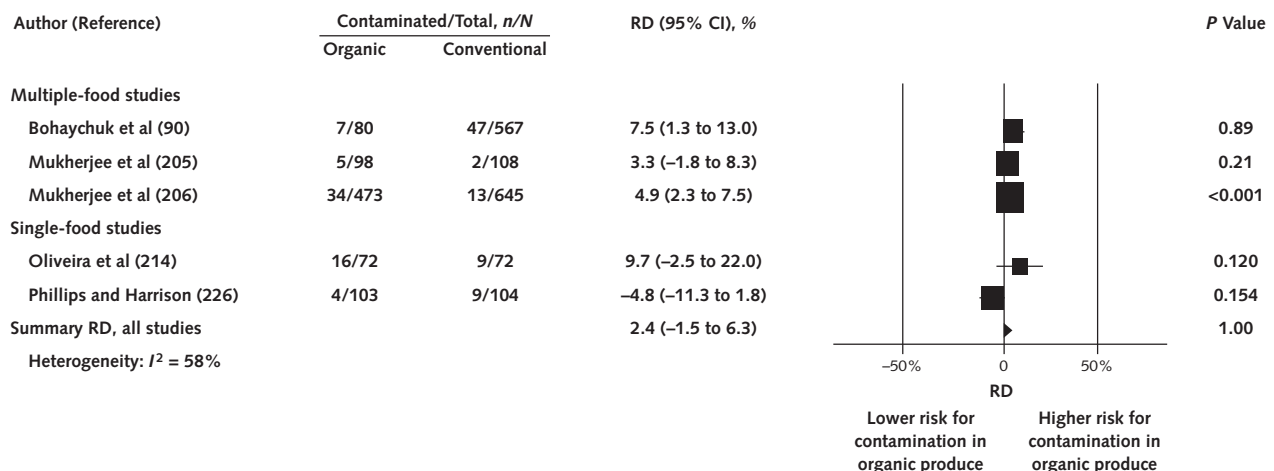
The included studies demonstrate mixed results about contamination of grains with fungal toxins. We found no difference in risk for contamination with or mean levels of ochratoxin A (**Table 2**). However, we found lower levels and lower risk for contamination with deoxynivalenol in organic grains than conventional alternatives (SMD, -0.82 [CI, -1.19 to -0.45]; $P < 0.001$; $I^2 = 69$; 8 studies; median difference, $-34 \mu\text{g/kg}$ [minimum difference, $-426 \mu\text{g/kg}$; maximum difference, $72 \mu\text{g/kg}$] (RD, -23% [CI, -37% to -8%]; $P = 0.043$; $I^2 = 89$; 9 studies). Results were similar in subgroup analyses by grain type (**Appendix**, available at www.annals.org). Among studies of produce, no significant differences in cadmium or lead content were identified (**Table 2**). All results were heterogeneous.

Heterogeneity and Subgroup Analyses

To explore causes of heterogeneity, we conducted subgroup analyses by specific food, testing method (fresh vs. dry weight, and peeled and washed vs. unpeeled and unwashed), study design, and organic standard used. Results remained heterogeneous when analyzed by food: No significant differences were found in the ascorbic acid content of cabbage (3 studies), carrots (3 studies), potatoes (3 studies), or tomatoes (9 studies); β -carotene content of tomatoes (3 studies); or protein content of wheat (6 studies) when grown organically versus conventionally. Subgroup analyses by testing method, study design, and organic standard remained heterogeneous and did not change findings, although sample sizes were smaller, limiting our ability to detect significant differences.

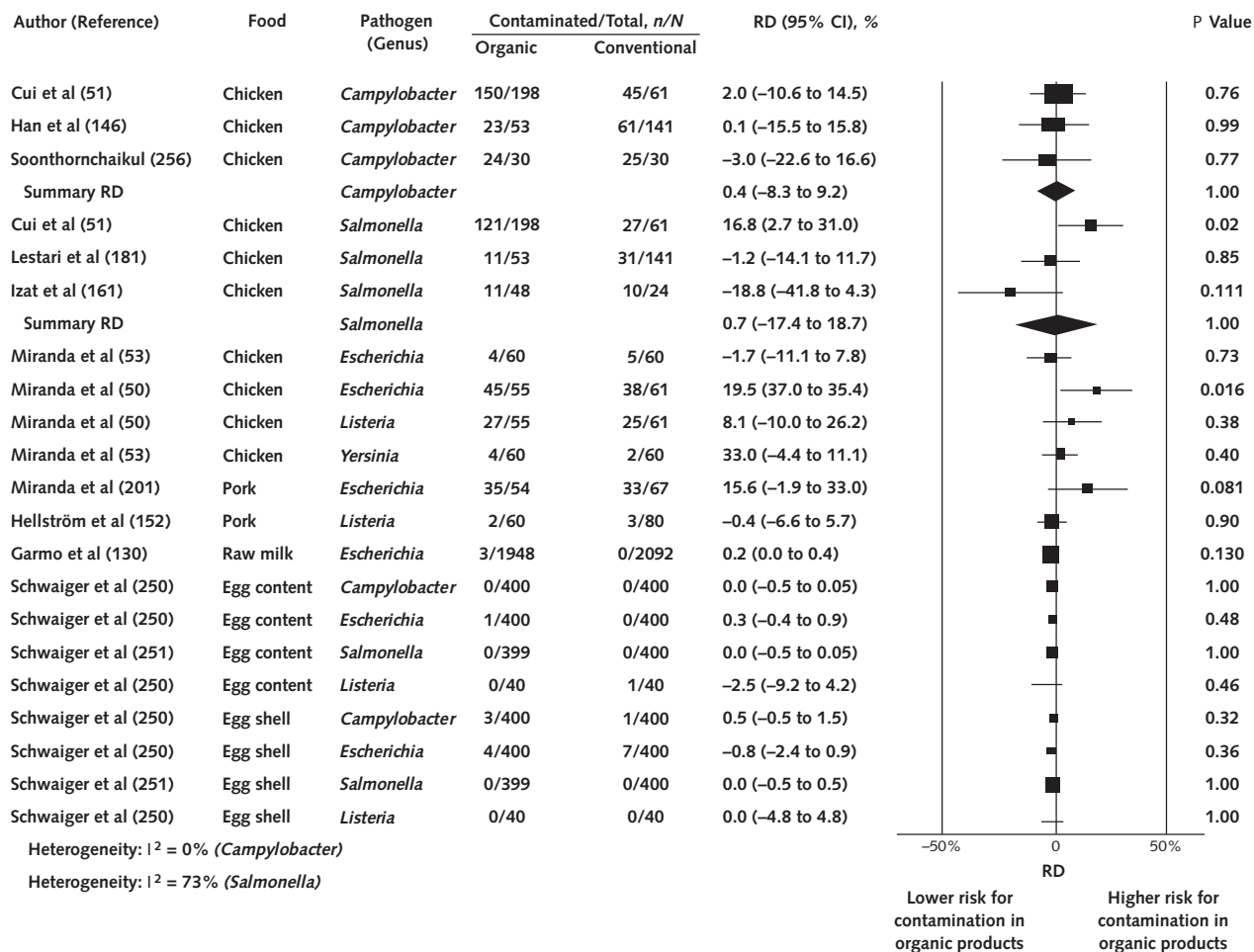
Only 1 data set reported peeling and washing produce before testing. However, the prevalence of contamination

Figure 3. RD of detecting *Escherichia coli* in organic and conventional fruits, vegetables, and grains.



All RDs are absolute RDs. Summary P value is an adjusted P value. Funnel plot did not suggest publication bias. Removal of 1 study (225) rendered results significant, suggesting higher contamination among organic produce (RD, 5.1% [95% CI, 2.92% to 7.18%]; $P < 0.001$; $I^2 = 0\%$). All studies sampled foods directly from farms, except Bohaychuk and colleagues (90), which sampled produce purchased in retail settings. RD = risk difference.

Figure 4. RD for contamination of organic and conventional meat products with bacterial pathogens.



Meat samples were obtained from retail stores, milk samples were raw milk obtained from farms, and all egg samples were obtained directly from farms. Risk difference is calculated as the risk for contamination in the organic group minus that in the conventional group; thus, a positive (negative) number indicates more (less) contamination in organic products. All RDs are absolute RDs. Summary effect measures reported are results of random-effect models. $I^2 > 25\%$ suggests heterogeneity. Summary P values are adjusted P values. Funnel plots did not suggest publication bias, and results were robust to removal of 1 study at a time. All studies sampled products from retail or wholesale settings with 4 exceptions: Lestari and colleagues (181), Hellstrom and colleagues (152), Garmo and colleagues (130), and Schwaiger and colleagues (250, 251) sampled foods obtained directly from farms. Results for *Salmonella* in pork (282) are not reported in this figure because the authors reported only median prevalence of contamination. RD = risk difference.

in this study could not be compared with other studies because of use of different levels of detection (79). One study tested products for pesticide residues before and after peeling, finding that pesticide residues were undetectable in both organic and conventional samples once apples were peeled (203).

Reporting and Publication Bias

Among nutrient studies of produce, those with null findings tended to report results incompletely (hence, they could not be included in summary effect size calculations), suggesting publication bias (Table 1). For example, among the 34 studies that evaluated phenol levels in produce, only 36 of the 102 comparisons (35%) found higher levels in organic produce. However, only 24 of the 34 studies re-

ported sufficient data for analysis, and among these, we found significantly higher levels of total phenols among organic produce (Table 1). In addition, for total phenols and several other nutrients in produce, funnel plots were asymmetric, raising concern for publication bias. Similarly, funnel plots of analyses of fatty acids in milk suggested possible publication bias.

We adjusted P values to assign significance to differences between organic and conventional foods due to the multiple statistical comparisons. It may be reasonable to use a less stringent criterion for the interpretation of contaminant results because consumers may have a lower threshold in their desire to avoid harms. However, examination of unadjusted P values changes the conclusions for

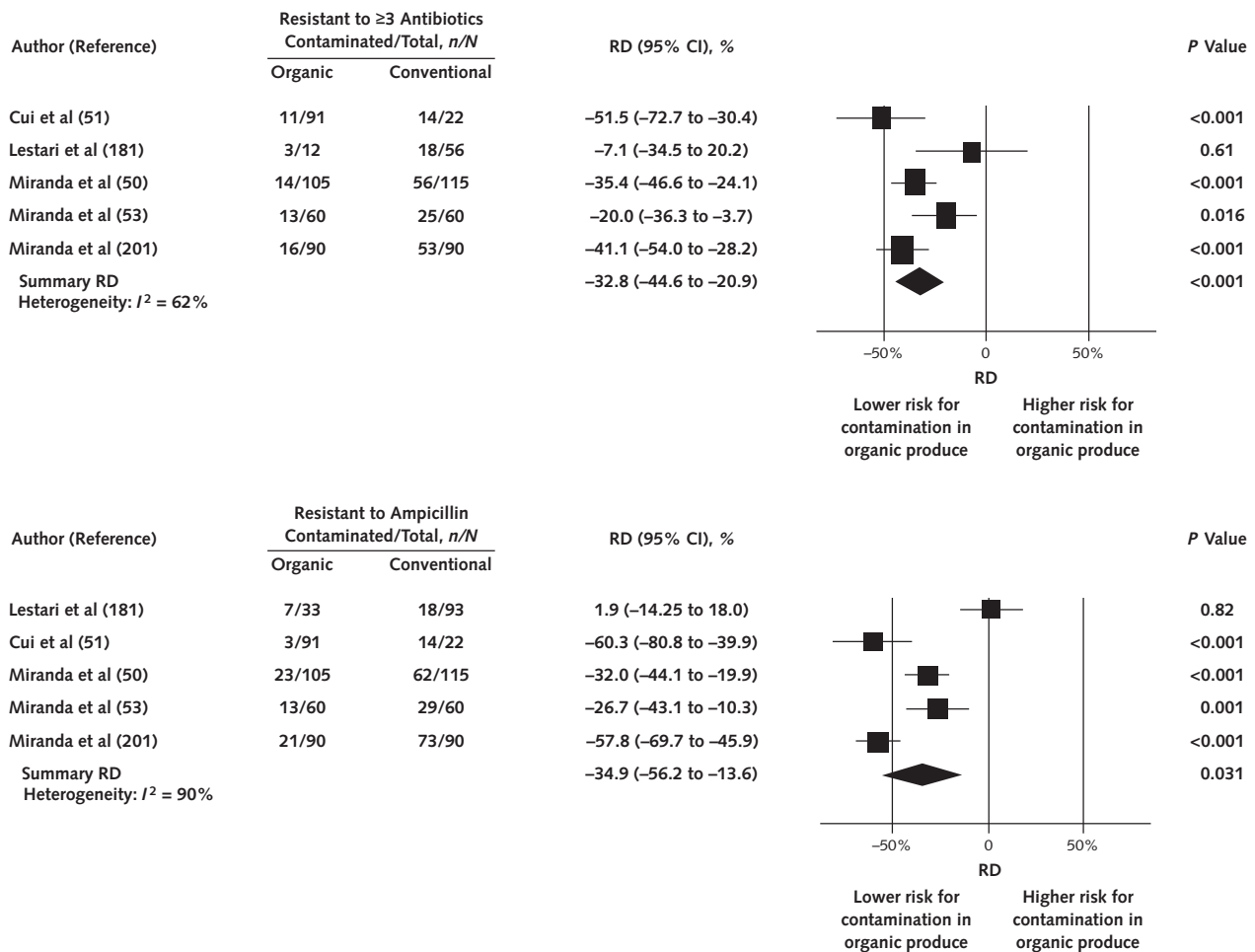
only a few outcomes: specifically, differences in contamination with bacteria resistant to cephalothin, sulfisoxazole, and tetracycline (Supplement 7).

DISCUSSION

Consumers purchase organic foods for many reasons. Despite the widespread perception that organically pro-

duced foods are more nutritious than conventional alternatives, we did not find robust evidence to support this perception. Of the nutrients evaluated, only 1 comparison, the phosphorus content of produce, demonstrated the superiority of organic foods (differences were statistically significant and homogenous), although removal of 1 study rendered this result statistically insignificant. Higher levels of phosphorus in organic produce than in conventional

Figure 5. RD for isolating antibiotic-resistant bacteria in selected analyses.



Risk difference is calculated as the risk for contamination in the organic group minus that in the conventional group; thus, a positive (negative) number indicates more (less) contamination in the organic group. All RDs are absolute RDs. Summary P values are adjusted P values. The number of antibiotics tested in the included studies ranged from 8 to 15 (median, 9.5). All summary effect measures reported are results of random-effects models. Funnel plots did not suggest publication bias. All studies sampled food purchased in retail settings except Lestari and colleagues (181), which sampled animal products obtained directly from farms. The top panel shows the difference in risk for detecting *Escherichia coli*, *Salmonella* species, and *Enterobacteriaceae* resistance to at least 3 antibiotics in organic vs. conventional chicken and pork. One study (50) examined drug resistance patterns for 3 organisms (*E. coli*, *Listeria*, and *Staphylococcus aureus*) identified on organic and conventional products. To avoid entering the same study twice in the analyses, we included only the resistance patterns reported for *E. coli*. However, in sensitivity analysis, we included the results for *Listeria* instead of *E. coli*. The results did not substantially change. Two studies (52, 53) reported antibiotic resistance patterns for different bacteria (*Enterobacteriaceae* [53] and *Enterococcus* species [52]) obtained from the same population of retail packaged chicken. To avoid entering the same chickens in the synthesis twice, we included *Enterobacteriaceae* results in the syntheses (reported above) because it is the family to which *E. coli* and *Salmonella* belong. In sensitivity analysis, we used the *Enterococcus* results, which did not substantially change findings. Results were robust to removal of 1 study at a time from summary effect estimate. The bottom panel shows the difference in risk for detecting *E. coli*, *Salmonella* species, and *Enterobacteriaceae* resistance to ampicillin in organic vs. conventional chicken and pork. The result was not robust to removal of 1 study at a time from summary effect estimate. RD = risk difference.

produce is consistent with previous reviews (19, 20), although it is unlikely to be clinically significant because near-total starvation is needed to produce dietary phosphorus deficiency (287).

We also found statistically higher levels of total phenols in organic produce, ω -3 fatty acids in organic milk and chicken, and vaccenic acid in organic chicken than in conventional products, although these results were highly heterogeneous and the number of studies examining fatty acids was small (≤ 5). Our finding of higher levels of these beneficial fatty acids in organic than in conventional milk is consistent with another recent meta-analysis of these outcomes (288). One study examining the breast milk of mothers consuming strictly organic diets found higher levels of trans-vaccenic acid (58), similar to our findings among organic dairy products. Otherwise, studies measuring nutrient levels among humans consuming organic and conventional diets did not find consistent differences.

Our study has 3 additional key findings. First, conventional produce has a 30% higher risk for pesticide contamination than organic produce. However, the clinical significance of this finding is unclear because the difference in risk for contamination with pesticide residue exceeding maximum allowed limits may be small. One study found that children switched to an organic diet for 5 days had significantly lower levels of pesticide residue in their urine (55), consistent with our findings among the food studies.

Second, we found no difference in the risk for contamination of produce or animal products with pathogenic bacteria. Both organic and conventional animal products were commonly contaminated with *Salmonella* and *Campylobacter* species. The reported rates of contamination are consistent with published contamination rates of U.S. retail meat samples (289–291). However, with removal of 1 study, results suggested that organic produce has a higher risk for contamination with *E. coli*, a finding that was both homogeneous and statistically significant. Similarly, an exploratory case-control study suggested that human consumption of organic meat in the winter is associated with symptomatic *Campylobacter* infection (70). These preliminary findings need to be confirmed with additional research. A recent U.S. study found that produce from organic farms using manure for fertilization was at significantly higher risk for contamination with *E. coli* than was produce from organic farms not using animal waste (odds ratio, 13.2 [CI, 2.6 to 61.2]) (292).

Third, we found that conventional chicken and pork have a higher risk for contamination with bacteria resistant to 3 or more antibiotics than were organic alternatives. This increased prevalence of antibiotic resistance may be related to the routine use of antibiotics in conventional animal husbandry. However, the extent to which antibiotic use for livestock contributes to antibiotic-resistant pathogens in humans continues to be debated (293) because inappropriate use of antibiotics in humans is the major cause of antibiotic-resistant infections in humans. A previ-

ous review (23) reported that ciprofloxacin-resistant *Campylobacter* was more common among conventional than organic chickens, a finding that our study did not detect. Unlike the previous study, most of our included studies were done after bans on fluoroquinolone use and we excluded fecal samples. As a precaution, the European Union banned the use of some antibiotics in animal feed for growth promotion in 2006 (294), and the United States banned the use of enrofloxacin in 2005 (295).

Finally, there have been no long-term studies of health outcomes of populations consuming predominantly organic versus conventionally produced food controlling for socioeconomic factors; such studies would be expensive to conduct. Only 3 short observational studies examined a very limited set of clinical outcomes: 2 studies evaluating allergic outcomes of a cohort of children consuming organic versus conventional diets in Europe found no association between diet and allergic outcomes (61, 64).

Our results should be interpreted with caution because summary effect estimates were highly heterogeneous. Three potential sources of heterogeneity are study methods (for example, measurement and sampling methods, study design, or organic standard used), physical factors (for example, season, weather, soil type, ripeness, cultivar, or storage practices [14, 111, 165, 171, 296]), and variation within organic practices.

For example, heterogeneity among studies of pesticide contamination likely reflects variation in the sensitivity of testing methods and differences in pesticide contamination by food type and country of origin (75, 297). To explore causes of heterogeneity, we conducted subgroup analyses by study design, assay method (fresh vs. dry weight), and organic standard used in the study; however, these subanalyses did not reduce observed heterogeneity.

Too few studies for any 1 outcome reported information about physical factors to conduct subgroup analyses, although many studies controlled for these factors (for example, 86% of meat studies specified sampling both production systems during the same season and approximately 60% of comparison produce pairs were of the same cultivar and harvested from neighboring farms). Many studies noted that season of sampling and brand of milk were important determinants of nutrient and fatty acid levels (93, 94, 123, 125) because organic and conventional cows may have similar diets in the winter but different diets in the summer when grass is available for organic cows.

Finally, variation within organic practices (even if certified under the same standard) may also explain heterogeneity. A review of organic practices concluded that “variation within organic and conventional farming systems is likely as large as differences between the two systems” (298). For example, the use and handling of manure fertilizers (a risk factor for bacterial contamination) varies among organic farms (292).

Our study has several additional limitations. First, produce studies, most of which were experimental field stud-

ies, may not reflect real-world organic practices. Subgroup analyses by study design did not change conclusions, although sample sizes were small. Additionally, studies with null findings frequently failed to adequately report results, potentially biasing our study to find differences where none exist. Finally, milk results should be interpreted with caution because most milk studies examined raw rather than pasteurized milk.

In summary, our comprehensive review of the published literature on the comparative health outcomes, nutrition, and safety of organic and conventional foods identified limited evidence for the superiority of organic foods. The evidence does not suggest marked health benefits from consuming organic versus conventional foods, although organic produce may reduce exposure to pesticide residues and organic chicken and pork may reduce exposure to antibiotic-resistant bacteria.

From Veterans Affairs Palo Alto Health Care System, Palo Alto, California; Division of General Medical Disciplines and Lane Medical Library, Stanford School of Medicine, Stanford, California; and Center for Health Policy/Center for Primary Care Outcomes Research, Department of Management Science & Engineering, and Department of Statistics, Stanford University, Stanford, California.

Note: As the corresponding author and guarantor of the manuscript, Crystal Smith-Spangler, MD, MS, takes full responsibility for the work as a whole, including the study design, access to data, and decision to submit the manuscript for publication.

Acknowledgment: The authors thank the staff of DocXpress at Lane Medical Library for document retrieval.

Financial Support: Ms. Pearson was supported by a Stanford Undergraduate Research Grant.

Potential Conflicts of Interest: None disclosed. Forms can be viewed at www.acponline.org/authors/icmje/ConflictOfInterestForms.do?msNum=M12-0192.

Requests for Single Reprints: Crystal Smith-Spangler, MD, MS, Stanford Center for Health Policy and Center for Primary Care and Outcomes Research, 117 Encina Commons, Stanford University, Stanford, CA 94305-6019; e-mail, csmithsp@stanford.edu.

Current author addresses and author contributions are available at www.annals.org.

References

1. Dimitri C, Oberholtzer L. Marketing U.S. Organic Foods: Recent Trends From Farms to Consumers. U.S. Department of Agriculture Economic Research Service, Economic Information Bulletin no. EIB-58. September 2009. Accessed at www.ers.usda.gov/Publications/EIB58/ on 14 July 2012.
2. Organic Trade Association. U.S. organic industry valued at nearly \$29 billion in 2010. Accessed at www.organicnewsroom.com/2011/04/us_organic_industry_valued_at.html on 15 July 2012.
3. Martin A, Severson K. Sticker shock in the organic aisles. New York Times. 18 April 2008. Accessed at www.nytimes.com/2008/04/18/business/18organic.html on 14 July 2012.

4. U.S. Department of Agriculture Economic Research Service. Data Products: Organic Prices. 2009. Accessed at www.ers.usda.gov/Data/OrganicPrices/ on 23 November 2009.
5. Winter CK, Davis SF. Organic foods. *J Food Sci*. 2006;71:R117-24.
6. International Federation of Organic Agriculture Movements (IFOAM). The IFOAM Norms for Organic Production and Processing Version 2005. Bonn, Germany: IFOAM; 2006. Accessed at http://shop.ifoam.org/bookstore/download_preview/IFOAM_NORMS_2005_intro.pdf on 18 June 2012.
7. National Archives and Records Administration. Electronic Code of Federal Regulations, Title 7: Agriculture, Part 205—National Organic Program, Subpart C—Organic Production and Handling Requirements. Washington, DC: U.S. Government Printing Office; 2010. Accessed at <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&trgn=div5&view=text&node=7:3.1.1.9.32&idno=7#7:3.1.1.9.32.3> on 18 June 2012.
8. Commission of European Communities. Council Regulation (EC) No. 834/2007. Brussels, Belgium: Commission of European Communities; 2007. Accessed at <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:189:0001:0023:EN:PDF> on 18 June 2012.
9. International Federation of Organic Agriculture Movements (IFOAM). The Principles of Organic Agriculture. Bonn, Germany: IFOAM; 2009. Accessed at www.ifoam.org/about_ifoam/principles/index.html on 12 May 2012.
10. Williams PR, Hammitt JK. A comparison of organic and conventional fresh produce buyers in the Boston area. *Risk Anal*. 2000;20:735-46. [PMID: 11110219]
11. Williams PR, Hammitt JK. Perceived risks of conventional and organic produce: pesticides, pathogens, and natural toxins. *Risk Anal*. 2001;21:319-30. [PMID: 11414540]
12. Jolly DA, Schutz HG, Diaz-Knauf KV, Johal J. Organic foods: consumer attitudes and use. *Food Technol*. 1989;43:60-6.
13. Woese K, Lange D, Boess C, Bögl KW. A comparison of organically and conventionally grown foods—results of a review of the relevant literature. *J Sci Food Agric*. 1997;74:281-93.
14. Magkos F, Arvaniti F, Zampelas A. Organic food: nutritious food or food for thought? A review of the evidence. *Int J Food Sci Nutr*. 2003;54:357-71. [PMID: 12907407]
15. Bourn D, Prescott J. A comparison of the nutritional value, sensory qualities, and food safety of organically and conventionally produced foods. *Crit Rev Food Sci Nutr*. 2002;42:1-34. [PMID: 11833635]
16. Heaton S. Organic farming, food quality and human health. A review of the evidence. Bristol, UK: British Soil Assoc; 2001. Accessed at www.soilassociation.org/LinkClick.aspx?fileticket=cY8kfP3Q%2BgA%3D&tabid=388 on 12 July 2012.
17. Huber M, Rembialkowska E, Średnicka D, Bügel S, van de Vijver LPL. Organic food and impact on human health: assessing the status quo and prospects of research. *NJAS—Wageningen Journal of Life Sciences*. 2011;58:103-9.
18. Lairon D. Nutritional quality and safety of organic food. A review. *Agronomy for Sustainable Development*. 2010;30:33-41.
19. Worthington V. Nutritional quality of organic versus conventional fruits, vegetables, and grains. *J Altern Complement Med*. 2001;7:161-73. [PMID: 11327522]
20. Dangour AD, Doddhia SK, Hayter A, Allen E, Lock K, Uauy R. Nutritional quality of organic foods: a systematic review. *Am J Clin Nutr*. 2009;90:680-5. [PMID: 19640946]
21. Benbrook C, Zhao X, Yanez J, Davies N, Andrews P. New evidence confirms nutritional superiority of plant-based organic foods. Boulder, CO: The Organic Center; March 2008. Accessed at www.organic-center.org/science.nutri.php?action=view&report_id=126 on 18 June 2012.
22. Brandt K, Leifert C, Sanderson R, Seal CJ. Agroecosystem management and nutritional quality of plant foods: the case of organic fruits and vegetables. *Critical Review in Plant Sciences*. 2011;30:177-97.
23. Young I, Rajić A, Wilhelm BJ, Waddell L, Parker S, McEwen SA. Comparison of the prevalence of bacterial enteropathogens, potentially zoonotic bacteria and bacterial resistance to antimicrobials in organic and conventional poultry, swine and beef production: a systematic review and meta-analysis. *Epidemiol Infect*. 2009;137:1217-32. [PMID: 19379542]
24. Champel A, Fourbet JF, Dore T, Rossignol L. Influence of cropping system on Fusarium head blight and mycotoxin levels in winter wheat. *Crop Prot*. 2004;23:531-7.
25. Stalenga J. Applicability of different indices to evaluate nutrient status of winter wheat in the organic system. *J Plant Nutr*. 2007;30:351-65.

26. Forster MP, Rodríguez Rodríguez E, Martín JD, Díaz Romero C. Statistical differentiation of bananas according to their mineral composition. *J Agric Food Chem*. 2002;50:6130-5. [PMID: 12358491]
27. Pettersson BD, von Wistinghausen E, Brinton WF, Woods End Agricultural Institute. *Organic, Biodynamic and Conventional Cropping Systems: A Long Term Comparison*. Mt. Vernon, ME: Woods End Agricultural Institute; 1988.
28. Nilsson T. Yield, storage ability, quality and chemical composition of carrot, cabbage and leek at conventional and organic fertilizing. *Acta Hortic*. 1979;209-23.
29. Krejčířová L, Capouchová I, Petr J, Bicanová E, Kvapil R. Protein composition and quality of winter wheat from organic and conventional farming. *Žemědělství-Agriculture*. 2006;93:285-96.
30. Fernandes ALT, Rodrigues GP, Testezlaf R. Mineral and organomineral fertirrigation in relation to quality of greenhouse-cultivated melon. *Scientia Agricola*. 2003;60:149-54.
31. Petr J, Škerik J, Psota V, Langer I. Quality of malting barley grown under different cultivation systems. *Monatsschrift für Brauwissenschaft*. 2000;53:90-4.
32. Singh SR. Effect of organic farming system on yield and quality of Brinjal (*Solanum melongena* L) var Pusa Purple Cluster under mid-hill conditions of Himachal Pradesh. *Haryana Journal of Horticultural Sciences*. 2004;33:265-6.
33. Kannan P, Saravanan A, Balaji T. Organic farming on tomato yield and quality. *Crop Research-Hisar*. 2006;32:196-200.
34. Daood HG, Tomoskozi-Farkas R, Kapitany J. Antioxidant content of bio and conventional spice red pepper (*Capsicum annuum* L) as determined by HPLC. *Acta Agronomica Hungarica*. 2006;54:133-40.
35. Anttonen MJ, Karjalainen RO. High-performance liquid chromatography analysis of black currant (*Ribes nigrum* L.) fruit phenolics grown either conventionally or organically. *J Agric Food Chem*. 2006;54:7530-8. [PMID: 17002418]
36. De Pascale S, Tamburrino R, Maggio A, Barbieri G, Fogliano V, Pernice R. Effects of nitrogen fertilization on the nutritional value of organically and conventionally grown tomatoes. *Acta Hortic*. 2006;700:107-10.
37. Sousa C, Pereira DM, Pereira JA, Bento A, Rodrigues MA, Dopico-García S, et al. Multivariate analysis of tronchuda cabbage (*Brassica oleracea* L. var. *costata* DC) phenolics: influence of fertilizers. *J Agric Food Chem*. 2008;56:2231-9. [PMID: 18290619]
38. Polat E, Demir H, Onus AN. Comparison of some yield and quality criteria in organically and conventionally-grown lettuce. *African Journal of Biotechnology*. 2008;7:1235-9.
39. Bahadur A, Singh J, Singh KP, Upadhyay AK, Mathura R. Effect of organic amendments and biofertilizer on growth, yield and quality attributes of Chinese cabbage (*Brassica pekinensis*). *The Indian Journal of Agricultural Sciences*. 2006;76:596-8.
40. Zahradník A, Petříková K. Effect of alternative organic fertilizers on the nutritional value and yield of head cabbage. *Horticultural Science*. 2007;34:65-71.
41. Pimpini F, Giardini L, Borin M, Gianquinto G. Effects of poultry manure and mineral fertilizers on the quality of crops. *The Journal of Agricultural Science*. 1992;118:215-21.
42. Saleha A. Studies on the effects of organic vs. inorganic form of nitrogen on the quality of okra. *Journal of Maharashtra Agricultural Universities*. 1992;17:133-4.
43. Srikumar TS, Ockerman PA. The effects of fertilization and manuring on the content of some nutrients in potato (var. Provita). *Food Chem*. 1990;37:47-60.
44. Termine E, Lairon D, Taupier-Letage B, Gautier S, Lafont R, Lafont H. Yield and content in nitrates, minerals and ascorbic acid of leeks and turnips grown under mineral or organic nitrogen fertilizations. *Plant Foods Hum Nutr*. 1987;37:321-32. [PMID: 2852803]
45. Vogtmann H, Matthies K, Kehres B, Meier-Ploeger A. Enhanced food quality: effects of composts on the quality of plant foods. *Compost Sci Util*. 1993;1:82-100.
46. Lazcano C, Revilla P, Malvar RA, Domínguez J. Yield and fruit quality of four sweet corn hybrids (*Zea mays*) under conventional and integrated fertilization with vermicompost. *J Sci Food Agric*. 2011;91:1244-53. [PMID: 21328364]
47. Citak S, Sonmez S. Mineral contents of organically and conventionally grown spinach (*Spinacea oleracea* L.) during two successive seasons. *J Agric Food Chem*. 2009;57:7892-8. [PMID: 19685878]
48. Sutton AJ, Duval SJ, Tweedie RL, Abrams KR, Jones DR. Empirical assessment of effect of publication bias on meta-analyses. *BMJ*. 2000;320:1574-7. [PMID: 10845965]
49. Centers for Disease Control and Prevention. FoodNet—Foodborne Diseases Active Surveillance Network. Atlanta: Centers for Disease Control and Prevention; 2011. Accessed at www.cdc.gov/foodnet on 23 April 2011.
50. Miranda JM, Vázquez BI, Fente CA, Calo-Mata P, Cepeda A, Franco CM. Comparison of antimicrobial resistance in *Escherichia coli*, *Staphylococcus aureus*, and *Listeria monocytogenes* strains isolated from organic and conventional poultry meat. *J Food Prot*. 2008;71:2537-42. [PMID: 19244911]
51. Cui S, Ge B, Zheng J, Meng J. Prevalence and antimicrobial resistance of *Campylobacter* spp. and *Salmonella* serovars in organic chickens from Maryland retail stores. *Appl Environ Microbiol*. 2005;71:4108-11. [PMID: 16000828]
52. Miranda JM, Guarddon M, Mondragon A, Vázquez BI, Fente CA, Cepeda A, et al. Antimicrobial resistance in *Enterococcus* spp. strains isolated from organic chicken, conventional chicken, and turkey meat: a comparative survey. *J Food Prot*. 2007;70:1021-4. [PMID: 17477278]
53. Miranda JM, Guarddon M, Vázquez BI, Fente CA, Barros-Velazquez J, Cepeda A, et al. Antimicrobial resistance in *Enterobacteriaceae* strains isolated from organic chicken, conventional chicken and conventional turkey meat: a comparative survey. *Food Control*. 2008;19:412-6.
54. Juhler RK, Larsen SB, Meyer O, Jensen ND, Spanò M, Giwercman A, et al. Human semen quality in relation to dietary pesticide exposure and organic diet. *Arch Environ Contam Toxicol*. 1999;37:415-23. [PMID: 10473800]
55. Curl CL, Fenske RA, Elgethun K. Organophosphorus pesticide exposure of urban and suburban preschool children with organic and conventional diets. *Environ Health Perspect*. 2003;111:377-82. [PMID: 12611667]
56. Grønder-Pedersen L, Rasmussen SE, Bügel S, Jørgensen LV, Dragsted LO, Gundersen V, et al. Effect of diets based on foods from conventional versus organic production on intake and excretion of flavonoids and markers of antioxidative defense in humans. *J Agric Food Chem*. 2003;51:5671-6. [PMID: 12952417]
57. Caris-Veyrat C, Amiot MJ, Tyssandier V, Grasselly D, Buret M, Mikolajczak M, et al. Influence of organic versus conventional agricultural practice on the antioxidant microconstituent content of tomatoes and derived purees; consequences on antioxidant plasma status in humans. *J Agric Food Chem*. 2004;52:6503-9. [PMID: 15479014]
58. Rist L, Mueller A, Barthel C, Snijders B, Jansen M, Simões-Wüst AP, et al. Influence of organic diet on the amount of conjugated linoleic acids in breast milk of lactating women in the Netherlands. *Br J Nutr*. 2007;97:735-43. [PMID: 17349086]
59. Lu C, Toepel K, Irish R, Fenske RA, Barr DB, Bravo R. Organic diets significantly lower children's dietary exposure to organophosphorus pesticides. *Environ Health Perspect*. 2006;114:260-3. [PMID: 16451864]
60. Lu C, Barr DB, Pearson MA, Walker LA, Bravo R. The attribution of urban and suburban children's exposure to synthetic pyrethroid insecticides: a longitudinal assessment. *J Expo Sci Environ Epidemiol*. 2009;19:69-78. [PMID: 18766203]
61. Kummeling I, Thijs C, Huber M, van de Vijver LP, Snijders BE, Penders J, et al. Consumption of organic foods and risk of atopic disease during the first 2 years of life in the Netherlands. *Br J Nutr*. 2008;99:598-605. [PMID: 17761012]
62. Briviba K, Stracke BA, Rüfer CE, Watzl B, Weibel FP, Bub A. Effect of consumption of organically and conventionally produced apples on antioxidant activity and DNA damage in humans. *J Agric Food Chem*. 2007;55:7716-21. [PMID: 17696483]
63. Lu C, Barr DB, Pearson MA, Waller LA. Dietary intake and its contribution to longitudinal organophosphorus pesticide exposure in urban/suburban children. *Environ Health Perspect*. 2008;116:537-42. [PMID: 18414640]
64. Fløistrup H, Swartz J, Bergström A, Alm JS, Scheynius A, van Hage M, et al; Parsifal Study Group. Allergic disease and sensitization in Steiner school children. *J Allergy Clin Immunol*. 2006;117:59-66. [PMID: 16387585]
65. Søltoft M, Bysted A, Madsen KH, Mark AB, Bügel SG, Nielsen J, et al. Effects of organic and conventional growth systems on the content of carotenoids in carrot roots, and on intake and plasma status of carotenoids in humans. *J Sci Food Agric*. 2011;91:767-75. [PMID: 21213256]
66. Stracke BA, Rüfer CE, Bub A, Seifert S, Weibel FP, Kunz C, et al. No effect of the farming system (organic/conventional) on the bioavailability of apple (*Malus domestica* Bork., cultivar Golden Delicious) polyphenols in healthy men: a comparative study. *Eur J Nutr*. 2010;49:301-10. [PMID: 20033417]

67. De Lorenzo A, Noce A, Bigioni M, Calabrese V, Della Rocca DG, Di Daniele N, et al. The effects of Italian Mediterranean organic diet (IMOD) on health status. *Curr Pharm Des*. 2010;16:814-24. [PMID: 20388092]
68. Mueller A, Thijs C, Rist L, Simões-Wüst AP, Huber M, Steinhart H. Trans fatty acids in human milk are an indicator of different maternal dietary sources containing trans fatty acids. *Lipids*. 2010;45:245-51. [PMID: 20148367]
69. Stracke BA, Rüfer CE, Bub A, Briviba K, Seifert S, Kunz C, et al. Bioavailability and nutritional effects of carotenoids from organically and conventionally produced carrots in healthy men. *Br J Nutr*. 2009;101:1664-72. [PMID: 19021920]
70. Gillespie IA, O'Brien SJ, Adak GK, Tam CC, Frost JA, Bolton FJ, et al; *Campylobacter Sentinel Surveillance Scheme Collaborators*. Point source outbreaks of *Campylobacter jejuni* infection—are they more common than we think and what might cause them? *Epidemiol Infect*. 2003;130:367-75. [PMID: 12825720]
71. Acharya T, Bhatnagar V. Quality assessment of organic and conventional Nagpur mandarins (*Citrus reticulata*). *Indian Journal of Nutrition and Dietetics*. 2007;44:403-6.
72. Aldrich HT, Salandanan K, Kendall P, Bunning M, Stonaker F, Külen O, et al. Cultivar choice provides options for local production of organic and conventionally produced tomatoes with higher quality and antioxidant content. *J Sci Food Agric*. 2010;90:2548-55. [PMID: 20718027]
73. Amodio ML, Colelli G, Hasey JK, Kader AA. A comparative study of composition and postharvest performance of organically and conventionally grown kiwifruits. *J Sci Food Agric*. 2007;87:1228-36.
74. Amvrazi EG, Albanis TA. Pesticide residue assessment in different types of olive oil and preliminary exposure assessment of Greek consumers to the pesticide residues detected. *Food Chem*. 2009;113:253-61.
75. Andersen JH, Poulsen ME. Results from the monitoring of pesticide residues in fruit and vegetables on the Danish market, 1998-99. *Food Addit Contam*. 2001;18:906-31. [PMID: 11569771]
76. Angood KM, Wood JD, Nute GR, Whittington FM, Hughes SI, Sheard PR. A comparison of organic and conventionally-produced lamb purchased from three major UK supermarkets: price, eating quality and fatty acid composition. *Meat Sci*. 2008;78:176-84. [PMID: 22062268]
77. Asami DK, Hong YJ, Barrett DM, Mitchell AE. Comparison of the total phenolic and ascorbic acid content of freeze-dried and air-dried marionberry, strawberry, and corn grown using conventional, organic, and sustainable agricultural practices. *J Agric Food Chem*. 2003;51:1237-41. [PMID: 12590461]
78. Bacchi MA, de Nadai Fernandes EA, Tsai SM, Santos LGC. Conventional and organic potatoes: assessment of elemental composition using k_0 -INAA. *Journal of Radioanalytical Nuclear Chemistry*. 2003;259:421-4.
79. Baker BP, Benbrook CM, Groth E 3rd, Lutz Benbrook K. Pesticide residues in conventional, integrated pest management (IPM)-grown and organic foods: insights from three US data sets. *Food Addit Contam*. 2002;19:427-46. [PMID: 12028642]
80. Barrett DM, Weakley C, Diaz JV, Watnik M. Qualitative and nutritional differences in processing tomatoes grown under commercial organic and conventional production systems. *J Food Sci*. 2007;72:C441-51. [PMID: 18034702]
81. Bavec M, Turinek M, Grobelnik-Mlakar S, Slatnar A, Bavec F. Influence of industrial and alternative farming systems on contents of sugars, organic acids, total phenolic content, and the antioxidant activity of red beet (*Beta vulgaris* L. ssp. *vulgaris* Rote Kugel). *J Agric Food Chem*. 2010;58:11825-31. [PMID: 20964342]
82. Beltran-Gonzalez F, Perez-Lopez AJ, Lopez-Nicolas JM, Carbonell-Barrachina AA. Effects of agricultural practices on instrumental colour, mineral content, carotenoid composition, and sensory quality of mandarin orange juice, cv. Hernandina. *J Sci Food Agric*. 2008;88:1731-8.
83. Bennedsen TW, Thamsborg SM, Aarestrup FM, Enevoldsen C, Vaarst M, Christoffersen AB. Resistance to penicillin of *Staphylococcus aureus* isolates from cows with high somatic cell counts in organic and conventional dairy herds in Denmark. *Acta Vet Scand*. 2006;48:24. [PMID: 17125515]
84. Beretta B, De Domenico R, Gaiaschi A, Ballabio C, Galli CL, Gigliotti C, et al. Ochratoxin A in cereal-based baby foods: occurrence and safety evaluation. *Food Addit Contam*. 2002;19:70-5. [PMID: 11817376]
85. Bergamo P, Fedele E, Iannibelli L, Marzillo G. Fat-soluble vitamin contents and fatty acid composition in organic and conventional Italian dairy products. *Food Chem*. 2003;82:625-31.
86. Bernhofs A, Clasen PE, Kristoffersen AB, Torp M. Less *Fusarium* infestation and mycotoxin contamination in organic than in conventional cereals. *Food Addit Contam Part A Chem Anal Control Expo Risk Assess*. 2010;27:842-52. [PMID: 20425661]
87. Bicanova E, Capouchova I, Krejcirova L, Petr J, Erhartova D. The effect of growth structure on organic winter wheat quality. *Zemdirbyste/Agriculture*. 2006;93:297-305.
88. Biffi R, Munari M, Dioguardi L, Ballabio C, Cattaneo A, Galli CL, et al. Ochratoxin A in conventional and organic cereal derivatives: a survey of the Italian market, 2001-02. *Food Addit Contam*. 2004;21:586-91. [PMID: 15204537]
89. Blanco-Penedo I, López-Alonso M, Miranda M, Hernández J, Prieto F, Shore RF. Non-essential and essential trace element concentrations in meat from cattle reared under organic, intensive or conventional production systems. *Food Addit Contam Part A Chem Anal Control Expo Risk Assess*. 2010;27:36-42. [PMID: 19750401]
90. Bohaychuk VM, Bradbury RW, Dimock R, Fehr M, Gensler GE, King RK, et al. A microbiological survey of selected Alberta-grown fresh produce from farmers' markets in Alberta, Canada. *J Food Prot*. 2009;72:415-20. [PMID: 19350990]
91. Bombyk RA, Bykowski AL, Draper CE, Savelkoul EJ, Sullivan LR, Wyckoff TJ. Comparison of types and antimicrobial susceptibility of *Staphylococcus* from conventional and organic dairies in west-central Minnesota, USA. *J Appl Microbiol*. 2008;104:1726-31. [PMID: 18179539]
92. Butler G, Collomb M, Rehberger B, Sanderson R, Eyre M, Leifert C. Conjugated linoleic acid isomer concentrations in milk from high- and low-input management dairy systems. *J Sci Food Agric*. 2009;89:697-705.
93. Butler G, Nielsen JH, Slots T, Seal C, Eyre MD, Sanderson R, et al. Fatty acid and fat-soluble antioxidant concentrations in milk from high- and low-input conventional and organic systems: seasonal variation. *J Sci Food Agric*. 2008;88:1431-41.
94. Butler G, Stergiadis S, Seal C, Eyre M, Leifert C. Fat composition of organic and conventional retail milk in northeast England. *J Dairy Sci*. 2011;94:24-36. [PMID: 21183013]
95. Carbanaro M, Mattera M. Polyphenoloxidase activity and polyphenol levels in organically and conventionally grown peach (*Prunus persica* L., cv. Regina binca) and pear (*Pyrus communis* L., cv. Williams). *Food Chem*. 2001;72:419-24.
96. Carbonaro M, Mattera M, Nicoli S, Bergamo P, Cappelloni M. Modulation of antioxidant compounds in organic vs conventional fruit (peach, *Prunus persica* L., and pear, *Pyrus communis* L.). *J Agric Food Chem*. 2002;50:5458-62. [PMID: 12207491]
97. Carcea M, Salvatorelli S, Turfani V, Mellara F. Influence of growing conditions on the technological performance of bread wheat (*Triticum aestivum* L.). *International Journal of Food Science and Technology*. 2006;41:102-7.
98. Castellini C, Mugnai C, Dal Bosco A. Effect of organic production system on broiler carcass and meat quality. *Meat Sci*. 2002;60:219-25. [PMID: 22063392]
99. Cayuela JA, Vidueira JM, Albi MA, Gutierrez F. Influence of the ecological cultivation of strawberries (*Fragaria X Ananassa* cv. chandler) on the quality of the fruit and on their capacity for conservation. *J Agric Food Chem*. 1997;45:1736-40.
100. Champagne ET, Bett-Garber KL, Grimm CC, McClung AM. Effects of organic fertility management on physicochemical properties and sensory quality of diverse rice cultivars. *Cereal Chemistry*. 2007;84:320-7.
101. Chang PT, Salomon M. Metals in grains sold under various labels—organic, natural conventional. *J Food Qual*. 1978;1:373-7.
102. Chassy AW, Bui L, Renaud EN, Van Horn M, Mitchell AE. Three-year comparison of the content of antioxidant microconstituents and several quality characteristics in organic and conventionally managed tomatoes and bell peppers. *J Agric Food Chem*. 2006;54:8244-52. [PMID: 17032035]
103. Cirillo T, Ritieni A, Visone M, Cocchieri RA. Evaluation of conventional and organic Italian foodstuffs for deoxynivalenol and fumonisins B(1) and B(2). *J Agric Food Chem*. 2003;51:8128-31. [PMID: 14690407]
104. Clarke RP, Merrow SB. Nutrient composition of tomatoes homegrown under different cultural procedures. *Ecol Food Nutr*. 1979;8:37-46.
105. Colla G, Mitchell JP, Poudel DD, Temple SR. Changes of tomato yield and fruit elemental composition in conventional, low input, and organic systems. *J Sustain Agric*. 2002;20:53-67.
106. Collins M, Nassif W. Pesticide residues in organically and conventionally grown fruit and vegetables in New South Wales, 1990-91. *Food Australia*. 1993;45:429-31.

107. Collomb M, Bisig W, Butikofer U, Sieber R, Bregy M, Etter L. Fatty acid composition of mountain milk from Switzerland: comparison of organic and integrated farming systems. *Int Dairy J*. 2008;18:976-82.
108. Coorevits A, De Jonghe V, Vandroemme J, Reekmans R, Heyrman J, Messens W, et al. Comparative analysis of the diversity of aerobic spore-forming bacteria in raw milk from organic and conventional dairy farms. *Syst Appl Microbiol*. 2008;31:126-40. [PMID: 18406093]
109. Corrales M, Fernandez A, Vizoso Pinto MG, Butz P, Franz CM, Schuele E, et al. Characterization of phenolic content, in vitro biological activity, and pesticide loads of extracts from white grape skins from organic and conventional cultivars. *Food Chem Toxicol*. 2010;48:3471-6. [PMID: 20870004]
110. Cuuubonn J, Foltys V, Hasszík P, Kačániová M, Ubrezziová I, Kráčmar S. The raw milk quality from organic and conventional agriculture. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*. 2008;56:25-30.
111. Czerwiecki L, Czajkowska D, Witkowska-Gwiazdowska A. On ochratoxin A and fungal flora in Polish cereals from conventional and ecological farms. Part 2: occurrence of ochratoxin A and fungi in cereals in 1998. *Food Addit Contam*. 2002;19:1051-7. [PMID: 12456276]
112. Dahl L, Opsahl JA, Meltzer HM, Julshamn K. Iodine concentration in Norwegian milk and dairy products. *Br J Nutr*. 2003;90:679-85. [PMID: 13129475]
113. D'Amico DJ, Donnelly CW. Microbiological quality of raw milk used for small-scale artisan cheese production in Vermont: effect of farm characteristics and practices. *J Dairy Sci*. 2010;93:134-47. [PMID: 20059912]
114. Dani C, Oliboni LS, Agostini F, Funchal C, Serafini L, Henriques JA, et al. Phenolic content of grapevine leaves (*Vitis labrusca* var. Bordo) and its neuroprotective effect against peroxide damage. *Toxicol In Vitro*. 2010;24:148-53. [PMID: 19699291]
115. Dani C, Oliboni LS, Vanderlinde R, Bonatto D, Salvador M, Henriques JA. Phenolic content and antioxidant activities of white and purple juices manufactured with organically- or conventionally-produced grapes. *Food Chem Toxicol*. 2007;45:2574-80. [PMID: 17683842]
116. Danilchenko H. Effect of growing method on the quality of pumpkins and pumpkin products. *Folia Horticulturae*. 2002;14:103-12.
117. DeEll JR, Prange RK. Postharvest physiological disorders, diseases and mineral concentrations of organically and conventionally grown McIntosh and Cortland apples. *Canadian Journal of Plant Science*. 1993;73:223-30.
118. del Amor FM. Yield and fruit quality response of sweet pepper to organic and mineral fertilization. *Renewable Agriculture and Food Systems*. 2007;22:233-8.
119. D'Evoli L, Tarozzi A, Hrelia P, Lucarini M, Cocchiola M, Gabrielli P, et al. Influence of cultivation system on bioactive molecules synthesis in strawberries: spin-off on antioxidant and antiproliferative activity. *J Food Sci*. 2010;75:C94-9. [PMID: 20492158]
120. do Amarante CVT, Steffens CA, Mafra AL, Albuquerque JA. Yield and fruit quality of apple from conventional and organic production systems. *Pesqui Agropecu Bras*. 2008;43:333-40.
121. Döll S, Valenta H, Kirchheim U, Dänicke S, Flachowsky G. *Fusarium* mycotoxins in conventionally and organically grown grain from Thuringia/Germany. *Mycotoxin Research*. 2000;16:38-41.
122. Edwards SG. *Fusarium* mycotoxin content of UK organic and conventional wheat. *Food Addit Contam Part A Chem Anal Control Expo Risk Assess*. 2009;26:496-506. [PMID: 19680924]
123. Ellis K. Studies of the composition of milk produced on organic and conventional dairy farms. *Organic Studies Centre Technical Bulletin Issue 8*. 2006. Accessed at www.organicstudiescornwall.co.uk/pdf_docs/bulletins/Bulletin%208.pdf on 14 July 2012.
124. Ellis KA, Innocent G, Grove-White D, Cripps P, McLean WG, Howard CV, et al. Comparing the fatty acid composition of organic and conventional milk. *J Dairy Sci*. 2006;89:1938-50. [PMID: 16702257]
125. Ellis KA, Monteiro A, Innocent GT, Grove-White D, Cripps P, McLean WG, et al. Investigation of the vitamins A and E and beta-carotene content in milk from UK organic and conventional dairy farms. *J Dairy Res*. 2007;74:484-91. [PMID: 17922933]
126. Eurola M, Hietaniemi V, Kontturi M, Tuuri H, Pihlaja JM, Saastamoinen M, et al. Cadmium contents of oats (*Avena sativa* L.) in official variety, organic cultivation, and nitrogen fertilization trials during 1997-1999. *J Agric Food Chem*. 2003;51:2608-14. [PMID: 12696945]
127. Fjellkner-Modig S, Bengtsson H, Stegmark R, Nystrom S. The influence of organic and integrated production on nutritional, sensory and agricultural aspects of vegetable raw materials for food production. *Acta Agriculturae Scandinavica. Section B, Soil and Plant Science*. 2000;50:102-13.
128. Forster MP, Rodríguez Rodríguez E, Díaz Romero C. Differential characteristics in the chemical composition of bananas from Tenerife (Canary Islands) and Ecuador. *J Agric Food Chem*. 2002;50:7586-92. [PMID: 12475275]
129. Gabryszuk M, Soniewski K, Sakowski T. Macro- and microelements in milk and hair of cows from conventional vs organic farms. *Animal Science Papers and Reports*. 2008;26:199-209.
130. Garmo RT, Waage S, Sviland S, Henriksen BI, Østerås O, Reksen O. Reproductive performance, udder health, and antibiotic resistance in mastitis bacteria isolated from Norwegian Red cows in conventional and organic farming. *Acta Vet Scand*. 2010;52:11. [PMID: 20141638]
131. Ghidini S, Zanardi E, Battaglia A, Varisco G, Ferretti E, Campanini G, et al. Comparison of contaminant and residue levels in organic and conventional milk and meat products from northern Italy. *Food Addit Contam*. 2005;22:9-14. [PMID: 15895606]
132. Giannenas I, Nisianakis P, Gavril A, Kontopidis G, Kyriazakis I. Trace mineral content of conventional, organic and courtyard eggs analysed by inductively coupled plasma mass spectrometry (ICP-MS). *Food Chem*. 2009;114:706-11.
133. González L, Juan C, Soriano JM, Moltó JC, Mañes J. Occurrence and daily intake of ochratoxin A of organic and non-organic rice and rice products. *Int J Food Microbiol*. 2006;107:223-7. [PMID: 16316704]
134. Gonzalez M, Miglirona KS, Aizpún de Moreno JE, Moreno VJ. Evaluation of conventionally and organically produced vegetables for high lipophilic organochlorine pesticide (OCP) residues. *Food Chem Toxicol*. 2005;43:261-9. [PMID: 15621339]
135. Griesshaber D, Kuhn F, Berger U, Oehme M. Comparison of trichothecene contaminations in wheat cultivated by three different farming systems in Switzerland: biodynamic, bioorganic and conventional. *Mitt Lebensmittelunters Hyg*. 2004;95:251-60.
136. Gundersen V, Bechmann IE, Behrens A, Stürup S. Comparative investigation of concentrations of major and trace elements in organic and conventional Danish agricultural crops. 1. Onions (*Allium cepa* Hysam) and peas (*Pisum sativum* ping pong). *J Agric Food Chem*. 2000;48:6094-102. [PMID: 11312781]
137. Gutierrez F, Arnaud T, Albi MA. Influence of ecological cultivation on virgin olive oil quality. *Journal of the American Oil Chemists' Society*. 1999;76:617-21.
138. Hajslová J, Schulzová V, Slanina P, Janné K, Hellenäs KE, Andersson CH. Quality of organically and conventionally grown potatoes: four-year study of micronutrients, metals, secondary metabolites, enzymic browning and organoleptic properties. *Food Addit Contam*. 2005;22:514-34. [PMID: 16019825]
139. Hakala MA, Lapveteläinen AT, Huopalahti R, Kallio HP, Tahvonen R. Effects of varieties and cultivation conditions on the composition of strawberries. *J Food Compost Anal*. 2003;16:67-80.
140. Häkkinen SH, Törrönen AR. Content of flavonols and selected phenolic acids in strawberries and *Vaccinium* species: influence of cultivar, cultivation site and technique. *Food Res Int*. 2000;33:517-24.
141. Halbert LW, Kaneene JB, Linz J, Mansfield LS, Wilson D, Ruegg PL, et al. Genetic mechanisms contributing to reduced tetracycline susceptibility of *Campylobacter* isolated from organic and conventional dairy farms in the mid-western and northeastern United States. *J Food Prot*. 2006;69:482-8. [PMID: 16541675]
142. Halbert LW, Kaneene JB, Ruegg PL, Warnick LD, Wells SJ, Mansfield LS, et al. Evaluation of antimicrobial susceptibility patterns in *Campylobacter* spp isolated from dairy cattle and farms managed organically and conventionally in the midwestern and northeastern United States. *J Am Vet Med Assoc*. 2006;228:1074-81. [PMID: 16579787]
143. Hallmann E, Rembiałkowska E. Comparison of the nutritive quality of tomato fruits from organic and conventional production in Poland. Presented at the 3rd International Congress of the European Integrated Project Quality Low Input Food (QLIF) Congress: Improving Sustainability in Organic and Low Input Food Production Systems, University of Hohenheim, Germany, 20-23 March 2007. Accessed at <http://orgprints.org/9944> on 12 July 2012.
144. Hamouz K, Lachman J, Dvůrák P, Pivec V. The effect of ecological growing on the potatoes yield and quality. *Plant, Soil and Environment*. 2005;51:397-402.

145. Hamouz K, Lachman J, Pivec V, Vokal B. Influence of environmental conditions and way of cultivation on the polyphenol and ascorbic acid content in potato tubers. *Rostlinna Vyroba*. 1999;45:293-8.
146. Han F, Lestari SI, Pu S, Ge B. Prevalence and antimicrobial resistance among *Campylobacter* spp. in Louisiana retail chickens after the enrofloxacin ban. *Foodborne Pathog Dis*. 2009;6:163-71. [PMID: 19099357]
147. Hanell U, L-Baekström G, Svensson G. Quality studies on wheat grown in different cropping systems: a holistic perspective. *Acta Agriculturae Scandinavica. Section B, Soil and Plant Science*. 2004;54:254-63.
148. Hansen H. Comparison of chemical composition and taste of biodynamically and conventionally grown vegetables. *Plant Foods Hum Nutr*. 1981;30:203-11.
149. Hansen LL, Claudi-Magnussen C, Jensen SK, Andersen HJ. Effect of organic pig production systems on performance and meat quality. *Meat Sci*. 2006;74:605-15. [PMID: 22063213]
150. Harcz P, De Temmerman L, De Voghel S, Waegeneers N, Wilmart O, Vromman V, et al. Contaminants in organically and conventionally produced winter wheat (*Triticum aestivum*) in Belgium. *Food Addit Contam*. 2007;24:713-20. [PMID: 17613056]
151. Heimler D, Isolani L, Vignolini P, Romani A. Polyphenol content and antiradical activity of *Cichorium intybus* L. from biodynamic and conventional farming. *Food Chem*. 2009;114:765-70.
152. Hellström S, Laukkanen R, Siekkinen KM, Ranta J, Majjala R, Korkeala H. *Listeria monocytogenes* contamination in pork can originate from farms. *J Food Prot*. 2010;73:641-8. [PMID: 20377951]
153. Hermansen JE, Badsberg JH, Kristensen T, Gundersen V. Major and trace elements in organically or conventionally produced milk. *J Dairy Res*. 2005;72:362-8. [PMID: 16174368]
154. Hietaniemi V, Kontturi M, Ramo S, Eurola M, Kangas A, Niskanen M, et al. Contents of trichothecenes in oats during official variety, organic cultivation and nitrogen fertilization trials in Finland. *Agricultural and Food Science*. 2004;13:54-67.
155. Hildermann I, Messmer M, Dubois D, Boller T, Wiemken A, Mäder P. Nutrient use efficiency and arbuscular mycorrhizal root colonisation of winter wheat cultivars in different farming systems of the DOK long-term trial. *J Sci Food Agric*. 2010;90:2027-38. [PMID: 20582996]
156. Högborg A, Pickova J, Andersson K, Lundström K. Fatty acid composition and tocopherol content of muscle in pigs fed organic and conventional feed with different n6/n3 ratios, respectively. *Food Chem*. 2003;80:177-86.
157. Hogstad S, Risvik E, Steinholt K. Sensory quality and chemical composition in carrots: a multivariate study. *Acta Agriculturae Scandinavica. Section B, Soil and Plant Science*. 1997;47:253-64.
158. Hoikkala A, Mustonen E, Saastamoinen I, Jokela T, Taponen J, Saloniemi H, et al. High levels of equol in organic skimmed Finnish cow milk. *Mol Nutr Food Res*. 2007;51:782-6. [PMID: 17576638]
159. Hoogenboom LA, Bokhorst JG, Northolt MD, van de Vijver LP, Broex NJ, Mevius DJ, et al. Contaminants and microorganisms in Dutch organic food products: a comparison with conventional products. *Food Addit Contam Part A Chem Anal Control Expo Risk Assess*. 2008;25:1195-207. [PMID: 18608495]
160. Husak RL, Sebranek JG, Bregendahl K. A survey of commercially available broilers marketed as organic, free-range, and conventional broilers for cooked meat yields, meat composition, and relative value. *Poult Sci*. 2008;87:2367-76. [PMID: 18931189]
161. Izat AL, Kopek JM, McGinnis JD. Research note: incidence, number, and serotypes of *Salmonella* on frozen broiler chickens at retail. *Poult Sci*. 1991;70:1438-40. [PMID: 1886849]
162. Jahan K, Paterson A. Lipid composition of retailed organic, free-range and conventional chicken breasts. *International Journal of Food Science and Technology*. 2007;42:251-62.
163. Jahan K, Paterson A, Spickett CM. Fatty acid composition, antioxidants and lipid oxidation in chicken breasts from different production regimes. *International Journal of Food Science and Technology*. 2004;39:443-53.
164. Jørgensen K, Jacobsen JS. Occurrence of ochratoxin A in Danish wheat and rye, 1992-99. *Food Addit Contam*. 2002;19:1184-9. [PMID: 12623679]
165. Jorhem L, Slanina P. Does organic farming reduce the content of Cd and certain other trace metals in plant foods? A pilot study. *Journal of the Science of Food and Agriculture*. 2000;80:43-8.
166. Juan C, Molto JC, Lino CM, Manes J. Determination of ochratoxin A in organic and non-organic cereals and cereal products from Spain and Portugal. *Food Chem*. 2008;107:525-30.
167. Juroszek P, Lumpkin HM, Yang RY, Ledesma DR, Ma CH. Fruit quality and bioactive compounds with antioxidant activity of tomatoes grown on-farm: comparison of organic and conventional management systems. *J Agric Food Chem*. 2009;57:1188-94. [PMID: 19178281]
168. Kahu K, Janes H, Luik A, Klaas L. Yield and fruit quality of organically cultivated blackcurrant cultivars. *Acta Agriculturae Scandinavica. Section B, Soil and Plant Science*. 2009;59:63-9.
169. Karavoltos S, Sakellari A, Dimopoulos M, Dasenakis M, Scoullas M. Cadmium content in foodstuffs from the Greek market. *Food Addit Contam*. 2002;19:954-62. [PMID: 12443557]
170. Krejcirova L, Capouchova I, Petr J, Bicanova E, Famera O. The effect of organic and conventional growing systems on quality and storage protein composition of winter wheat. *Plant, Soil and Environment*. 2007;53:499-505.
171. Kristensen M, Østergaard LF, Halekoh U, Jørgensen H, Lauridsen C, Brandt K, et al. Effect of plant cultivation methods on content of major and trace elements in foodstuffs and retention in rats. *J Sci Food Agric*. 2008;88:2161-72.
172. La Torre A, Leandri A, Lolletti D. Comparison of health status between organic and conventional products. *Commun Agric Appl Biol Sci*. 2005;70:351-63. [PMID: 16637200]
173. Lairon D, Spitz N, Termine E, Ribaud P, Lafont H, Hauton J. Effect of organic and mineral nitrogen fertilization on yield and nutritive value of butterhead lettuce. *Qualitas Plantarum-Plant Food for Human Nutrition*. 1984;34:97-108.
174. Lamperi L, Chiuminatto U, Cincinelli A, Galvan P, Giordani E, Lepri L, et al. Polyphenol levels and free radical scavenging activities of four apple cultivars from integrated and organic farming in different Italian areas. *J Agric Food Chem*. 2008;56:6536-46. [PMID: 18642842]
175. Langenkämper G, Zörb C, Seifert M, Mäder P, Fretzdorff B, Betsche T. Nutritional quality of organic and conventional wheat. *Journal of Applied Botany and Food Quality*. 2006;80:150-4.
176. Larsen MK, Nielsen JH, Butler G, Leifert C, Slots T, Kristiansen GH, et al. Milk quality as affected by feeding regimens in a country with climatic variation. *J Dairy Sci*. 2010;93:2863-73. [PMID: 20630203]
177. Laukkanen R, Martínez PO, Siekkinen KM, Ranta J, Majjala R, Korkeala H. Transmission of *Yersinia pseudotuberculosis* in the pork production chain from farm to slaughterhouse. *Appl Environ Microbiol*. 2008;74:5444-50. [PMID: 18641149]
178. L-Baekström G, Hanell U, Svensson G. Baking quality of winter wheat grown in different cultivating systems, 1992-2001: a holistic approach. *J Sustain Agric*. 2004;24:53-79.
179. Leclerc J, Miller ML, Joliet E, Rocquelin G. Vitamin and mineral contents of carrot and celeriac grown under mineral or organic fertilization. *Biological Agriculture and Horticulture*. 1991;7:339-48.
180. Lehesranta SJ, Koistinen KM, Massat N, et al. Effects of agricultural production systems and their components on protein profiles of potato tubers. *Proteomics*. 2007;7:597-604. [PMID: 17309105]
181. Lestari SI, Han F, Wang F, Ge B. Prevalence and antimicrobial resistance of *Salmonella* serovars in conventional and organic chickens from Louisiana retail stores. *J Food Prot*. 2009;72:1165-72. [PMID: 19610326]
182. Lester GE, Manthey JA, Buslig BS. Organic vs conventionally grown Rio Red whole grapefruit and juice: comparison of production inputs, market quality, consumer acceptance, and human health-bioactive compounds. *J Agric Food Chem*. 2007;55:4474-80. [PMID: 17474757]
183. Lesueur C, Gartner M, Knittl P, List P, Wimmer S, Sieler V, et al. Pesticide residues in fruit and vegetable samples: analytical results of 2 year's pesticide investigations. *Ernährung/Nutrition*. 2007;31:247-59.
184. Lindén A, Andersson K, Oskarsson A. Cadmium in organic and conventional pig production. *Arch Environ Contam Toxicol*. 2001;40:425-31. [PMID: 11443376]
185. Lombardi-Boccia G, Lucarini M, Lanzi S, Aguzzi A, Cappelloni M. Nutrients and antioxidant molecules in yellow plums (*Prunus domestica* L.) from conventional and organic productions: a comparative study. *J Agric Food Chem*. 2004;52:90-4. [PMID: 14709018]
186. Lu C, Bravo R, Caltabiano LM, Irish RM, Weerasekera G, Barr DB. The presence of dialkylphosphates in fresh fruit juices: implication for organophosphorus pesticide exposure and risk assessments. *J Toxicol Environ Health A*. 2005;68:209-27. [PMID: 15762180]
187. Mäder P, Hahn D, Dubois D, Gunst L, Alföldi T, Bergmann H, et al. Wheat quality in organic and conventional farming: results of a 21 year field experiment. *J Sci Food Agric*. 2007;87:1826-35.

188. Mäder P, Pfiffner L, Niggli U, Plochberger K, Balzer U, Balzer F, et al. Effect of three farming systems (bio-dynamic, bio-organic, conventional) on yield and quality of beetroot (*Beta vulgaris* L. var. esculenta L.) in a seven year crop rotation. *Acta Hort.* 1993;339:11-31.
189. Malmauret L, Parent-Massin D, Hardy JL, Verger P. Contaminants in organic and conventional foodstuffs in France. *Food Addit Contam.* 2002;19:524-32. [PMID: 12042017]
190. Mansour SA, Belal MH, Abou-Arab AA, Ashour HM, Gad MF. Evaluation of some pollutant levels in conventionally and organically farmed potato tubers and their risks to human health. *Food Chem Toxicol.* 2009;47:615-24. [PMID: 19138717]
191. Mansour SA, Belal MH, Abou-Arab AA, Gad MF. Monitoring of pesticides and heavy metals in cucumber fruits produced from different farming systems. *Chemosphere.* 2009;75:601-9. [PMID: 19237184]
192. Martino G, Ponzelli V, Grotta L. Healthier fat content through organic production. *World Poultry.* 2008;24:33-4.
193. Masamba KG, Nguyen M. Determination and comparison of vitamin C, calcium and potassium in four selected conventionally and organically grown fruits and vegetables. *African Journal of Biotechnology.* 2008;7:2915-9.
194. Mason H, Navabi A, Frick B, O'Donovan J, Niziol D, Spaner D. Does growing Canadian Western Hard Red Spring wheat under organic management alter its breadmaking quality? *Renewable Agriculture and Food Systems.* 2007;22:157-67.
195. Mazzoncini M, Belloni P, Risaliti R, Antichi D. Organic vs conventional winter wheat quality and organoleptic bread test. Improving Sustainability in Organic and Low Input Food Production Systems. Presented at the 3rd International Congress of the European Integrated Project Quality Low Input Food (QLIF) Congress: Improving Sustainability in Organic and Low Input Food Production Systems, University of Hohenheim, Germany, 20–23 March 2007. Accessed at <http://orgprints.org/9753> on 14 July 2012.
196. Meier Ploeger A, Duden R, Vogtmann H. Quality of food plants grown with compost from biogenic waste. *Agric Ecosyst Environ.* 1989;27:483-91.
197. Mercadante AZ, Rodriguez-Amaya DB. Carotenoid composition of a leafy vegetable in relation to some agricultural variables. *J Agric Food Chem.* 1991;39:1094-7.
198. Messens W, Grijspeerd K, De Reu K, De Ketelaere B, Mertens K, Bamelis F, et al. Eggshell penetration of various types of hens' eggs by *Salmonella enterica* serovar Enteritidis. *J Food Prot.* 2007;70:623-8. [PMID: 17388050]
199. Mikkonen TP, Määttä KR, Hukkanen AT, Kokko HI, Törrönen AR, Kärenlampi SO, et al. Flavonol content varies among black currant cultivars. *J Agric Food Chem.* 2001;49:3274-7. [PMID: 11453762]
200. Millet S, Hesta M, Seynaeve M, Ongena E, De Smet S, Debraekeleer J, et al. Performance, meat and carcass traits of fattening pigs with organic versus conventional housing and nutrition. *Livestock Production Science.* 2004;87:109-19.
201. Miranda JM, Vazquez BI, Fente CA, Barros-Velazquez J, Cepeda A, Abuin CMF. Antimicrobial resistance in *Escherichia coli* strains isolated from organic and conventional pork meat: a comparative survey. *European Food Research and Technology.* 2008;226:371-5.
202. Mitchell AE, Hong YJ, Koh E, Barrett DM, Bryant DE, Denison RF, et al. Ten-year comparison of the influence of organic and conventional crop management practices on the content of flavonoids in tomatoes. *J Agric Food Chem.* 2007;55:6154-9. [PMID: 17590007]
203. Mladenova R, Shtereva D. Pesticide residues in apples grown under a conventional and integrated pest management system. *Food Addit Contam Part A Chem Anal Control Expo Risk Assess.* 2009;26:854-8. [PMID: 19680960]
204. Moreira MDR, Roura SI, del Valle CED. Quality of Swiss chard produced by conventional and organic methods. *Lebensmittel Wissenschaft Und Technologie—Food and Science Technology.* 2003;36:135-41.
205. Mukherjee A, Speh D, Dyck E, Diez-Gonzalez F. Preharvest evaluation of coliforms, *Escherichia coli*, *Salmonella*, and *Escherichia coli* O157:H7 in organic and conventional produce grown by Minnesota farmers. *J Food Prot.* 2004;67:894-900. [PMID: 15151224]
206. Mukherjee A, Speh D, Jones AT, Buesing KM, Diez-Gonzalez F. Longitudinal microbiological survey of fresh produce grown by farmers in the upper midwest. *J Food Prot.* 2006;69:1928-36. [PMID: 16924919]
207. Nakamura YN, Fujita M, Nakamura Y, Gotoh T. Comparison of nutritional composition and histological changes of the soybean seeds cultivated by conventional and organic farming systems after long-term storage—preliminary study. *Journal of the Faculty of Agriculture Kyushu University.* 2007;52:1-10.
208. Ninfali P, Bacchiocca M, Biagiotti E, Esposto S, Servili M, Rosati A, et al. A 3-year study on quality, nutritional and organoleptic evaluation of organic and conventional extra-virgin olive oils. *Journal of the American Oil Chemists' Society.* 2008;85:151-8.
209. Nitika, Punia D, Khetarpaul N. Physico-chemical characteristics, nutrient composition and consumer acceptability of wheat varieties grown under organic and inorganic farming conditions. *Int J Food Sci Nutr.* 2008;59:224-45. [PMID: 17852472]
210. Nowak B, Mueffling TV, Caspari K, Hartung J. Validation of a method for the detection of virulent *Yersinia enterocolitica* and their distribution in slaughter pigs from conventional and alternative housing systems. *Vet Microbiol.* 2006;117:219-28. [PMID: 16837145]
211. Nyanjage MO, Wainwright H, Bishop CFH, Cullum FJ. A comparative study on the ripening and mineral content of organically and conventionally grown Cavendish bananas. *Biological Agriculture and Horticulture.* 2001;18:221-34.
212. O'Donnell AM, Spatny KP, Vicini JL, Bauman DE. Survey of the fatty acid composition of retail milk differing in label claims based on production management practices. *J Dairy Sci.* 2010;93:1918-25. [PMID: 20412905]
213. Ogbadu GH, Easmon JP. Influence of inorganic and organic fertilizers on the chemical composition of three eggplant cultivars. *Tropical Science.* 1989;29:237-46.
214. Oliveira M, Usall J, Viñas I, Anguera M, Gatiús F, Abadías M. Microbiological quality of fresh lettuce from organic and conventional production. *Food Microbiol.* 2010;27:679-84. [PMID: 20510788]
215. Olivo CJ, Beck LI, Mossate Gabbi A, Santini Charão P, Sobczak MF, Gomez Uberty LF, et al. Composition and somatic cell count of milk in conventional and agro-ecological farms: a comparative study in Depressão Central, Rio Grande do Sul state, Brazil. *Livestock Research for Rural Development.* 2005;17, Article 72. Accessed at www.lrrd.org/lrrd17/6/oliv17072.htm on 14 July 2012.
216. Olsson IM, Jonsson S, Oskarsson A. Cadmium and zinc in kidney, liver, muscle and mammary tissue from dairy cows in conventional and organic farming. *J Environ Monit.* 2001;3:531-8. [PMID: 11695124]
217. Olsson ME, Andersson CS, Oredsson S, Berglund RH, Gustavsson KE. Antioxidant levels and inhibition of cancer cell proliferation in vitro by extracts from organically and conventionally cultivated strawberries. *J Agric Food Chem.* 2006;54:1248-55. [PMID: 16478244]
218. Olsson V, Andersson K, Hansson I, Lundström K. Differences in meat quality between organically and conventionally produced pigs. *Meat Sci.* 2003;64:287-97. [PMID: 22063015]
219. Ottesen AR, White JR, Skaltsas DN, Newell MJ, Walsh CS. Impact of organic and conventional management on the phyllosphere microbial ecology of an apple crop. *J Food Prot.* 2009;72:2321-5. [PMID: 19903395]
220. Peck GM. Orchard Productivity and Apple Fruit Quality of Organic, Conventional, and Integrated Farm Management Systems. Pullman, WA: Washington State University; 2004. Accessed at <http://ecommons.library.cornell.edu/bitstream/1813/2720/1/Peck%202004%20WSU%20MS%20Thesis.pdf> on 18 June 2012.
221. Pérez-López AJ, del Amor FM, Serrano-Martinez A, Fortea MI, Nunez-Delgado E. Influence of agricultural practices on the quality of sweet pepper fruits as affected by the maturity stage. *J Sci Food Agric.* 2007;87:2075-80.
222. Pérez-López AJ, López-Nicolás JM, Carbonell-Barrachina AA. Effects of organic farming on minerals contents and aroma composition of Clemenules mandarin juice. *European Food Research and Technology.* 2007;225:255-60.
223. Pérez-López AJ, López-Nicolás JM, Núñez-Delgado E, Del Amor FM, Carbonell-Barrachina AA. Effects of agricultural practices on color, carotenoids composition, and minerals contents of sweet peppers, cv. Almuden. *J Agric Food Chem.* 2007;55:8158-64. [PMID: 17822289]
224. Perkowski J, Wiwart M, Busko M, Laskowska M, Berthiller F, Kandler W, et al. Fusarium toxins and total fungal biomass indicators in naturally contaminated wheat samples from north-eastern Poland in 2003. *Food Addit Contam.* 2007;24:1292-8. [PMID: 17852394]
225. Petr J. Quality of triticale from ecological and intensive farming. *Scientia Agriculturae Bohemica.* 2006;37:95-103.
226. Phillips CA, Harrison MA. Comparison of the microflora on organically and conventionally grown spring mix from a California processor. *J Food Prot.* 2005;68:1143-6. [PMID: 15954699]

227. Pieper JR, Barrett DM. Effects of organic and conventional production systems on quality and nutritional parameters of processing tomatoes. *J Sci Food Agric*. 2009;89:177-94.
228. Pla M. A comparison of the carcass traits and meat quality of conventionally and organically produced rabbits. *Livestock Science*. 2008;115:1-12.
229. Pla M, Ramirez JA, Diaz I, Hernandez P, Arino B. Prediction of fatty acid content in rabbit meat and discrimination between conventional and organic production systems by NIRS methodology. *Food Chem*. 2007;100:165-70.
230. Porretta S. Qualitative comparison between commercial "traditional" and "organic" tomato products using multivariate statistical analysis. *Acta Hort*. 1994;376:259-70.
231. Poulsen ME, Andersen JH. Results from the monitoring of pesticide residues in fruit and vegetables on the Danish market, 2000-01. *Food Addit Contam*. 2003;20:742-57. [PMID: 13129791]
232. Pozzo L, Cavallarin L, Nucera D, Antoniazzi S, Schiavone A. A survey of ochratoxin A contamination in feeds and sera from organic and standard swine farms in northwest Italy. *J Sci Food Agric*. 2010;90:1467-72. [PMID: 20549798]
233. Prandini A, Sigolo S, Piva G. Conjugated linoleic acid (CLA) and fatty acid composition of milk, curd and Grana Padano cheese in conventional and organic farming systems. *J Dairy Res*. 2009;76:278-82. [PMID: 19445826]
234. Procidia G, Pertoldi Marletta G, Ceccon L. Heavy metal content of some vegetables farmed by both conventional and organic methods. *Italian Journal of Food Science*. 1998;27:181-9.
235. Pussemier L, Piérard JY, Anselme M, Tangni EK, Motte JC, Larondelle Y. Development and application of analytical methods for the determination of mycotoxins in organic and conventional wheat. *Food Addit Contam*. 2006;23:1208-18. [PMID: 17071524]
236. Raigon MD, Palomares G, Ortiz-Perez M, Ordone I. Ca, K, Fe, P and Na content in different varietal types of dry bean using two growing systems: organic and conventional. Reports of Bean Improvement Cooperative and National Dry Bean Council Research Conference. Annual Report. 2003;46:109-10.
237. Raigón MD, Rodríguez-Burruezo A, Prohens J. Effects of organic and conventional cultivation methods on composition of eggplant fruits. *J Agric Food Chem*. 2010;58:6833-40. [PMID: 20443597]
238. Reganold JP, Glover JD, Andrews PK, Hinman HR. Sustainability of three apple production systems. *Nature*. 2001;410:926-30. [PMID: 11309616]
239. Rembialkowska E. [A comparison of selected parameters of potatoes health quality from ecologically oriented and conventional farms]. *Rocz Panstw Zakl Hig*. 1998;49:159-67. [PMID: 9847674]
240. Rodriguez J, Rios D, Rodriguez E, Diaz C. Physico-chemical changes during ripening of conventionally, ecologically and hydroponically cultivated Tylrain (TY 10016) tomatoes. *International Journal of Agricultural Research*. 2006;1:452-61.
241. Roesch M, Doherr MG, Blum JW. Management, feeding, production, reproduction and udder health on organic and conventional Swiss dairy farms. *Schweiz Arch Tierheilkd*. 2006;148:387-95. [PMID: 16933702]
242. Roesch M, Perreten V, Doherr MG, Schaeren W, Schällibaum M, Blum JW. Comparison of antibiotic resistance of udder pathogens in dairy cows kept on organic and on conventional farms. *J Dairy Sci*. 2006;89:989-97. [PMID: 16507693]
243. Rossi F, Bertuzzi T, Comizzoli S, Turconi G, Roggi C, Pagani M, et al. Preliminary survey on composition and quality of conventional and organic wheat. *Italian Journal of Food Science*. 2006;18:355-66.
244. Rossi F, Godani F, Bertuzzi T, Trevisan M, Ferrari F, Gatti S. Health-promoting substances and heavy metal content in tomatoes grown with different farming techniques. *Eur J Nutr*. 2008;47:266-72. [PMID: 18604621]
245. Ruimy R, Brisabois A, Bernede C, Skurnik D, Barnat S, Arlet G, et al. Organic and conventional fruits and vegetables contain equivalent counts of Gram-negative bacteria expressing resistance to antibacterial agents. *Environ Microbiol*. 2010;12:608-15. [PMID: 19919536]
246. Ryan MH, Derrick JW, Dann PR. Grain mineral concentrations and yield of wheat grown under organic and conventional management. *J Sci Food Agric*. 2004;84:207-16.
247. Sablani SS, Andrews PK, Davies NM, Walters T, Saez H, Syamaladevi RM, et al. Effect of thermal treatments on phytochemicals in conventionally and organically grown berries. *J Sci Food Agric*. 2010;90:769-78. [PMID: 20355111]
248. Sato K, Bennedsgaard TW, Bartlett PC, Erskine RJ, Kaneene JB. Comparison of antimicrobial susceptibility of *Staphylococcus aureus* isolated from bulk tank milk in organic and conventional dairy herds in the midwestern United States and Denmark. *J Food Prot*. 2004;67:1104-10. [PMID: 15222534]
249. Schollenberger M, Jara HT, Suchy S, Drochner W, Müller HM. Fusarium toxins in wheat flour collected in an area in southwest Germany. *Int J Food Microbiol*. 2002;72:85-9. [PMID: 11843417]
250. Schwaiger K, Schmied EM, Bauer J. Comparative analysis of antibiotic resistance characteristics of Gram-negative bacteria isolated from laying hens and eggs in conventional and organic keeping systems in Bavaria, Germany. *Zoonoses Public Health*. 2008;55:331-41. [PMID: 18667026]
251. Schwaiger K, Schmied EM, Bauer J. Comparative analysis on antibiotic resistance characteristics of *Listeria* spp. and *Enterococcus* spp. isolated from laying hens and eggs in conventional and organic keeping systems in Bavaria, Germany. *Zoonoses Public Health*. 2010;57:171-80. [PMID: 19486494]
252. Shier NW, Kelman J, Dunson JW. A comparison of crude protein, moisture, ash and crop yield between organic and conventionally grown wheat. *Nutrition Reports International*. 1984;30:71-6.
253. Skaug MA. Analysis of Norwegian milk and infant formulas for ochratoxin A. *Food Addit Contam*. 1999;16:75-8. [PMID: 10435076]
254. Slots T, Butler G, Leifert C, Kristensen T, Skibsted LH, Nielsen JH. Potentials to differentiate milk composition by different feeding strategies. *J Dairy Sci*. 2009;92:2057-66. [PMID: 19389964]
255. Slots T, Sorensen J, Nielsen JH. Tocopherol, carotenoids and fatty acid composition in organic and conventional milk. *Milchwissenschaft*. 2008;63:352-5.
256. Soonthornchaikul N, Garelick H, Jones H, Jacobs J, Ball D, Choudhury M. Resistance to three antimicrobial agents of *Campylobacter* isolated from organically- and intensively-reared chickens purchased from retail outlets. *Int J Antimicrob Agents*. 2006;27:125-30. [PMID: 16417991]
257. Sousa C, Valentão P, Rangel J, Lopes G, Pereira JA, Ferreres F, et al. Influence of two fertilization regimens on the amounts of organic acids and phenolic compounds of tronchuda cabbage (*Brassica oleracea* L. Var. *costata* DC). *J Agric Food Chem*. 2005;53:9128-32. [PMID: 16277412]
258. Srikumar TS, Ockerman PA. The effects of organic and inorganic fertilization on the content of trace elements in cereal grains. *Food Chem*. 1991;42:225-30.
259. Stracke BA, Eitel J, Watzl B, Mäder P, Rüfer CE. Influence of the production method on phytochemical concentrations in whole wheat (*Triticum aestivum* L.): a comparative study. *J Agric Food Chem*. 2009;57:10116-21. [PMID: 19817369]
260. Stracke BA, Rüfer CE, Weibel FP, Bub A, Watzl B. Three-year comparison of the polyphenol contents and antioxidant capacities in organically and conventionally produced apples (*Malus domestica* Bork. Cultivar 'Golden Delicious'). *J Agric Food Chem*. 2009;57:4598-605. [PMID: 19388640]
261. Tarozzi A, Hrelia S, Angeloni C, Morroni F, Biagi P, Guardigli M, et al. Antioxidant effectiveness of organically and non-organically grown red oranges in cell culture systems. *Eur J Nutr*. 2006;45:152-8. [PMID: 16096701]
262. Tarozzi A, Marchesi A, Cantelli-Forti G, Hrelia P. Cold-storage affects antioxidant properties of apples in Caco-2 cells. *J Nutr*. 2004;134:1105-9. [PMID: 15113953]
263. Tasiopoulou S, Chiodini AM, Vellere F, Visentin S. Results of the monitoring program of pesticide residues in organic food of plant origin in Lombardy (Italy). *J Environ Sci Health B*. 2007;42:835-41. [PMID: 17763041]
264. Tikofsky LL, Barlow JW, Santisteban C, Schukken YH. A comparison of antimicrobial susceptibility patterns for *Staphylococcus aureus* in organic and conventional dairy herds. *Microb Drug Resist*. 2003;9 Suppl 1:S39-45. [PMID: 14633366]
265. Toledo P, Andren A, Bjorck L. Composition of raw milk from sustainable production systems. *International Dairy Journal*. 2002;12:75-80.
266. Tran thi Ngoc S, Vu van T, Luu Hong M, Hiraoka H. Effect of organic and bio-fertilizer on quality, grain yield and soil properties of soybean under rice based cropping system. *Omonrice*. 2001;55-61. Accessed at <http://wenku.baidu.com/view/80b49684ec3a87c24028c4be.html> on 14 July 2012.
267. Tsatsakis AM, Tsakiris IN, Tzatzarakis MN, Agourakis ZB, Tutudaki M, Alegakis AK. Three-year study of fenthion and dimethoate pesticides in olive oil from organic and conventional cultivation. *Food Addit Contam*. 2003;20:553-9. [PMID: 12881128]
268. Tsiplakou E, Kotrotsios V, Hadjigeorgiou I, Zervas G. Differences in sheep and goats milk fatty acid profile between conventional and organic farming systems. *J Dairy Res*. 2010;77:343-9. [PMID: 20482951]

269. Turgut C, Ornek H, Cutright TJ. Determination of pesticide residues in Turkey's table grapes: the effect of integrated pest management, organic farming, and conventional farming. *Environ Monit Assess*. 2011;173:315-23. [PMID: 20213057]
270. Vanova M, Klem K, Misa P, Matusinsky P, Hajslova J, Lancova K. The content of *Fusarium* mycotoxins, grain yield and quality of winter wheat cultivars under organic and conventional cropping systems. *Plant Soil Environment*. 2008; 54:395-402.
271. Vicini J, Etherton T, Kris-Etherton P, Ballam J, Denham S, Staub R, et al. Survey of retail milk composition as affected by label claims regarding farm-management practices. *J Am Diet Assoc*. 2008;108:1198-203. [PMID: 18589029]
272. Walshe BE, Sheehan EM, Delahunty CM, Morrissey PA, Kerry JP. Composition, sensory and shelf life stability analyses of *Longissimus dorsi* muscle from steers reared under organic and conventional production systems. *Meat Sci*. 2006; 73:319-25. [PMID: 22062304]
273. Wang SY, Chen CT, Sciarappa W, Wang CY, Camp MJ. Fruit quality, antioxidant capacity, and flavonoid content of organically and conventionally grown blueberries. *J Agric Food Chem*. 2008;56:5788-94. [PMID: 18590274]
274. Warman PR, Havard KA. Yield, vitamin and mineral contents of organically and conventionally grown carrots and cabbage. *Agric Ecosyst Environ*. 1997;61:155-62.
275. Warman PR, Havard KA. Yield, vitamin and mineral content of four vegetables grown with either composted manure or conventional fertilizer. *Journal of Vegetable Crop Production*. 1996;2:13-25.
276. Warman PR, Havard KA. Yield, vitamin and mineral contents of organically and conventionally grown potatoes and sweet corn. *Agric Ecosyst Environ*. 1998;68:207-16.
277. Wszelaki AL, Delwiche JF, Walker SD, Liggett RE, Scheerens JC, Kleinhenz MD. Sensory quality and mineral and glycoalkaloid concentrations in organically and conventionally grown redskin potatoes (*Solanum tuberosum*). *J Sci Food Agric*. 2005;85:720-6.
278. Wunderlich SM, Feldman C, Kane S, Hazhin T. Nutritional quality of organic, conventional, and seasonally grown broccoli using vitamin C as a marker. *Int J Food Sci Nutr*. 2008;59:34-45. [PMID: 17852499]
279. Young JE, Zhao X, Carey EE, Welti R, Yang SS, Wang W. Phytochemical phenolics in organically grown vegetables. *Mol Nutr Food Res*. 2005;49:1136-42. [PMID: 16302198]
280. Zhao X, Carey EE, Young JE, Wang W, Iwamoto T. Influences of organic fertilization, high tunnel environment, and postharvest storage on phenolic compounds in lettuce. *HortScience*. 2007;42:71-6. Accessed at <http://hortsci.ashspublications.org/content/42/1/71.full.pdf> on 14 July 2012.
281. Zhao X, Nechols JR, Williams KA, Wang WQ, Carey EE. Comparison of phenolic acids in organically and conventionally grown pac choy (*Brassica rapa* L. *chinensis*). *J Sci Food Agric*. 2009;89:940-6.
282. Zheng DM, Bonde M, Sorensen JT. Associations between the proportion of *Salmonella* seropositive slaughter pigs and the presence of herd level risk factors for introduction and transmission of *Salmonella* in 34 Danish organic, outdoor (non-organic) and indoor finishing-pig farms. *Livestock Science*. 2007;106:189-99.
283. Zörb C, Betsche T, Langenkämper G. Search for diagnostic proteins to prove authenticity of organic wheat grains (*Triticum aestivum* L.). *J Agric Food Chem*. 2009;57:2932-7. [PMID: 19253955]
284. Zörb C, Niehaus K, Barsch A, Betsche T, Langenkämper G. Levels of compounds and metabolites in wheat ears and grains in organic and conventional agriculture. *J Agric Food Chem*. 2009;57:9555-62. [PMID: 20560625]
285. Zuchowski J, Jonczyk K, Pecio L, Oleszek W. Phenolic acid concentrations in organically and conventionally cultivated spring and winter wheat. *J Sci Food Agric*. 2011;91:1089-95. [PMID: 21308690]
286. Molentin J, Giesemann A. Differentiation of organically and conventionally produced milk by stable isotope and fatty acid analysis. *Anal Bioanal Chem*. 2007;388:297-305. [PMID: 17393158]
287. Standing Committee on the Scientific Evaluation of Dietary Reference Intakes, Food and Nutrition Board, Institute of Medicine. Dietary reference intakes for calcium, phosphorus, magnesium, vitamin D, and fluoride. Washington, DC: National Academies Pr; 1997. Accessed at www.nap.edu/openbook.php?record_id=5776&page=R2 on 26 April 2011.
288. Palupi E, Jayanegara A, Ploeger A, Kahl J. Comparison of nutritional quality between conventional and organic dairy products: a meta-analysis. *J Sci Food Agric*. 2012. [PMID: 22430502]
289. Zhao C, Ge B, De Villena J, Sudler R, Yeh E, Zhao S, et al. Prevalence of *Campylobacter* spp., *Escherichia coli*, and *Salmonella* serovars in retail chicken, turkey, pork, and beef from the Greater Washington, D.C., area. *Appl Environ Microbiol*. 2001;67:5431-6. [PMID: 11722889]
290. Bokany RP Jr, Stephens JF, Foster DN. Isolation and characterization of *Salmonella* from broiler carcasses or parts. *Poult Sci*. 1990;69:592-8. [PMID: 2356175]
291. M'ikanatha NM, Sandt CH, Localio AR, Tewari D, Rankin SC, Whichard JM, et al. Multidrug-resistant *Salmonella* isolates from retail chicken meat compared with human clinical isolates. *Foodborne Pathog Dis*. 2010;7:929-34. [PMID: 20443729]
292. Mukherjee A, Speh D, Diez-Gonzalez F. Association of farm management practices with risk of *Escherichia coli* contamination in pre-harvest produce grown in Minnesota and Wisconsin. *Int J Food Microbiol*. 2007;120:296-302. [PMID: 17997496]
293. Mathews KH. Antimicrobial Drug Use and Veterinary Costs in U.S. Livestock Production. Agricultural Information Bulletin No. (AIB-766). Washington, DC: U.S. Department of Agriculture; 2001. Accessed at www.ers.usda.gov/publications/aib766/aib766.pdf on 18 June 2012.
294. European Food Safety Authority (EFSA). Antimicrobial Resistance: EFSA's Role. 2011. Accessed at www.efsa.europa.eu/en/topics/topic/amr.htm on 18 June 2012.
295. Nelson JM, Chiller TM, Powers JH, Angulo FJ. Fluoroquinolone-resistant *Campylobacter* species and the withdrawal of fluoroquinolones from use in poultry: a public health success story. *Clin Infect Dis*. 2007;44:977-80. [PMID: 17342653]
296. Harker FR. Organic food claims cannot be substantiated through testing of samples intercepted in the marketplace: a horticulturalist's opinion. *Food Quality and Preference*. 2004;15:91-5.
297. Food and Drug Administration. Pesticide Monitoring Program—FY 2008. Washington, DC: U.S. Food and Drug Administration; 2008. Accessed at www.fda.gov/downloads/Food/FoodSafety/FoodContaminantsAdulteration/Pesticides/ResidueMonitoringReports/UCM230537.pdf on 18 June 2012.
298. Knoblauch WA, Brown R, Braster M. Organic field crop production: a review of the economic literature. Ithaca, NY: Agriculture Experimental Research, Department of Agricultural Economics, Cornell University; 1990. Accessed at <http://dyson.cornell.edu/research/researchpdf/rb/1990/Cornell-Dyson-rb9010.pdf> on 14 July 2012.

Current Author Addresses: Dr. Smith-Spangler: Division of General Medical Disciplines, Stanford University, 1265 Welch Road, Medical School Office Building, MC 5411, Stanford, CA 94305.

Dr. Brandeau: Department of Management Science and Engineering, Huang Engineering Center, Room 262, Stanford University, Stanford, CA 94205-4026.

Ms. Hunter, Mr. Bavinger, Ms. Pearson, Mr. Eschbach, Ms. Sundaram, and Drs. Liu and Bravata: Center for Health Policy, Stanford University, 117 Encina Commons, Stanford, CA 94305-6019.

Dr. Schirmer: Veterans Affairs Palo Alto Health Care System, 3801 Miranda Avenue (132), Palo Alto, CA 94304.

Mr. Stave: Lane Medical Library, 300 Pasteur Drive, L-109, Stanford, CA 94305-5123.

Dr. Olkin: Department of Statistics, Sequoia Hall, 390 Serra Mall, Stanford University, Stanford, CA 94305-4065.

Author Contributions: Conception and design: C. Smith-Spangler, J.C. Bavinger, M. Pearson, V. Sundaram, D.M. Bravata, I. Olkin.

Analysis and interpretation of the data: C. Smith-Spangler, M.L. Brandeau, G.E. Hunter, J.C. Bavinger, M. Pearson, P.J. Eschbach, V. Sundaram, P. Schirmer, D.M. Bravata, I. Olkin.

Drafting of the article: C. Smith-Spangler, M.L. Brandeau, J.C. Bavinger, V. Sundaram, P. Schirmer, D.M. Bravata.

Critical revision of the article for important intellectual content: C. Smith-Spangler, M.L. Brandeau, V. Sundaram, H. Liu, D.M. Bravata, I. Olkin.

Final approval of the article: C. Smith-Spangler, M.L. Brandeau, J.C. Bavinger, P.J. Eschbach, V. Sundaram, H. Liu, P. Schirmer, D.M. Bravata, I. Olkin.

Provision of study materials or patients: C. Smith-Spangler, D.M. Bravata.

Statistical expertise: C. Smith-Spangler, D.M. Bravata, I. Olkin.

Administrative, technical, or logistic support: G.E. Hunter, M. Pearson, C. Stave.

Collection and assembly of data: C. Smith-Spangler, M.L. Brandeau, G.E. Hunter, J.C. Bavinger, M. Pearson, P.J. Eschbach, V. Sundaram, H. Liu, P. Schirmer, C. Stave, D.M. Bravata.

APPENDIX: SUPPLEMENTAL INFORMATION ABOUT STATISTICAL ANALYSES AND OUTCOMES THAT COULD NOT BE SYNTHESIZED

Continuity Correction

In an effort to include all eligible studies, a continuity correction was applied for studies with 0 events in 1 or more groups. In practice, we applied the continuity correction in 2 analyses: contamination with any pesticide residues (**Figure 2**) and contamination of chicken or pork with bacteria resistant to ciprofloxacin.

Among the 9 pesticide contamination studies, 2 had 0 events (**Figure 2**). These were small, single-food studies. Removal of the small studies with 0 events did not substantially change results (**Figure 2**).

Among the contamination of chicken or pork with bacteria resistant to ciprofloxacin, removal of the 2 studies with 0 events (146, 256) did not substantially change results, although only 3 studies remained for analysis (RD, -4% [CI, -25% to 17%]; $P = 1.00$, $I^2 = 93\%$).

Results were not synthesized if the number of studies was less than 3 after those studies with 0 events were removed. This

was the case with pesticide residues exceeding maximum allowed limits (we report a range); contamination of milk with *S. aureus* resistant to erythromycin, oxacillin, and tetracycline; and contamination of chicken and pork with bacteria resistant to doxycycline and gentamicin.

Other Nutrients in Produce

Too few studies evaluated selenium, manganese, zinc, and vitamins B, D, and K to be synthesized (**Supplement 2**).

Other Nutrients in Animal Products

Only 3 studies (110, 129, 153) evaluated the calcium content of milk: 2 studies (129, 153) reported no difference by farming method and the other (110) reported significantly higher levels of calcium in organically produced milk ($P < 0.010$). Two studies evaluated the lutein and zeaxanthin content of milk (93, 255), finding significantly higher levels of both antioxidants in organic than conventional milk. Two studies examined the zinc content of eggs (132) and beef products (216), finding significantly less zinc in organic egg yolks and beef kidney and significantly more zinc in beef muscle than their conventional counterparts.

Two studies compared protein content of chicken: 1 study found significantly more protein in organic than conventional chicken (160) and the other found no difference (192).

Botanical Pesticides in Produce

Two studies (95, 172) tested for 2 botanical pesticides allowed in organic cultivation: Neither pesticide was detectable in organic or conventional produce samples.

Antibiotic Resistance of Bacteria in Produce

Only 1 study examined the prevalence of antibiotic resistance in bacteria in produce, finding no difference between organic and conventional produce (245).

Subgroup Analyses of Deoxynivalenol and Ochratoxin A in Produce

In subgroup analyses, we found a higher risk for ochratoxin A (OTA) contamination in organically grown rice (84, 133, 166) (RD, 35% [CI, 17% to 53%]; $P < 0.001$; $I^2 = 22$) but not in wheat (84, 111, 164, 166, 189, 235) compared with conventional alternatives.

Seven studies examined deoxynivalenol levels in wheat (135, 150, 224, 235, 243, 249, 270), finding significantly lower levels of deoxynivalenol in organic wheat (SMD, -0.94 [CI, -1.27 to -0.62]; $P < 0.001$; $I^2 = 63$), although 1 large study, which did not report sufficient detail to be included in summary effect size calculations, found no significant differences in deoxynivalenol concentrations (122).

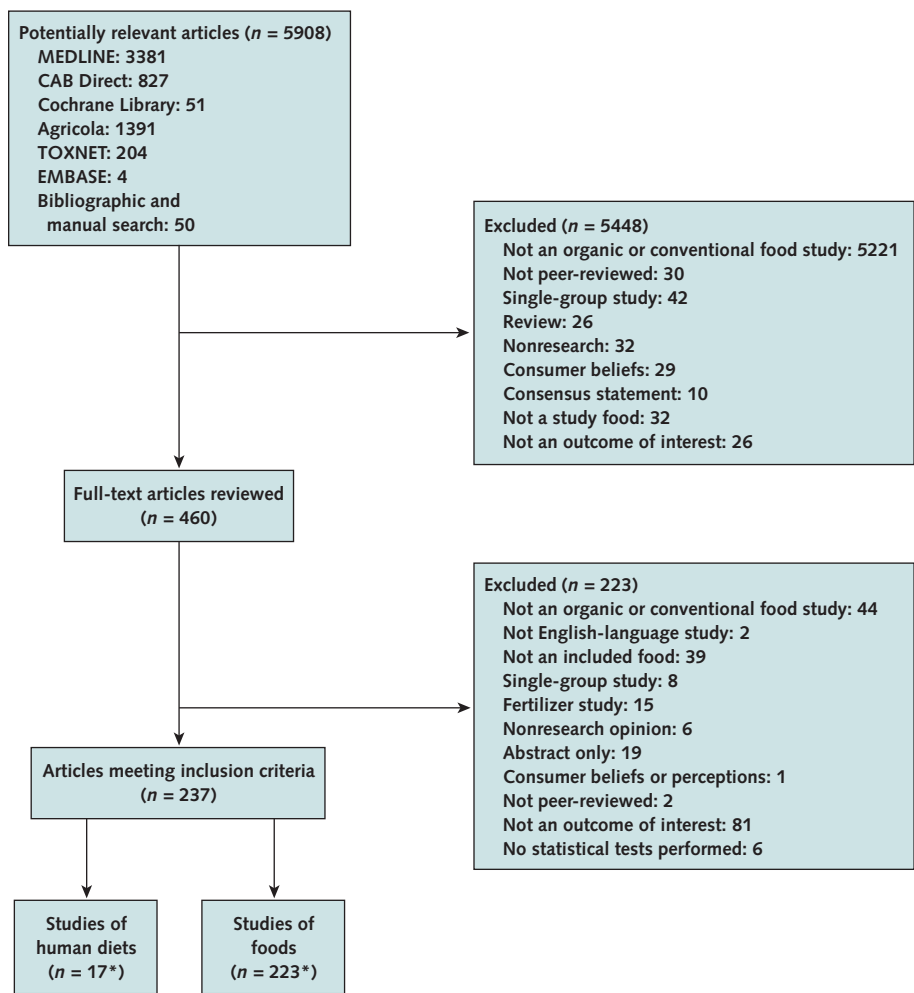
Other Fungal Toxin Results in Milk and Meats

Two studies evaluated mycotoxin contamination of milk: 1 study found significantly higher levels of aflatoxin in organic than conventional milk (131), whereas another study found no difference in OTA contamination (253). One study found that OTA contamination of porcine serum samples was significantly higher among organic than conventional samples (1.32 vs. $0.16 \mu\text{g/kg}$; $P < 0.001$) (232).

Two studies evaluated mycotoxin contamination of milk: 1 study found significantly higher levels of aflatoxin in organic than conventional milk (131), whereas another study found no difference in OTA contamination (253). One study found

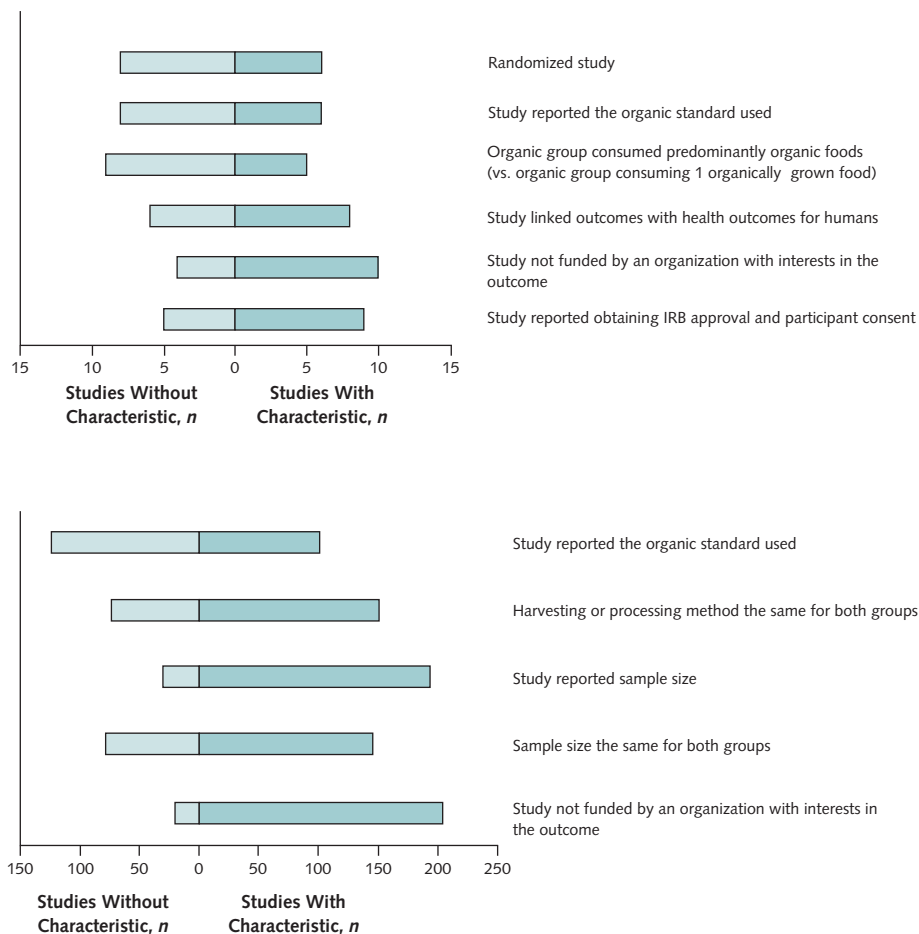
that OTA contamination of porcine serum samples was significantly higher among organic than conventional samples (1.32 vs. 0.16 $\mu\text{g/kg}$; $P < 0.001$) (232).

Appendix Figure 1. Summary of evidence search and selection.



* Three studies reported on human diets and on the foods themselves.

Appendix Figure 2. Selected characteristics of included studies.



The top panel presents the characteristics of the included human studies. Seventeen publications compared the human health effects of consuming organic vs. conventional food. Three publications report data from the same population and are counted only once in the figure. Hence, the number of studies sums to 14. The bottom panel presents the characteristics of the 223 included studies of food. IRB = institutional review board.

Supplement 1. Search Strategies for Each Database

OID MEDLINE In-Process & Other Non-Indexed Citations and Ovid MEDLINE

1. (organic\$ or bio-dynamic\$ or biodynamic\$ or bio-organic\$ or bioorganic\$ or biorganic\$ or biologically or ecologically or naturally).mp. [mp=title, original title, abstract, name of substance word, subject heading word]
2. (conventional\$ or nonorganic\$ or "non-organic\$").mp. [mp=title, original title, abstract, name of substance word, subject heading word]
3. 1 AND 2
4. food\$ or fruit\$ or vegetable\$ or cereal\$ or cruciform\$ or grain\$ or seed or seeds or nuts or nut or honey or crop or crops or granary or wholegrain or wholewheat or legume\$ or herbs or spices or juice\$ or beverage\$ or dairy or dairies or beef\$ or meat\$ or poultry\$ or egg\$ or pork\$ or milk\$.mp. [mp=title, original title, abstract, name of substance word, subject heading word] OR exp agriculture/ or exp plants/ or exp "food and beverages"/ or exp food industry/
5. 3 AND 4
6. (produce\$ or raise or raising or grown\$ or cultivate\$ or raised or farm\$).mp. [mp=title, original title, abstract, name of substance word, subject heading word]
7. 3 AND 6
8. exp health food/
9. comparative study.pt.
10. 8 AND (9 OR 2)
11. 5 OR 7 OR 10
12. Limit 11 to English, exclude letters and editorials

EMBASE (Dialog)

S1 (organic? OR bio(w)dynamic? OR biodynamic? OR bio(w)organic? OR bioorganic? OR biorganic? OR biologically OR ecologically OR naturally OR **organic farming/de**) AND (conventional? OR nonorganic? OR non(w)organic? OR **conventional tillage/de**)

AND

S2 agriculture! OR plants! OR food and beverages! OR food industry! **OR food! OR plant! OR beverage! OR food? OR fruit? OR vegetable? OR cereal? OR cruciform? OR grain? OR seed OR seeds OR nuts OR nut OR honey OR crop OR crops OR granary OR wholegrain OR wholewheat OR legume? OR herbs OR spices OR juice? OR beverage? OR dairy OR dairies OR beef? OR meat? OR poultry? OR egg? OR pork? OR milk?**

S3 (organic? OR bio(w)dynamic? OR biodynamic? OR bio(w)organic? OR bioorganic? OR biorganic? OR biologically OR ecologically OR naturally OR **organic farming/de**) AND (conventional? OR nonorganic? OR non(w)organic? OR **conventional tillage/de**)

AND

S4 produc? OR raise OR raising OR grown? OR cultivat? OR raised OR farm?

(S1 AND S2) OR (S3 AND S4) OR S5

limited to English

CAB Direct

1. Topic=((Organic OR "bio-dynamic*" OR Biodynamic* OR "Bio-organic*" OR Biorganic* OR bioorganic* OR biologically OR ecologically OR naturally)) AND Topic=((conventional OR conventionally OR "non-organic*" OR nonorganic*)) Refined by: CABICODES=(PRION, VIRAL, BACTERIAL AND FUNGAL PATHOGENS OF HUMANS (NEW MARCH 2000) OR FOOD COMPOSITION AND QUALITY OR PESTICIDE AND DRUG RESIDUES AND ECOTOXICOLOGY (NEW MARCH 2000) OR FOOD CONTAMINATION, RESIDUES AND TOXICOLOGY OR HUMAN NUTRITION (GENERAL)) AND Document Type=(JOURNAL ARTICLE)
2. Topic=((Organic OR "bio-dynamic*" OR Biodynamic* OR "Bio-organic*" OR Biorganic* OR bioorganic* OR biologically OR ecologically OR naturally)) AND Topic=((conventional OR conventionally OR "non-organic*" OR nonorganic*)) Refined by: CC=(UU485 OR VV800 OR VV130 OR VV810 OR VV710 OR VV600 OR VV500 OR VV220 OR VV210 OR VV100 OR VV065 OR VV055 OR VV000) OR CC=(UU485 OR VV800 OR VV810 OR VV130 OR VV810 OR VV710 OR VV600 OR VV500 OR VV220 OR VV210 OR VV100 OR VV065 OR VV055 OR VV000
3. 1 OR 2
4. Timespan=All Years. Databases=CAB Abstracts.
5. Limit to Journal Articles AND English
6. 1039 citations

Agricola

((Organic OR "bio-dynamic*" OR Biodynamic* OR "Bio-organic*" OR Biorganic* OR bioorganic* OR biologically OR ecologically OR naturally) AND (conventional OR conventionally OR "non-organic*" OR nonorganic*))

TOXNET

1. ((((organic* OR "bio dynamic" OR bio dynamically" OR biodynamic* OR "bio organic" OR "bio organically" OR biorganic* OR bioorganic* OR biologically OR ecologically OR naturally) AND (conventional* OR nonorganic* OR "non organic" OR "non organically"))) AND ((food) OR (foods OR food) OR (fruit) OR (fruits OR fruit) OR (vegetable OR vegetables) OR (vegetables) OR (cereals) OR (cereal OR cereals) OR cruciform* OR (grains OR cereals) OR (seeds) OR (grain OR cereals) OR (seed OR seeds) OR (nuts) OR (nut OR nuts) OR (honey) OR (crop OR crop avian) OR crops OR granary OR wholegrain OR wholewheat OR (legume OR fabaceae) OR (legumes OR fabaceae) OR herb OR herbs OR (spices) OR (spice OR spices) OR juice OR juices OR (beverage OR beverages) OR (beverages) OR dairy OR dairies OR beef OR (meat) OR (poultry) OR (egg OR eggs) OR (eggs) OR pork OR (milk))) NOT PubMed [org] NOT pubdart [org]
2. Limit 1 to English

Cochrane Library

1. (conventional\$ or nonorganic\$ or "non-organic\$").mp. [mp=title, original title, abstract, mesh headings, heading words, keyword]
AND
2. (Organic\$ or bio-dynamic\$ or Biodynamic\$ or Bio-organic\$ or Biorganic\$ or bioorganic\$ or biologically or ecologically or naturally).mp. [mp=title, original title, abstract, mesh headings, heading words, keyword]
AND
3. (exp agriculture/ or exp plants/ or exp "food and beverages"/ or exp food industry/) OR ((food\$ or fruit\$ or vegetable\$ or cereal\$ or cruciform\$ or grain\$ or seed or seeds or nuts or nut or honey or crop or crops or granary or wholegrain or wholewheat or legume\$ or herbs or spices or juice\$ or beverage\$ or dairy or dairies or beef\$ or meat\$ or poultry\$ or egg\$ or pork\$ or milk\$).mp. [mp=title, original title, abstract, mesh headings, heading words, keyword])
4. (produce\$ or raise or raising or grown\$ or cultivate\$ or raised or farm\$).mp. [mp=title, original title, abstract, mesh headings, heading words, keyword]
5. 1 AND 2 AND 3
6. 1 AND 2 AND 4
7. 5 OR 6
8. 7 OR exp health food

Supplement 2. Included Studies by Outcome and Subgroup Analysis

A. Included Studies for Each Outcome^a

Outcome	All Included Studies	Studies Included in Summary Effects Calculations
ALL PRODUCE^b		
Benefits		
Vitamins		
Vitamin C (ascorbic acid)	(57, 71-73, 80, 96, 99, 102, 104, 115, 116, 119, 128, 138, 139, 143, 145, 167, 168, 179, 182, 185, 193, 196, 204, 213, 217, 221, 222, 227, 239, 240, 244, 257, 261, 262, 274-276, 278)	(57, 71, 72, 96, 99, 102, 104, 115, 119, 128, 138, 139, 143, 167, 179, 185, 193, 204, 213, 217, 221, 227, 239, 240, 244, 257, 261, 262, 274, 276, 278)
Vitamin E (alpha-tocopherol)	(96, 116, 137, 185, 208, 274-276)	(96, 185, 208, 274, 276)
Vitamin A (beta-carotene)	(65, 69, 82, 116, 118, 143, 157, 167, 179, 185, 197, 223, 244, 274)	(65, 69, 82, 118, 143, 167, 179, 185, 197, 223, 244, 274)
Minerals		
Potassium	(71, 73, 78, 82, 105, 109, 116, 117, 120, 136, 139, 148, 171, 173, 179, 180, 182, 185, 187, 188, 193, 211, 220, 222, 223, 227, 236-238, 246, 266, 274, 276, 277, 281, 284)	(71, 78, 82, 109, 136, 139, 179, 185, 193, 223, 227, 274, 276, 284)
Calcium	(71, 78, 82, 99, 100, 104, 105, 117, 120, 136, 139, 171, 173, 179, 182, 185, 187, 188, 193, 208, 209, 211, 220, 222, 223, 227, 236, 237, 274, 276, 277, 281, 284)	(71, 78, 82, 99, 104, 136, 139, 179, 185, 193, 223, 227, 274, 276, 284)
Phosphorous	(73, 100, 104, 105, 117, 136, 155, 171, 173, 179, 180, 182, 185, 187, 188, 195, 209, 211, 220, 227, 236-238, 246, 266, 274-277, 281)	(104, 136, 179, 185, 227, 274, 276)
Magnesium	(71, 73, 82, 99, 100, 104, 105, 117, 120, 136, 138, 139, 171, 173, 179, 182, 185, 187, 188, 209, 211, 220, 222, 223, 227, 237, 238, 246, 274-277, 281, 284)	(71, 82, 104, 136, 138, 139, 179, 185, 223, 227, 274, 276, 284)
Iron	(78, 82, 99, 100, 104, 116, 136, 138, 139, 171, 173, 182, 185, 209, 222, 223, 236, 237, 246, 258, 274, 276, 277, 281)	(78, 82, 99, 104, 136, 138, 139, 185, 223, 258, 274, 276)
Protein	(87, 97, 100, 104, 115, 128, 147, 157, 170, 175, 178, 185, 187, 194, 195, 207, 209, 213, 225, 237, 243, 244, 252, 270, 283, 284)	(104, 115, 128, 175, 178, 185, 207, 209, 213, 243, 244, 252, 283, 284)
Fiber	(71, 115, 128, 175, 185, 209, 213, 243)	(71, 115, 128, 185, 209, 213, 243)
Macronutrients		
Total polyphenols	(72, 73, 77, 80, 81, 95, 96, 102, 114, 115, 137, 144, 145, 151, 167, 174, 175, 185, 195, 208, 209, 217, 237, 240, 247,	(72, 81, 95, 96, 102, 114, 115, 151, 167, 175, 185, 208, 209, 217, 240, 247, 259-262, 279, 285)

Outcome	All Included Studies	Studies Included in Summary Effects Calculations
	259-262, 273, 279, 281, 285)	
Quercetin	(57, 102, 109, 114, 119, 140, 143, 174, 185, 199, 202, 279, 280)	(57, 102, 109, 114, 119, 140, 143, 185, 199, 202, 279)
Kaempferol	(102, 109, 114, 119, 140, 185, 199, 202, 279)	(102, 109, 114, 119, 140, 185, 199, 202, 279)
Total flavonols	(114, 151, 199, 217, 260)	(114, 151, 199, 217, 260)
Harms		
Pesticides		
Any detectable pesticide residue	(72, 74, 75, 79, 106, 109, 115, 127, 134, 139, 150, 159, 172, 183, 186, 190, 191, 203, 230, 231, 263, 267, 269)	(74, 75, 79, 106, 159, 183, 230, 231, 263)
Pesticide residue exceeding MRL	(159, 183, 263)	(159, 183, 263)
Pathogenic bacteria		
<i>E. coli</i> contamination	(90, 205, 206, 214, 219, 226, 245)	(90, 205, 206, 214, 226)
<i>Salmonella</i> contamination	(90, 159, 205, 206, 214, 226)	--
Enterohemorrhagic <i>E. coli</i> contamination	(90, 159, 205, 206, 214)	(90, 159, 205, 206, 214)
<i>Listeria</i> contamination	(214, 226)	--
Fungal toxins		
DON contamination	(103, 121, 135, 159, 189, 224, 235, 243, 249)	(103, 121, 135, 159, 189, 224, 235, 243, 249)
DON level	(86, 122, 135, 150, 154, 224, 235, 243, 249, 270)	(135, 150, 154, 224, 235, 243, 249, 270)
OTA contamination	(84, 111, 133, 164, 166, 189, 235)	(84, 111, 133, 164, 166, 189, 235)
OTA level	(88, 166, 235, 243)	(88, 166, 235, 243)
Heavy metals		
Cadmium	(101, 126, 138, 139, 150, 159, 165, 169, 189-191, 234, 239, 243, 244)	(126, 138, 139, 150, 169, 190, 191, 234, 239, 243, 244)
Lead	(101, 138, 139, 150, 165, 189-191, 234, 239, 243, 244)	(138, 150, 190, 191, 234, 239, 243, 244)
Mercury	(138, 150, 189)	--
Arsenic	(138, 189)	--
CABBAGE		
Vitamin C (ascorbic acid)	(127, 193, 257, 274, 275)	(193, 257, 274)
CARROTS		
Vitamin C (ascorbic acid)	(127, 179, 193, 274, 275)	(179, 193, 274)
POTATOES		
Vitamin C (ascorbic acid)	(127, 138, 145, 239, 275, 276)	(138, 239, 276)
TOMATOES		

Outcome	All Included Studies	Studies Included in Summary Effects Calculations
Vitamin C (ascorbic acid)	(57, 72, 80, 102, 104, 143, 167, 227, 240, 244)	(57, 72, 102, 104, 143, 167, 227, 240, 244)
Vitamin A (beta-carotene)	(57, 104, 143, 167, 244)	(143, 167, 244)
WHEAT		
Protein	(87, 97, 147, 170, 175, 178, 187, 194, 195, 209, 243, 252, 270, 283-285)	(178, 209, 243, 252, 283, 284)
OTA contamination	(84, 88, 111, 164, 166, 235, 243)	(84, 111, 164, 166, 189, 235)
DON contamination	(86, 103, 121, 135, 150, 159, 187, 189, 224, 235, 243, 249, 270)	(135, 150, 224, 235, 243, 249, 270)
RICE		
OTA contamination	(84, 88, 133, 166)	(84, 133, 166)
ALL ANIMAL PRODUCTS		
Heavy metals		
Cadmium	(89, 129, 131, 132, 153, 184, 189, 216)	(129, 132, 184, 216)
Lead	(89, 129, 131, 153, 189)	--
Arsenic	(89, 129, 132, 153)	(129, 132, 153)
Mercury	(89, 129)	--
MILK		
Protein	(92-94, 110, 129, 215, 241, 265, 268, 271)	(94, 110, 129, 265, 268, 271)
Fat	(85, 94, 215, 241, 254, 265, 268, 271)	(85, 94, 254, 265, 268, 271)
Fatty acids		
CLA	(85, 92, 94, 107, 123, 124, 233, 286)	(85, 107, 124)
Linoleic acid	(94, 176, 212, 233, 254, 268)	(176, 212, 254, 268)
MUFA	(93, 94, 107, 123, 124, 212, 233, 254, 268)	(93, 107, 124, 212, 254, 268)
Omega-3	(107, 123, 124, 176, 212, 268)	(107, 124, 176, 212, 268)
Omega-6	(107, 123, 124, 176, 212, 268)	(107, 124, 176, 212, 268)
PUFA	(93, 94, 107, 123, 124, 212, 233, 254, 268)	(93, 107, 124, 212, 254, 268)
SFA	(93, 94, 107, 124, 212)	(93, 107, 124, 212)
Vaccenic acid	(93, 124, 212, 233, 254, 268)	(93, 124, 212, 254, 268)
Nutrients		
Alpha-tocopherol	(93, 125, 254, 255)	(93, 125, 254, 255)
Beta-carotene	(93, 125, 254, 255)	(93, 125, 254, 255)
Calcium	(110, 129, 153)	--
Lutein	(93, 255)	--
Zeaxanthin	(93, 255)	--

Outcome	All Included Studies	Studies Included in Summary Effects Calculations
<i>Vitamin A (retinol)</i>	(125)	--
<i>Iodine</i>	(112)	--
<i>Phytoestrogens</i>	(158)	--
Bacterial contamination	(83, 91, 113, 130, 248)	(83, 91, 130, 248)
Bacterial counts (CFUs)	(110, 271)	--
Bacterial spore counts	(108)	--
Antibiotic resistance		
<i>Overall</i>	(91, 130, 248, 264)	--
<i>Erythromycin</i>	(91, 141, 142, 242, 248, 264)	-- ^c
<i>Oxacillin</i>	(142, 242, 248, 264)	-- ^c
<i>Penicillin</i>	(91, 130, 142, 242, 248, 264)	(91, 130, 242, 248, 264)
<i>Tetracycline</i>	(91, 141, 142, 242, 248, 264)	-- ^c
<i>Other antibiotics</i>	(141, 142, 242)	--
Mycotoxin contamination	(131, 253)	--
Heavy metals		
<i>Lead</i>	(129, 131, 153, 189)	--
<i>Cadmium</i>	(129, 131, 153, 189)	--
<i>Arsenic</i>	(129, 153)	--
<i>Mercury</i>	(129)	--
EGGS		
Bacterial contamination		
<i>Salmonella</i>	(250)	--
<i>Campylobacter</i>	(250)	--
<i>Listeria</i>	(251)	--
<i>Enterococcus</i>	(251)	--
<i>Salmonella</i> counts penetrating eggshells	(198)	--
Antibiotic resistance	(250, 251)	--
Heavy metals		
<i>Arsenic</i>	(132)	--
<i>Cadmium</i>	(132)	--
Trace minerals	(132)	--
ALL MEATS AND POULTRY		
Antibiotic resistance	(50-53, 146, 181, 201, 256)	(50, 52, 53, 181, 201)
Resistance to		
<i>Ampicillin</i>	(50-53, 181, 201)	(50, 51, 53, 181, 201)
<i>Cephalothin</i>	(50, 51, 53, 201)	(50, 51, 53, 201)
<i>Chloramphenicol</i>	(50, 52, 53, 201)	(50, 53, 201)

Outcome	All Included Studies	Studies Included in Summary Effects Calculations
<i>Ciprofloxacin</i>	(50-53, 146, 256)	-- ^c
<i>Doxycycline</i>	(50, 52, 53, 201)	-- ^c
<i>Erythromycin</i>	(50-52, 146, 256)	(50-52, 146, 256)
<i>Gentamicin</i>	(50-53, 146, 181, 201)	-- ^c
<i>Nitrofurantoin</i>	(50, 52, 53, 201)	(50, 53, 201)
<i>Streptomycin</i>	(50, 52, 201)	(50-52, 201)
<i>Sulfisoxazole</i>	(50, 53, 201)	(50, 53, 201)
<i>Tetracycline</i>	(51, 146, 181)	(51, 146, 181)
<i>Other antibiotics</i>	(50-52, 181, 201)	--
POULTRY		
Protein	(160, 192)	--
Fat	(160, 192)	--
Fatty acids		
<i>MUFA</i>	(98, 160, 162, 163, 192)	(98, 160, 162, 192)
<i>Omega-3</i>	(98, 160, 162, 163)	(98, 160, 162)
<i>Omega-6</i>	(160, 162, 163)	--
<i>PUFA</i>	(98, 160, 162, 163, 192)	(98, 160, 162, 192)
<i>SFA</i>	(98, 160, 162, 163, 192)	(98, 160, 162, 192)
Bacterial contamination	(50, 51, 146, 161, 181)	(50, 51, 146, 181)
Bacterial counts	(50, 52, 53, 161)	--
Antibiotic resistance	(50-53, 146, 181, 256)	--
BEEF		
Protein	(272)	--
Fat	(272)	--
Fatty acids		
<i>Omega-3</i>	(272)	--
<i>Omega-6</i>	(272)	--
Nutrients		
<i>Beta-carotene</i>	(272)	--
<i>Vitamin A (retinol)</i>	(272)	--
Heavy metals		
<i>Lead</i>	(89, 131)	--
<i>Cadmium</i>	(89, 131, 216)	--
<i>Arsenic</i>	(89)	--
<i>Mercury</i>	(89)	--
PORK		
Protein	(218)	--
Fat	(156, 200, 218)	--

Outcome	All Included Studies	Studies Included in Summary Effects Calculations
Fatty acids		
<i>MUFA</i>	(149, 156)	--
<i>Omega-3</i>	(156)	--
<i>Omega-6</i>	(156)	--
<i>PUFA</i>	(149, 156)	--
<i>SFA</i>	(149, 156)	--
<i>HUFA</i>	(156)	--
Nutrients		
<i>Beta-carotene (pork liver)</i>	(149)	--
Bacterial contamination	(152, 177, 201, 210, 282)	--
Antibiotic resistance	(201)	--
Mycotoxin contamination (OTA)	(232)	--
Heavy metals		
<i>Cadmium</i>	(184)	--
LAMB		
Fat	(76)	--
Fatty acids		
<i>Linoleic acid</i>	(76)	--
<i>MUFA</i>	(76)	--
<i>Omega-3</i>	(76)	--
<i>Omega-6</i>	(76)	--
<i>PUFA</i>	(76)	--
<i>SFA</i>	(76)	--
RABBIT		
Protein	(228, 229)	--
Fat	(228, 229)	--
Fatty acids		
<i>Linoleic acid</i>	(228, 229)	--
<i>MUFA</i>	(228, 229)	--
<i>Omega-3</i>	(228, 229)	--
<i>Omega-6</i>	(228, 229)	--
<i>PUFA</i>	(228, 229)	--
<i>SFA</i>	(228, 229)	--

^a Outcomes abbreviations: CLA – conjugated linoleic acid, HUFA – highly unsaturated fatty acid, MUFA – monounsaturated fatty acid, PUFA – polyunsaturated fatty acid, SFA – saturated fatty acid. Subgroup analyses (e.g., by food) were performed when there were at least 3 studies reporting outcomes in the subgroup.

^b Forty-nine produce studies reported results of statistical testing but could not be included in summary effect calculations because they did not report standard deviation or standard error. Generally, these poorly reported studies reported null results. The exception to this was that of the 30 comparisons (n=14 studies) of organic versus

conventional wheat and grains, 21 comparisons were statistically significant and all showed less protein in organic wheat and grains than conventional.

^c Results could not be combined statistically because of concerns about sparse data. For these outcomes, studies reported zero events (e.g., no samples were resistant to antibiotic of interest). When the studies with zero events were removed, only 2 studies or fewer remained for each outcome. Due to the limited data, these summary effect sizes were not calculated.

B. Included Studies for Analyses by Measurement Method: Fresh Weight vs. Dry Weight (Produce)^d

Subgroup Analysis	Included Studies
Potassium	
Fresh weight	(71, 82, 109, 136, 139, 179, 185, 223, 227, 276, 284)
Dry weight	(78, 193, 274)
Calcium	
Fresh weight	(71, 136, 139, 185, 223, 276)
Dry weight	(78, 82, 99, 104, 179, 193, 227, 274, 284)
Phosphorous	
Fresh weight	(136, 185, 276)
Dry weight	(104, 179, 227, 274)

^d Subgroup analyses were performed when there were at least 3 studies reporting outcomes in the subgroup.

Supplement 3. Description of Included Human Studies^a

Study	Institution	Funding	Population	Study Design and Description	Foods of Interest	Duration	Key Findings
Briviba et al. (62)	Institute of Nutritional Physiology, Federal Research Center for Nutrition and Food (Germany), Research Institute of Organic Agriculture (Switzerland)	German Federal Agency for Agriculture and Food; German Federal Organic Farming Scheme	6 adult, nonsmoking men, mean age 27 yrs	Double-blind, randomized, crossover study; Participants avoided foods high in polyphenols 3 days before and during the intervention. On 2 experimental days, each volunteer consumed (after an overnight fast) 1000g of either organically or conventionally produced apples. Washout period of 7 days between each experimental day.	Apples (Golden Delicious cultivar)	2 days	Statistically significant increase in the plasma triacylglycerol and uric acid concentrations after apple consumption in the organic group only. No change in LDL levels or capacity to protect DNA against damage caused by hydrogen peroxide or iron chloride (stand breaks and endonuclease II and Fpg protein-sensitive sites) in either group.
Caris-Veyrat et al. (57)	Multiple university and research centers throughout France	Not stated	20 non-smoking, healthy females aged 21 to 39 years (10 organic, 10 conventional)	RCT; Participants' usual diets estimated by 5-day food diary. Subjects randomly assigned to either consume 100g/day of puree of organically or conventionally grown tomatoes for 3 wks; then avoided tomato products for 3 wks.	Three cultivars of tomatoes	6 weeks	Consumption of both organically and conventionally farmed tomatoes increased both beta-carotene and lycopene but no difference between the groups. Serum vitamin C levels did not increase with either type of tomato (no difference between conventional vs. organic tomatoes).
Curl et al. (55)	University of Washington, Seattle	US EPA STAR program, and National Institute for Occupational	39 preschool children aged 2-5 years living in suburban Seattle eating either	Cross-sectional study; 2 home visits 4 days apart. Parents reported pesticide use at home, in the garden, or on pets;	Juice and fresh produce	6 days (two home visits spaced 4 days apart	Children with organic diets had significantly lower levels of total dimethyl metabolites in their urine than did children with conventional diets (p=0.0003).

Study	Institution	Funding	Population	Study Design and Description	Foods of Interest	Duration	Key Findings
		Safety and Health Agricultural Center program	mostly organic or mostly conventional juices and fresh fruits/vegetables;18 children on organic diets and 21 children on conventional diets.	children’s frequency of thumb sucking, hand washing, hand-to-mouth activity, and time spent outside the home. Parents completed a food diary for the child and collected a 24hr urine sample.		with a food diary that started 2 days prior to the first visit).	
De Lorenzo et al. (67)	University of Tor Vergata (Italy), National Institute for Mediterranean Diet and Nutrigenomics (Italy), University of Catania (Italy)	Ministry of Agricultural and Forest Policies (INDIM, Italy), Istituto Nazionale per la Dieta Mediterranea e la Nutrigenomica (Italy)	130 non-smoking men, mean age 45 years (2/3 healthy, 1/3 with stable chronic kidney disease)	Crossover study. Participants consumed a conventionally produced Italian Mediterranean diet (Nicotera diet) for 14 days, and then consumed an organically produced version of the same diet for 14 days.	Italian Mediterranean diet	4 weeks	After 2 weeks of the conventional Mediterranean diet, no changes to measured serum parameters (total plasma homocysteine [tHcy] level; serum phosphorous, sodium, and calcium; glycemia concentrations; lipid profile; microalbuminuria; vitamin B12 plasma level) or body composition parameters (BMI, weight, fat mass, lean mass). After 2 weeks of the organic Mediterranean diet, statistically significant reductions in tHcy, blood phosphorous levels, and fat mass in all subjects; and statistically significant reductions in microalbuminuria, weight, and BMI in CKD subjects. No statistically significant changes in the other measured parameters after 2 weeks of the organic diet.
Flöistrup et al. (64)	Numerous institutions throughout Europe and Boston, Massachusetts	European Union, and Swedish Foundation for Health Care Science and	6630 children age 5 to 13 years in 5 European countries attending Steiner schools and controls from non-	Cross-sectional study. Parental questionnaires provided information on environmental exposures, history of infections, diet, animal contact, lifestyle,	Whole diet	Cross-sectional	No association between diet (biodynamic vs. conventional) and allergic outcomes was identified after adjusting for confounders (OR 0.97; 95%CI: 0.76 to 1.24).

Study	Institution	Funding	Population	Study Design and Description	Foods of Interest	Duration	Key Findings
		Allergy Research	Steiner schools in similar regions (4606 students from Steiner schools and 2024 students from control schools)	and symptoms and diagnoses of allergic diseases. Blood samples taken from children and measured allergen-specific IgE.			
Gillespie et al. (70)	PHLS Communicable Disease Surveillance Centre, London, UK	Not stated	3489 cases of <i>Campylobacter jejuni</i> during one year	Case-control study. Information about exposure submitted via form to health department. "Cases" were confirmed <i>Campylobacter jejuni</i> infections in which there was a household contact also sickened by <i>C. jejuni</i> ; "controls" were cases of <i>C. jejuni</i> infection in which no other household members were sickened.	Meats	Case-control study	Outbreaks among household contacts were associated with consuming organic meats in the winter (but not organic meat in general), [CS1]having contact with a pet suffering from diarrhea, or visiting a farm in the 2 weeks before the onset of symptoms. Outbreaks in the community were associated with the consumption of foods in restaurants or drinking unpasteurized milk.
Grinder-Pedersen et al. (56)	Royal Veterinary and Agricultural University, Denmark; Institute of Food Safety and Nutrition, Denmark; Risø National Laboratory,	Danish Ministry for Foods	16 healthy adults aged 21-35 years	Randomized controlled, crossover study; 2 intervention periods of 22 days each of strict control of dietary intake (either conventional or organic foods) separated by a 3 week washout period of "usual diet." Each intervention period had	Potato, carrot, leek, cabbage, onion, broccoli, wheat, rye, apple, egg, pork	9 weeks	Urinary excretion of two flavonoids (quercetin and kaempferol) was significantly higher (p<0.05) after organic diets than after conventional diets but not for 3 other flavonoids (herperetin, naringenin, and isorhamnetin). No difference in 7 of 8 serum markers of antioxidation (only Troxlox Equivalent Antioxidant Capacity was higher after consumption of conventional than organic foods (p <0.05)).

Study	Institution	Funding	Population	Study Design and Description	Foods of Interest	Duration	Key Findings
	Denmark			1week run-in during which subjects avoided flavonoid-containing foods.			
Juhler et al. (54)	Royal Veterinary and Agricultural University, Denmark; Institute of Food Safety and Nutrition, Denmark; Risø National Laboratory, Denmark	Danish Ministry for Foods	256 farmers (166 on conventional diet, 39 on medium amount of organic foods, 46 on diet high in organic foods)	Prospective cohort study; Conventional diet defined as 0% organic fruits and vegetables consumed; medium organic defined as 1-49% organic fruits and vegetables consumed; high organic defined as 50-100% organic fruits and vegetables consumed. ^b Farmers answered food frequency questionnaires and provided a semen sample before and after the spraying season. Average length between the data collection points was 19.4 weeks.	Whole diet	19.4 weeks	No differences in 8 measures of sperm quality between the no and high organic consumers and no differences between groups on any parameter except for a lower proportion of normal sperm (2.5% vs. 3.7%; p=0.003). Dietary exposure (calculated as standard servings size x food frequency x pesticide residues found in the National Danish Pesticide Survey) to 155 of 160 insecticides, fungicide, and pesticides residues were higher in the no organic group than the high organic group (p<0.01 for each comparison). Overall, no association between semen quality and dietary pesticide exposure.
Kummeling et al. (61)	Maastricht University, The Netherlands; Imperial College, London	Netherlands Organization for Health Research and Development, Royal Friesland Foods, Triodos Foundation, UDEA organic	2764 Dutch children; 2306 on conventional diets, 283 on a moderately organic diets, and 175 on a strictly organic diets	Prospective cohort study; Conventional diet defined as <50% organic; moderately organic defined as 50-90% organic; strictly organic defined as >90% organic foods in the diet.	Meat, eggs, vegetables, fruit, dairy products, bread and dry goods such as pasta, rice, beans, and wheat.	2 years	A non-statistically significant trend for an association between organic food consumption and lower eczema risk (OR 0.95; 95%CI 0.70 to 1.28 for moderately organic and OR 0.76; 95%CI 0.50 to 1.17 for strictly organic vs. conventional.) No statistically significant associations for recurrent wheeze, prolonged wheeze, or atopic sensitization. No association between

Study	Institution	Funding	Population	Study Design and Description	Foods of Interest	Duration	Key Findings
		retail, Biologica organization for organic farming and food, Consumer Association for Bio-Dynamic Agriculture Zurich, and Weleda AG Arlesheim (Switzerland)					maternal diet during pregnancy and outcomes for children at 2 years. Consuming strictly organic dairy products was associated with a reduced risk of eczema but not a moderately organic dairy diet and not for other foods (OR 0.64, 95%CI: 0.44 to 0.93).
Lu et al. (59, 60, 63)	University of Washington, Seattle; Emory University, Atlanta; Centers for Disease Control and Prevention	US EPA STAR program	23 children aged 3-11years in public elementary and Montessori schools in suburban Seattle	Crossover study and prospective cohort study; Children eating principally conventional diets were recruited. Days 1-3 = phase 1; days 4-8=phase 2; and days 9-15=phase 3. During phase 2 organic foods were substituted for most of the children's conventional diet (as detected by a food diary completed by parents during the first phase of the study). Tested same children during 4 seasons; did dietary cross over trial during 2 of	All foods except meats and dairy	278 days (Consumed organic for 15 days in the summer, 12 days in the fall, 7 days in the spring, and 7 days in the winter)	Lu <i>et al.</i> (59) found mean levels of urinary metabolites of the pesticides malathion and clorpyrifos decreased 3 to 10 fold when children's diets were switched from conventional to organic diet for 5 days (p<0.01 for both analyses). They tested the children's urine for metabolites of 5 organophosphate pesticides and pyrethroid insecticide exposure. Two residues, MDA (malathion dicarboxylic acid) and TCPY (3,5,6-trichloro-2-pyridinol), had statistically significantly less urinary excretion among children on organic than conventional diets (MDA: 60% of conventional samples contaminated vs. 22% of organic samples; TCPY: 78% vs. 50% contaminated samples). No effect of diet on excretion of metabolites of other pesticides or insecticides. Seasonal differences (increased pesticide contamination) possibly

Study	Institution	Funding	Population	Study Design and Description	Foods of Interest	Duration	Key Findings
				these seasons.			associated with increased consumption of fruits, juices, and vegetables in the summer; higher insecticide contamination possibly associated with increased spraying in the fall. More contamination among children whose parents reported greater pesticide use.
Mueller et al. (68) and Rist et al. (58)	University of Hamburg (Germany), Maastricht University (The Netherlands), Paracelsus Hospital (Richterswil, Switzerland), Louis Bolk Institute (The Netherlands), Imperial College (London, UK)	Netherlands Organization for Health Research and Development; Royal Friesland Foods; Triodos Foundation; UDEA Organic Retail, Biologica Organization for Organic Farming and Food; Consumer Association for Bio-Dynamic Agriculture Zurich; Johannes Kreyenbuhl Academy; Weleda AG Arlesheim (Switzerland)	312 Dutch breastfeeding women (186 on conventional diets, 33 on a moderately organic diet, 37 on a strictly organic diet, and 56 on other diets)	Cross-sectional study. Women answered an extensive food frequency questionnaire. Consumption of dairy and meat products were classified as: C diet defined as <50% O; moderately-O defined as 50-90% O; strictly-O defined as >90% O foods in the diet.	Meats and dairy products	For each woman, one breast milk sample was collected 1 month postpartum	No difference in total fatty acid content in breast milk of women who consumed organic vs. conventional meats and dairy products. Rumenic acid (the main conjugated linoleic acid (CLA) isomer) and trans-vaccenic acid in the mothers' breast milk was significantly higher among women on strictly organic compared to conventional diets (0.34 weight % vs. 0.25 weight %; p < .001; 0.54 weight % vs. 0.48 weight %; p < .001).

Study	Institution	Funding	Population	Study Design and Description	Foods of Interest	Duration	Key Findings
Søltoft et al. (65)	International Center for Research in Organic Food Systems	Danish Ministry of Food, Agriculture and Fisheries	36 subjects (6 on conventional diet, 6 on organic diet with produce grown using animal manure, 6 on organic diet with produce grown using cover crops). Repeated in 2 consecutive years with new subjects.	RCT, double-blind trial; Adult men were given prepared diets for each meal and snack consisting of either organic or conventionally grown foods. Study measured participants' blood plasma carotene concentrations.	Produce and grains	12 days	No systematic differences in plasma carotenoid concentrations between the agricultural production systems were observed.
Stracke et al. (66)	German Federal Research Institute of Nutrition and Food, Research Institute of Organic Agriculture (Switzerland)	German Federal Agency for Agriculture and Food	6 subjects for short-term cross-over study (3 O, 3 C); 43 subjects for long term study (16 O, 16 C, 11 restricted polyphenol diet)	Short-term crossover study; and longer-term double-blind RCT. Each group consumed equal daily amount of organically or conventionally grown apples, in addition to regular diet. Long-term study also contained a control group that consumed no apples.	Apples	3 days; 5 weeks	No differences found in plasma apple polyphenol bioavailability, antioxidant activity, or immune system parameters between subjects consuming organic vs. conventional apples.
Stracke et al. (69)	German Federal Research Institute of Nutrition and Food, Research Institute of Organic Agriculture (Switzerland)	German Federal Agency for Agriculture and Food	36 subjects (12 on diet with organic carrots, 12 on diet with conventional carrots, 12 on control diet with no carrots)	RCT, double-blind trial. Male subjects in each group consumed daily 200g blanched carrots from organic or conventional agriculture systems; a control group kept a carotenoid-	Carrots	4 weeks carotene restricted diet; 2 weeks intervention diet	No significant differences in plasma antioxidant status, endogenous DNA strand breaks and parameters of the immune system between individuals consuming organic vs. conventional carrots vs. a carotene-restricted diet.

Study	Institution	Funding	Population	Study Design and Description	Foods of Interest	Duration	Key Findings
-------	-------------	---------	------------	------------------------------	-------------------	----------	--------------

^aSeventeen publications describing 14 unique populations of 13,806 subjects met our inclusion criteria. EPA = Environmental Protection Agency, OR = odds ratio, RCT= randomized controlled trial, STAR = Science to Achieve Results, BMI = Body Mass Index

^bDetermination of type of diet (conventional vs. organic) was based on farmers’ consumption of fruits and vegetables (conventional vs. organic), but the authors note that farmers consuming mostly organic fruits and vegetables also consumed mostly organic meats, milk, and bread

Supplement 4. Description of Included Studies of Foods^a
A. Description of Included Studies of Fruits, Vegetables, and Grains

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
FRUITS								
Acharya and Bhatnagar (71)	India	Not stated	Oranges	--	FS	Vitamin C, Ca, Mg, Na, K, ash, total sugar	6 O, 6 C	Organic oranges had more vitamin C, Ca, Mg, Na, K, and ash, and less total sugar than conventional (p < .01).
Amodio et al. (73)	USA	Not stated	Kiwifruit	USDA	RFT	N, P, K, S, B, Ca, Mg, soluble solids, organic acids, sugars, vitamin C, total phenolics, antioxidant activity	15 O, 15 C (40 fruits per sample)	Organic kiwifruit had statistically more of each mineral tested (N, P, K, S, B, Ca, Mg), total phenolics, and total antioxidant activity than conventional kiwifruit (p < .05). No difference in levels of vitamin C, organic acids, sugars, and soluble solids by farming type.
Andersen and Poulsen (75)	Denmark	Danish Veterinary and Food Administration	Representative set of 40 fruits and vegetables typically consumed by Danes	--	MW, R	Pesticides	81 O, 4069 C	Pesticide residues detected in 4.9% of organic samples (all were below the MRL) and 33.3% of conventional samples (of samples with detectable residues, 3% were above the MRL).
Asami et al. (77)	USA	Not stated	Marionberries	USDA	FS	Vitamin C, total phenolic content	100 g fresh weight O, 100 g fresh weight C	Statistically higher levels of total phenols were found in organically grown marionberries than in conventional. Levels of vitamin C were too low to detect.
Baker (79)	USA	Organic Materials Review Institute, Consumers Union of United States	21 fruits and vegetables	USDA	R	Pesticides	Three data sets: PDP (127 O, 26,571 C); DPR (1,097 O, 66,057 C);	Lower frequency of detectable pesticide residues in organic vs. conventional fruits and vegetables (PDP samples, 23% vs. 73%; CDP samples, 6.5% vs. 30.9%; CU samples, 27% vs. 79%).

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
Beltran-Gonzalez et al. (82)	Spain	Not stated	Orange juice	BOAM	RFT	Vitamin C, carotenoids (13 examined, including alpha-carotene, beta carotene, xanthins, lutein), Ca, Mg, K, Na, Fe, Cu, Mn, Zn, soluble solids	CU (67 O, 68 C) 6000 kg O, 15,000 kg C	Organic oranges had more vitamin C, Ca, Mg, K, Mn, Zn, and total carotenoids than conventional, and more of 8 of 13 examined carotenoids (p < .005). No difference in soluble solids, Fe, Cu.
Bohaychuk et al. (90)	Canada	Canadian Ministry of Agriculture	Carrots, lettuce, scallions, spinach, strawberries, tomatoes	--	R	<i>E. coli</i> , <i>Salmonella</i> , EHEC, <i>Campylobacter</i> , <i>Cryptosporidium</i>	80 O, 567 C (total over all produce examined) ^f	<i>E. coli</i> prevalence and level of contamination did not differ between organic vs. conventional produce. <i>Salmonella</i> , EHEC, <i>Campylobacter</i> , and <i>Cryptosporidium</i> were not detected in any samples.
Carbonaro and Mattera (95)	Italy	Italian Ministry of Agriculture (MIPAF)	Peaches, pears	EEC	RFT	Phenolics (total polyphenol activity, caffeic acid, chlorogenic acid)	Not stated	Organic pears and peaches had higher total polyphenol content than conventional (p < .05). No difference in levels of caffeic acid or chlorogenic acid by farming type. Botanical pesticides undetectable in both groups.
Carbonaro et al. (96)	Italy	Italian Ministry of Agriculture (MIPAF)	Peaches, pears	EEC	RFT	Alpha-tocopherol, gamma-tocopherol, vitamin C, citric acid, polyphenols	Not stated	Organic peaches had more vitamin C, citric acid, total polyphenols, and alpha- and gamma-tocopherol than conventional peaches (p < .05). Organic pears had more total polyphenols and alpha-tocopherol than conventional pears (p < .05); no difference in levels of vitamin C, citric acid and gamma-tocopherol by farming type.

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
Cayuela et al. (99)	Spain	National Program for Scientific Research and Technological Development (Spain), Andalusian Committee for Organic Agriculture (CAAE, Spain)	Strawberries	--	RFT	Vitamin C, Ca, Mg, Fe, Mn, Zn, Cu, brix (soluble solids)	11 O, 11 C	Organic strawberries had significantly higher sugar content than conventional ($p < .01$). No difference in levels of vitamin C or metals (Ca, Mg, Fe, Mn, Zn, Cu) by farming type.
Collins and Nassif (106)	Australia	New South Wales Department of Health (Australia)	26 fruits and vegetables	--	R	Pesticides	118 O, 230 C	Organic produce was less likely to contain pesticide residues than conventional produce (11.9% of organic samples vs. 29.6% of conventional samples).
Corrales et al. (109)	Germany, Spain	German Academic Exchange Service	Grape skin extract	Germany	FS	Quercetin, kaempferol, total antioxidant activity, pesticides	Not stated	Organic grape extracts had higher levels of quercetin and kaempferol than conventional grape extracts. Conventional grape skins had higher total antioxidant activity than organic grape skins. Pesticide levels for all samples were below MRLs.
Dani et al. (115)	Brazil	University of Caxios do Sul (Brazil), Brazilian Wine Institute (IBRAVIN, Brazil)	Grape juice	--	MW	Pesticides, phenolics (resveratrol, anthocyanin, catechins, procyanidins, total polyphenols), antioxidant activity	Not stated	Organic grape juice had more total polyphenols than conventional ($p < .01$). Organic purple grape juice had more resveratrol and anthocyanins than conventional purple grape juice ($p < .01$). No consistent differences in antioxidant activity, catechins, or procyanidins by farming type. None of the examined

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
								pesticides were found in any grape juice samples.
Dani et al. (114)	Brazil	Research Council of State of Rio Grande do Sul, Universidad de Caxias do Sul	Grape leaves	Ecovida	FS	Total phenols, flavonols, quercetin, kaempferol	Not stated	Organic grape leaves had lower levels of quercetin and kaempferol but higher levels of resveratrol than conventional grape leaves. No differences in total phenol content.
D'Evoli et al. (119)	Italy	Not stated	Strawberries	--	FS	Ascorbic acid, quercetin, kaempferol, antioxidant activity	3 O, 3 C	Organic strawberries had higher levels of ascorbic acid, quercetin, and kaempferol than conventional strawberries, as well as higher cellular antioxidant activity in differential Caco-2 cells.
DeEll and Prange (117)	Canada	Agriculture Canada	Apples	OCIA	FS	Ca, Mg, P, K, N	7 O, 7 C	Organic apples had more P and K and less N than conventional apples ($p < .05$). No difference in levels of Mg and Ca by farming type.
do Amarante et al. (120)	Brazil	National Council of Scientific and Technological Development (CNPq, Brazil); Research and Projects Financing Program (FINEP, Brazil); Santa Catarina Foundation for Science and Technology (FUNCITEC,	Apples	--	FS	Ca, K, Mg, N	20 O, 20 C	Organic apples had less K, Mg, and N than conventional ($p < .01$). Ca did not differ by farming type. Differences in mineral content were attributed to differences in soil mineral composition between the conventional and organic orchard.

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
Forster et al. (128)	Spain	Brazil) European Union, Government of the Canary Islands	Bananas	EEC	FS	Vitamin C, protein, ash, glucose, fructose, total sugars	11 O, 84 C	Organic bananas had more sucrose and vitamin C and less glucose and fructose than conventional bananas ($p < .05$). No differences in levels of protein, ash, or total sugars by farming type.
Hakala et al. (139)	Finland	National Technology Agency (Tekes, Finland)	Strawberries	--	FS	Ca, Mg, K, Fe, Zn, Cu, Mn, Cd, Pb, vitamin C, pesticides	18 O, 18 C for each of 3 cultivars	No significant differences in vitamin C or any of the examined minerals between conventional vs. organic strawberries. Organic strawberries had less pesticide residue than conventional strawberries (no residues detected in organic; very low levels detected in conventional).
Hakkinen and Torronen (140)	Finland	Academy of Finland, Finnish Graduate School on Applied Bioscience, Juho Vainio Foundation, Jenny and Antti Wihuri Fund, Finnish Research and Information Center for Fruit Wines	Strawberries	--	FS	Flavonols (quercetin, myricetin, kaempferol), phenolic acids (ellagic, p-coumaric, caffeic and ferulic acids)	20 O, 20 C for each cultivar	For one cultivar, organic strawberries had more total phenolics than conventional, but similar levels of flavonols. For the other two cultivars examined, no difference in levels of flavonols and phenolic acids by farming type.
Kahu et al. (168)	Estonia	Estonian Ministry of Agriculture, Ministry of Education and	Black currants	--	RFT	Vitamin C	Not stated	Organic black currents had more vitamin C than conventional black currants ($p < .05$).

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
Karavoltsos et al. (169)	Greece	Research (Estonia) European Commission	Tomatoes, peaches, potatoes, green pepper, green beans, lentils, amaranthus blitum, beets, lettuce	EEC	R	Cd	9 O, 9 C	Organic produce had less Cd than conventional.
Kristensen et al. (171)	Denmark	International Center for Research in Organic Food Systems (ICROFS, Denmark)	Carrots, kale, peas, potatoes, apples	--	RFT	Ca, Mg, P, K, Na, Cu, Fe, Mn, Zn, Mo, Cd, Co, V	Not stated	No significant differences in levels of examined elements between conventional and organic carrots, peas, kale, potatoes, and apples. Element content varied more by year than by farming type.
La Torre et al. (172)	Italy	Plant Pathology Research Institute (CRA, Italy)	Apples, oranges, peaches, plums, pears	--	FS	Fungal pathogens, pesticide residues (3 pesticides), Cu, S	Not stated	No difference in fungal contamination between organic vs. conventional apples, oranges, peaches, plums, or pears. Organic peaches, plums, and pears had more Cu residues than their conventional counterparts, although the levels were below the Italian MRL. Organic peaches had less S residue than conventional peaches; no difference in S residues for plums and pears. No differences in levels of the 3 examined pesticides by farming type for peaches, plums, and pears.
Lamperi et al. (174)	Italy	Not stated	Apples	--	FS	Polyphenols (flavonols,	30 O, 30 C	No significant differences in total polyphenols and radical scavenging activity

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
						anthocyanins, procyanidins, total polyphenols), radical scavenging activity		between organic vs. conventional apples. Cultivar was a better predictor of total polyphenols and radical scavenging activity.
Lester et al. (182)	USA	USDA	Grapefruit juice	Certified	FS	Vitamin C, B, Cl, Cu, Fe, Na, P, Zn, K, Mg, Mn, Ca, N, lycopene, sugars, phenols	40 O, 40 C at each of 9 harvests	Organic grapefruit juice had more vitamin C, total sugars, total phenols, N, K, Mg, and Mn but less lycopene than conventional grapefruit (p < .05). No statistical difference in B, Ca, Cl, Cu, Fe, Na, P, or Zn by farming type.
Lesueur et al. (183)	Austria and other European countries	Not stated	22 fruits, 22 vegetables	--	Not stated	Pesticides	600 O, 900 C in 2004; 450 O, 1350 C in 2005	Organic fruits and vegetables had lower prevalence of detectable pesticide residues than conventional fruits and vegetables (10% vs. 60%) and a lower prevalence of samples with pesticide residues exceeding the MRL (5.7% vs. 8.0%).
Lombardi-Boccia (185)	Italy	National Institute for Research on Food and Nutrition (Italy)	Plums	--	RFT	Vitamin C, alpha and beta tocopherol, beta carotene, vitamin K, P, Na, K, Mg, Ca, Fe, Zn, Cu, Mn, protein, fiber, carbohydrates, organic acids, lipids, polyphenols, flavonols	Not stated	Organic plums had higher concentrations of K, Mg, Zn and two types of flavonols. Conventional plums had higher concentrations of Na, Cu, vitamin E, vitamin K, total polyphenols, total fiber, citric acid and one type of flavonol. No significant difference by farming type for other minerals tested, protein levels, lipids, total sugars, vitamin C, malic acid, and gamma-tocopherol.
Lu et al. (186)	USA	US Environmental Protection Agency	Apple juice, orange juice	--	R	Pesticides (6 dialkylphosphates)	5 O, 4 C	Organic orange juice had less of 2 examined pesticides than conventional; no differences by farming type for the other 4 pesticides examined. Organic apple juice had less of all 6 examined pesticides than conventional

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
Malmauret et al. (189)	France	Ministry for Food (DGAL, France), Dannon Foods, Regional Council of Brittany	Apples	--	FS	As, Cd, Hg, Pb	6 O, 6 C	apple juice. No difference in As, Cd, Hg, or Pb content between organic vs. conventional apples.
Masamba and Nguyen (193)	Australia	Australian Government	Oranges	--	R	Vitamin C, Ca, K	Not stated	Organic oranges had more vitamin C but less Ca and K than conventional (statistical tests not provided).
Mikkonen et al. (199)	Finland	Not stated	Black currants	--	RFT, FS	Flavonols (myricetin, quercetin, kaempferol)	5 O, 5 C	No consistent differences in the contents of flavonols between the same black currant cultivars grown organically vs. conventionally.
Mladenova and Shtereva (203)	Bulgaria	Bulgarian Ministry of Education and Science	Apples	--	FS	Pesticide residues	28 O, 28 C	Conventional apples had higher pesticide levels than organic apples. Pesticide levels found in the whole fruits were much lower than in the peels.
Mukherjee et al. (206)	USA	USDA Sustainable Agriculture Research and Education Program	Strawberries, raspberries, blueberries	USDA	FS	<i>Salmonella</i> , <i>E. coli</i> , EHEC, coliform count	Total berries: 25 O, 77 C	Significantly higher total coliform count in organic berries than conventional for both years examined ($p < .05$). No significant differences in prevalence of <i>E. coli</i> contamination by farming type (but significant differences by produce type). No detection of <i>Salmonella</i> or EHEC.
Mukherjee et al. (205)	USA	State of Minnesota	Apples, strawberries	--	FS	<i>Salmonella</i> , <i>E. coli</i> , EHEC, coliform count	Strawberries: 8 O, 3 C; apples: 10 O, 6 C	<i>E. coli</i> prevalence did not differ statistically by farming type. EHEC was not detected in any samples. <i>Salmonella</i> was detected in too few samples to draw conclusions.
Nyanjage et al.	UK	Not stated	Bananas	--	MW	N, K, P, Ca, Mg,	30 O, 30 C	Organic bananas had more P and less N

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
(211)						soluble solids		than conventional bananas ($p < .05$). No difference in levels of K, Ca, Mg, and soluble solids.
Olsson et al. (217)	Sweden	Not stated	Strawberries	Sweden	RFT	Vitamin C, antioxidants (ascorbate, dehydroascorbate, phenolics, ellagic acid, flavonols, hydroxycinnamic acids, anthocyanins)	4 O, 4 C for 2 different cultivars	Organic strawberries had more total phenolics ($p < .05$) and more vitamin C ($p < .005$) than conventional. Results differed within the two cultivars examined. For one cultivar, organic strawberries had more vitamin C than conventional ($p < .005$); for the other cultivar, no difference by farming type. For one cultivar, organic strawberries had more total phenolics than conventional ($p < .005$); for the other cultivar, organic strawberries had less total phenolics than conventional ($p < .005$). No differences in levels of other antioxidants examined.
Ottesen et al. (219)	USA	USDA, University of Maryland, Joint Institute for Food Safety and Applied Nutrition (JIFSAN)	Apples	--	RFT	<i>E. coli</i> , <i>Salmonella</i>	Not stated	Neither <i>E. coli</i> nor <i>Salmonella</i> detected in any samples.
Peck (220)	USA	USDA	Apples	USDA, WSDA	RFT	N, P, K Ca, Mg, B, Zn, titratable (malic) acidity, soluble solids concentration, total antioxidant activity	180 O, 180 C	Organic apples had higher total antioxidant activity than conventional apples. No differences in mineral concentrations, malic acid levels, and solid soluble concentrations by farming type.
Perez-Lopez et al.	Spain	Not stated	Orange juice	BOAM	RFT	Vitamin C, Ca, Mg,	5,000 kg O,	Organic orange juice had more of all

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
(222)						K, Na, Fe, Cu, Mn, Zn, soluble solids	15,000 kg C	analyzed minerals (Ca, Mg, K, Na, Fe, Cu, Mn, Zn) than conventional (p < .005). No difference was found in levels of vitamin C or soluble solids by farming type.
Poulsen and Andersen (231)	Denmark	Danish Veterinary and Food Administration	Representative set of 28 fruits and vegetables typically consumed by Danes	--	MW, R	Pesticides	216 O, 4188 C	Pesticide residues detected in 2.8% of organic samples (all were below the MRL) and 37.8% of conventional samples (of samples with detectable residues, 10.1% were above the MRL).
Reganold et al. (238)	USA	USDA	Apples	--	RFT	N, P, K, Ca, Mg, B, Zn	4 O, 4 C	No consistent differences in mineral content between conventional vs. organic apples over the four-year study.
Ruimy et al. (245)	France	French Ministry of Fishery and Agriculture	Variety of fruits and vegetables	--	R	Antibiotic resistant bacteria	181 O, 218 C	No difference in prevalence of antibiotic resistant bacteria between organic and conventional fruits and vegetables.
Sablani et al. (247)	USA	Washington State University	Raspberries, Blueberries	WSDA	FS	Total phenolics, anthocyanins	24 O, 24 C	Total phenolic and anthocyanin content did not differ by farming type.
Stracke et al. (260)	Germany, Switzerland	Not stated	Apples	Switzerland	FS	Total phenols, antioxidant capacity, flavonols	75 O, 75 C	Year-to-year variations in phenol content and antioxidant capacity were greater than differences between cultivation systems. . No consistent differences in flavonols between organic and conventional apples.
Tarozzi et al.(261)	Italy	Italian Ministry of Teaching and Research, Fondazione del Monte di Bologna e Ravenna	Red oranges	EEC	FS	Vitamin C, total polyphenols	4 O, 4 C	Organic red oranges had more vitamin C and total phenols than conventional (p < .05).

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
Tarozzi et al. (262)	Italy	Italian Ministry of Teaching and Research, Foundation del Monte di Bologna e Ravenna	Apples	EEC	FS	Vitamin C, total polyphenols	3 O, 3 C	No differences in levels of vitamin C or total phenolics in organically vs. conventionally grown apples.
Tasiopoulou et al. (263)	Italy	Not stated	Cereals, citrus fruits, other fruits, legumes, potatoes, other vegetables	--	FS, R	Pesticides	266 O, 3242 C	Organic food samples had a lower prevalence of pesticide residues than conventional food samples (2.6% vs. 27.0%).
Turgut et al. (269)	Turkey	Adnan Menderes University	Grapes	--	FS	Pesticides	120 O, 828 C	No pesticides detected in grapes from organics farms. Pesticides only detected in grapes grown conventionally.
Wang et al. (273)	USA	Not stated	Blueberries	Certified	FS	Glucose, fructose, citric acid, malic acid, antioxidant capacity, total anthocyanins, total phenolics, chlorogenic acid, resveratrol, myricetin 3-arabinoside, quercetin 3-galactoside, quercetin 3-glucoside	5 O, 5 C	Organic blueberries had more sugars, malic acid, total phenolics, total anthocyanins, antioxidant activity, chlorogenic acid, myricetin 3-arabinosie, quercetin 3-glucoside than conventional blueberries. No differences in citric acid levels, resveratrol, nor quercetin 3-galactoside were found by farming type.

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
VEGETABLES								
Aldrich et al. (72)	USA	USDA	Tomatoes	USDA	RFT	Total phenols, antioxidant activity, ascorbic acid	6 O, 6 C	Differences between conventional vs. organic tomatoes in total phenols, antioxidant activity, and ascorbic acid were found by cultivation year and farming type but these differences were not consistent. Consistent differences were seen between cultivars.
Andersen and Poulsen (75)	Denmark	Danish Veterinary and Food Administration	Representative set of 40 fruits and vegetables typically consumed by Danes	--	MW, R	Pesticides	81 O, 4069 C	Pesticide residues detected in 4.9% of organic samples (all were below the MRL) and 33.3% of conventional samples (of samples with detectable residues, 3% were above the MRL).
Bacchi et al. (78)	Brazil	Foundation for Research Support of Sao Paulo (FAPESP, Brazil), National Council of Scientific and Technological Development (CNPq, Brazil); Research and Projects Financing Program (FINEP, Brazil)	Potatoes	--	RFT	Br, Ca, Ce, Co, Fe, K, Na, Rb, Sc, Zn	8 O, 8 C	Organic potatoes had less Br and Zn, and more Co and Rb than the conventional potatoes, in both the peel and the flesh. No differences in levels of other minerals tested.

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
Baker et al. (79)	USA	Organic Materials Review Institute, Consumers Union of United States	21 fruits and vegetables	USDA	R	Pesticides	Three data sets: PDP (127 O, 26,571 C); DPR (1,097 O, 66,057 C); CU (67 O, 68 C)	Lower frequency of detectable pesticide residues in organic vs. conventional fruits and vegetables (PDP samples, 23% vs. 73%; CDP samples, 6.5% vs. 30.9%; CU samples, 27% vs. 79%).
Barrett et al. (80)	USA	Small Planet Foods	Tomatoes	USDA	RFT	Vitamin C, DHAA, lycopene, total phenolics, Brix (soluble solids)	8 O, 8 C for each of 4 cultivars	No consistent differences in any of the measured outcomes (vitamin C, DHAA, lycopene, total phenolics, soluble solids) by farming type over all 4 tomato cultivars examined. For some cultivars, there were significant differences in some measured outcomes between organic vs. conventional tomatoes, but the direction of the difference was not consistent across cultivars.
Bavec et al. (81)	Slovenia	Not stated	Red beets	EEC	RFT	Total phenolics	4 O, 4 C	No significant difference in total phenol levels between organic and conventional beets.
Bohaychuk et al. (90)	Canada	Canadian Ministry of Agriculture	Carrots, lettuce, scallions, spinach, strawberries, tomatoes	--	R	<i>E. coli</i> , <i>Salmonella</i> , EHEC, <i>Campylobacter</i> , <i>Cryptosporidium</i>	80 O, 567 C (total over all produce examined)	<i>E. coli</i> prevalence and level of contamination did not differ between organic vs. conventional produce. <i>Salmonella</i> , EHEC, <i>Campylobacter</i> , and <i>Cryptosporidium</i> were not detected in any samples.
Caris-Veyrat et al. (57)	France	Not stated	Tomatoes	--	RFT	Vitamin C, lycopene, carotenoids and phenolic compounds	12 O, 12 C for each of 3 cultivars	Organic tomatoes had significantly more vitamin C, carotenoids, lycopene, and polyphenols (except for chlorogenic acid)

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
						(chlorogenic acid, rutin, naringen)		than conventional tomatoes (p < .001).
Chang and Salomon (101)	USA	Not stated	Lentils	--	R	Cd, Cu, Fe, Pb, Zn	2 O, 2 C	Few differences in levels of Cd, Cu, Fe, Pb, Zn between organic vs. conventional lentils. Sample sizes too small to make statistical inferences.
Chassy et al. (102)	USA	Not stated	Bell peppers, tomatoes	Certified	RFT	Vitamin C, total phenolic content, antioxidants (quercetin, kaempferol, luteolin)	Tomatoes: 9 O, 9 C for each of 2 cultivars; bell peppers: 10 O, 10 C for each of 2 cultivars	When three-year averages were taken, organic tomatoes had significantly higher levels of some flavonoids; however, annual comparisons showed significant year-to-year variability. No differences in vitamin C or total phenols between organic and conventional tomatoes. No differences found in examined nutrients between organic and conventional bell peppers.
Clarke and Merrow (104)	USA	Not stated	Tomatoes	--	RFT, FS	Vitamin C, carotene, Ca, Fe, Zn, Mg, Na, protein	36 O, 36 C for each of 2 years	No differences in any of the examined nutrients (vitamin C, carotene, Ca, Fe, Zn, Mg, Na, protein) by farming type.
Colla et al. (105)	USA	Not stated	Tomatoes	CCOF	RFT	N, P, K, Ca, Mg, Na	8 O, 8 C	Organic tomatoes had less N (p < .001) and more P (p < .05) than conventional tomatoes. No difference in levels of Ca, Na, K, and Mg by farming type.
Collins and Nassif (106)	Australia	New South Wales (Australia) Department of Health	26 fruits and vegetables	--	R	Pesticides	118 O, 230 C	Organic produce was less likely to contain pesticide residues than conventional produce (11.9% of organic samples vs. 29.6% of conventional samples).
Danilchenko (116)	Lithuania	Not stated	Pumpkins	--	RFT	Vitamin C, beta-carotene, vitamin E, vitamin B1, vitamin	2 O, 2 C for each of 5 cultivars	Organic pumpkins had more beta-carotene and vitamin E, and less vitamin C than conventionally grown pumpkins. No

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
del Amor (118)	Spain	Spanish Ministry of Science and Technology	Sweet peppers	--	RFT	B2, Mg, Ca, P, K, C, N, Mn, Fe, Zn, Cu, B Antioxidant capacity, beta carotene, soluble solids	24 O, 24 C	differences in minerals tested (Mg, Ca, P, K, C, N, Mn, Fe, Zn, Cu, B) or vitamins B1 or B2 by farming type. Organic peppers had more antioxidant activity (statistical significance not given) and less beta-carotene (p < .05) than conventional peppers. No difference in soluble solids by farming type.
Fjelkner-Modig et al. (127)	Sweden	Findus Foods AB	Dill, cabbage, potatoes, onions, carrots, spinach, peas	EEC	RFT	Pesticides, vitamin C, 25 minerals and trace elements	38 O, 38 C	No pesticide residues detected in any of the 7 examined vegetables. No significant differences in vitamin C content for any of the 7 vegetables tested. Significant differences found for only 4 trace elements, but not for the other 21 minerals and trace elements tested.
Gonzalez et al. (134)	Argentina	Argentinean National Council on Scientific and Technical Research (CONICET, Argentina), Secretary of Investigation and Technological Development (SIyDT, Argentina), Antorchas Foundation (Argentina)	Chard, lettuce	Argentina	FS	Pesticides (organochlorine pesticides, OCPs)	Not stated	No significant differences in OCP residues by farming type.

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
Gundersen et al. (136)	Denmark	Danish Food Technology and Development Program (FOTEK, Denmark)	Peas, onions	EEC, Denmark	FS	9 major elements (e.g., P, Ca, Fe, K), 54 trace elements (e.g., Cd, Pb, Cu)	Onions: 100 O, 110 C, peas: 180 O, 200C peapods	Of the major elements, organic onions had significantly less Ca and significantly more Mg than conventional onions; of the minor elements, organic onions had significantly less B, Eu, Lu, Sb, Se, Sr, Ti, U, and Y and significantly more Bi, Dy, Gd, and Rb than conventional (p < .05). Of the major elements, organic peas had significantly more P than conventional peas; of the minor elements, organic peas had significantly less Ti and significantly more Gd than conventional (p < .05).
Hajslová et al. (138)	Czech Republic, Sweden	Ministry of Education, Youth and Sports (Czech Republic)	Potatoes	IFOAM	RFT	As, Cd, Co, Cu, Fe, Hg, Mn, Ni, Pb, Se, Zn, vitamin C, glycoalkaloids, chlorogenic acid, polyphenol oxidase	11 O, 11 C, for each of 8 varieties	No statistical differences in levels of any of the examined nutrients/properties by farming type.
Hallmann and Rembialkowska (143)	Poland	Not stated	Tomatoes	Certified	FS	Vitamin C, total and reducing sugars, lycopene, beta-carotene, total flavonoids	6 O, 6 C	Organic tomatoes had more total and reducing sugars, vitamin C, total flavones and beta-carotene, and less lycopene than conventionally grown tomatoes (p < .05).
Hamouz et al. (145)	Czech Republic	Czech Ministry of Agriculture	Potatoes	--	RFT	Vitamin C, sugars, polyphenols	2 O, 2 C for each of 2 cultivars and 3 years	No difference in vitamin C content between farming methods (but significant variation by growing year). Significantly higher polyphenol content in organic potatoes than in conventional (p < 0.01).
Hansen (148)	Denmark	FDB (Danish Co-operative	Potatoes, carrots, beets,	--	RFT	N, K, Na, Ca, Mg, P, ash	40 O, 40 C	No significant differences in mineral content (N, K, Na, Ca, Mg, P) or ash of

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
		Retail and Wholesale Society), IRMA (Danish supermarket chain)	kale					organically vs. conventionally grown potatoes, carrots, beets, and kale.
Heimler et al. (151)	Italy	Banca CR de Firenze (Credit Bank of Florence, Italy)	Chicory	--	RFT	Polyphenols	18 O, 18 C for each of 2 sample dates	No difference in polyphenol content between organic vs. conventional chicory.
Hogstad et al. (157)	Norway	Norwegian Research Council, Norwegian Crop Research Institute (Planteforsk), Norwegian Food Research Institute (MATFORSK), Agricultural University of Norway	Carrots	--	RFT, FS	Carotene, protein, glucose, fructose, sucrose, total sugars	10 O, 58 C	Organic carrots had more sucrose (p < .0001), total sugars (p < .0001), carotene (p < .0001), and protein (p < .05) than conventional carrots. No difference in levels of glucose and fructose by farming type.
Hoogenboom et al. (159)	Netherlands	Dutch Ministry of Agriculture, Nature and Food Quality; Food and Consumer Products Safety Authority	Lettuce	--	FS, MW, R	Pesticides, Hg, Pb, Cd, As, <i>Salmonella</i> , EHEC, DON, ZEA	Iceberg lettuce: 13 O, 13 C; head lettuce: 19 O, 19 C	No difference in pesticides, heavy metals (Pb, Cd, Hg, As), or mycotoxins (<i>Salmonella</i> , EHEC) by farming type.

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
Jorhem and Slanina (165)	Sweden	(Netherlands) National Food Administration (Sweden)	Carrots, potatoes	--	RFT	Pb, Cd, Cr, Zn	Potatoes: 10 O, 10 C; carrots: 6 O, 6 C	No differences in Cd, Pb, Cr, or Zn were detected in organic vs. conventional carrots, or potatoes.
Juroszek et al. (167)	Taiwan	World Vegetable Center (AVDRC, Taiwan)	Tomatoes	Taiwan	FS	Vitamin C, beta carotene, lycopene, phenolics, antioxidant activity, soluble solids	40 O, 40 C	No difference in soluble solids, beta-carotene, lycopene, vitamin C, total phenolics, or antioxidant activity between conventional vs. organic tomatoes.
Karavoltzos et al. (169)	Greece	European Commission	Tomatoes, bell pepper, green beans, lentils, amaranthus blitum, beets, lettuce	EEC	R	Cd	9 O, 9 C	Organic produce had less Cd than conventional.
La Torre et al. (172)	Italy	Plant Pathology Research Institute (CRA, Italy)	Tomatoes	--	FS	Fungal pathogens	Not stated	No difference in fungal contamination between organic vs. conventional tomatoes.
Lairon et al. (173)	France	Regional Council of Provence-Alps-Cote d'Azur (France)	Lettuce	--	RFT	Protein, P, K, Ca, Mg, Na, Fe, Cu, Mn	5 O, 5 C	No significant differences in protein or mineral content of lettuce grown with organic vs. conventional fertilizer.
Leclerc et al. (179)	France	French National Institute for Agricultural Research (INRA)	Carrots, celeriac	--	FS	Vitamin C, B1, B2, B6, Ca, Mg, K, N, P, Cu, Zn, Fe, Mn	12 O, 12 C	Organic carrots had more beta-carotene and vitamin B1 than conventional (p < .05); no differences in other vitamins or minerals. Organic celeriac had more vitamin C and less N and Zn than conventional (p < .05);

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
Lehesranta et al. (180)	UK	European Commission, Scottish Executive Environment and Rural Affairs Department	Potatoes	Soil Association	RFT	N, P, K, proteins	12 O, 12 C	no differences in other vitamins or minerals. Organic potatoes had more K and less N and P than conventional potatoes (statistical significance not stated). Of 160 examined proteins, 45 differed significantly by farming type: 40 were found at higher levels in organic potatoes, and 5 were found at higher levels in conventional potatoes (statistical significance not stated).
Lesueur et al. (183)	Austria and other European countries	Not stated	22 fruits, 22 vegetables	--	Not stated	Pesticides	600 O, 900 C in 2004; 450 O, 1350 C in 2005	Organic fruits and vegetables had lower prevalence of detectable pesticide residues than conventional fruits and vegetables (10% vs. 60%) and a lower prevalence of samples with pesticide residues exceeding the MRL (5.7% vs. 8.0%).
Mader et al. (188)	Switzer-land	Swiss Federal Office of Agriculture, Swiss Foundation of Biological Husbandry	Beets	IFOAM	RFT	P, K, Ca, Mg, vitamin C, saccharose	10 O, 10 C for each of 3 years	Organic beets had less K than conventional beets (p < .001). No difference in levels of P, Ca, Mg, vitamin C and saccharose by farming type.
Malmauret et al. (189)	France	Ministry for Food (DGAL, France), Dannon Foods, Regional Council of Brittany	Lettuce, carrot, spinach	--	FS	As, Cd, Hg, Pb	Lettuce, carrot: 6 O, 6 C; spinach: 5 O, 6 C	Organic carrots had significantly more Pb than conventional (p < .05); no differences for spinach, or lettuce by farming type. Organic spinach had significantly more Cd than conventional (p < .05); no differences for carrots and lettuce by farming type. No difference in As or Hg contamination by farming type for lettuce, carrots, spinach.

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
Mansour et al. (191)	Egypt	Not stated	Cucumbers	--	R	Pesticides, Zn, Cu, Mn, Fe, Cd, Cr, Pb, Ni, Co	36 O, 36 C	No difference in levels of pesticide residues or heavy metal contamination (Zn, Cu, Mn, Fe, Cd, Cr, Pb, Ni, Co) between conventional vs. organic cucumbers. Season was a better predictor of pesticide residues than farming type.
Mansour et al. (190)	Egypt	Not stated	Potatoes	--	R	Pesticides, Zn, Cu, Mn, Fe, Cd, Cr, Pb, Ni, Co	36 O, 36 C	Organic potatoes had less concentration of pesticides and heavy metals (Zn, Cu, Mn, Fe, Cd, Cr, Pb, Ni, Co) than conventional potatoes (statistical significance not reported). No difference in prevalence of pesticide contamination by farming type.
Masamba and Nguyen (193)	Australia	Australian Government	Carrots, cabbage, lettuce	--	R	Vitamin C, Ca, K	Not stated	Organic cabbages, carrots and lettuce contained more Ca and K than conventional (statistical tests not provided); no difference in vitamin C content by farming type for these foods.
Meier-Ploeger et al. (196)	Germany	Not stated	Cabbage	--	RFT	Vitamin C	4 O, 4 C	No significant difference in vitamin C content of cabbage grown with organic vs. conventional fertilizer.
Mercadante et al. (197)	Brazil	National Council of Scientific and Technological Development (CNPq, Brazil)	Kale	--	FS	Vitamin A, beta-carotene, total carotenoids	10 O, 10 C	Organic kale had more beta-carotene, total carotenoids, and vitamin A than conventional (p < .05).
Mitchell et al. (202)	USA	Not stated	Tomatoes	--	RFT	Flavonoids (quercetin, kaempferol, naringenin)	100 O, 100 C	Organic tomatoes had more quercetin and kaempferol than conventional (p < 0.05). No difference in level of naringenin by farming type.
Moreira et al. (204)	Argentina	Not stated	Swiss chard	APROBA	FS	Vitamin C, yeasts,	20 O, 23 C	No statistical differences in vitamin C or

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
						molds, and psychotrophic, mesophilic, and lactic acid bacteria		any of the microorganisms examined by farming type.
Mukherjee et al. (205)	USA	State of Minnesota	Bell peppers, pac choi, broccoli, cabbages, cucumbers, leafy greens, onions, summer squash, tomatoes, zucchini, lettuce,	--	FS	<i>Salmonella</i> , <i>E. coli</i> , EHEC, coliform count	98 O, 108 C	<i>E. coli</i> prevalence did not differ statistically by farming type. EHEC was not detected in any samples. <i>Salmonella</i> was detected in too few samples to draw conclusions.
Mukherjee et al. (206)	USA	USDA Sustainable Agriculture Research and Education Program	Broccoli, cabbages, cucumber, leafy greens, lettuce, peppers, summer squash, tomatoes, zucchini	USDA	FS	<i>Salmonella</i> , <i>E. coli</i> , EHEC, coliform count	450 O, 603 C	Significantly higher total coliform count in organic cabbages, peppers, and summer squash than conventional counterparts for both years examined (p < .05); no significant differences by farming type for both years for cucumbers, leafy greens, lettuces, zucchini, and tomatoes. No significant differences in prevalence of <i>E. coli</i> contamination by farming type (but significant differences by produce type). No detection of <i>Salmonella</i> or EHEC.
Nakamura et al. (207)	Japan	Not stated	Soybeans	yes	RFT	K, Ca, P, protein, ash, lipids	Not stated	No significant differences in proteins, lipids after harvest. Small differences in Ca, K, P after harvest (but no statistical test performed); organic had more of each.
Oliveira (214)	Spain	National	Lettuce	EEC	FS	<i>E. coli</i> contamination	72 O, 72 C	No significant differences in <i>E. coli</i>

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
		Research Institute for Agriculture and Food Technology (INIA, Spain), European Foundation for Regional Development (FEDER)						contamination of organic vs. conventional lettuce.
Ogbadu and Easmon (213)	Nigeria	Not stated	Eggplant	--	RFT	Protein, vitamin C, Na, K, P, Ca, Cu, Fe, Mg, Mn, Zn	Not stated	Eggplant grown with organic fertilizer had less protein and vitamin C and more Fe than eggplant grown with conventional fertilizer (p < .05). No differences by farming type in levels of other minerals tested.
Pérez-López et al. (223)	Spain	Not stated	Sweet peppers	BOAM	RFT	Carotenoids, Fe, Cu, Mn, Zn, Ca, Mg, K	60 O, 60 C	Organic sweet red peppers had more Fe, Cu, Ca and total carotenoids, and less Mn, than conventional (p < .001). No differences in levels of K, Mg, Zn by farming type.
Pérez-López et al. (221)	Spain	Foundation Seneca Regional Agency for Science and Technology (Murcia, Spain)	Sweet peppers	--	RFT	Vitamin C, total carotenoids, total phenolics	20 O, 20 C	Organic sweet peppers had more vitamin C, total phenolics, and total carotenoids than conventionally grown peppers (p < .001).
Phillips and Harrison (226)	USA	Not stated	Leafy greens (spring mix/ bagged mesclun salad)	--	FS	<i>Salmonella</i> , <i>Listeria</i> , <i>E. coli</i> , psychotropes, mesophiles, lactic acid bacteria, all coliforms,	108 O, 108 C	No difference in mean populations of mesophilic and psychotrophic bacteria, yeasts, molds, lactic acid bacteria, and coliforms by farming type. (Washed spring mix had significantly smaller populations of

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
						Fungi/mycotoxins		these quantities than unwashed.) <i>E. coli</i> found in only a few samples, with no statistical difference by farming type. <i>Salmonella</i> and <i>Listeria</i> not detected in any samples.
Pieper and Barrett (227)	USA	Campbell Soup Company	Tomatoes	USDA	FS	Vitamin C, DHAA, amino acids, N, P, K, Ca, Mg, B, S, Mn, lycopene, soluble solids	18 O, 18 C for each of 2 years	Organic tomatoes had more soluble solids, P and K, and less N, Ca and Mn than conventional tomatoes (p < .05). Of 19 amino acids examined, 3 were lower in organic tomatoes (p < .05); no difference for the other 16 amino acids by farming type. No difference in lycopene content, vitamin C, DHAA by farming type.
Porretta (230)	Italy	Experimental Station for Food Processing and Preservation (SSICA, Italy)	Tomatoes	--	R	Pesticides	5 O, 5 C	No significant differences in pesticide levels between organic vs. conventional canned tomatoes.
Poulsen and Andersen (231)	Denmark	Danish Veterinary and Food Administration	Representative set of 28 fruits and vegetables typically consumed by Danes	--	MW, R	Pesticides	216 O, 4188 C	Pesticide residues detected in 2.8% of organic samples (all were below the MRL) and 37.8% of conventional samples (of samples with detectable residues, 10.1% were above the MRL).
Procida et al. (234)	Italy	Not stated	Lettuce, chicory, arugula (rocket)	APB	RFT	Pb, Cd, Cr, Ni, Zn	Not stated	Few differences in metals content by farming type. Greens grown in a greenhouse had higher metals content than greens grown in an open field, regardless of farming type.
Raigon et al (236)	Spain	Polytechnic	Dry beans	--	RFT	Ca, K, Fe, P, Na	Not stated	Organic beans had more K, Fe, and P and

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
Raigón et al (237)	Spain	University of Valencia (Spain) Not stated	Eggplant	Certified	RFT	K, Mg, Ca, P, Fe, protein, total phenolics	6 O, 6 C	less Na than conventional (p < .05). No difference in levels of Ca by farming type. Higher levels of several minerals and total phenolics in organic eggplant; significant year-to-year variation in nutrient content also noted.
Rembialkowska (239)	Poland	Jurzykowski Foundation (USA), Rockefeller Brothers Fund (USA)	Potatoes	EKOLAND	FS	Vitamin C, Cd, Pb	26 O, 26 C	No difference in levels of vitamin C or Pb between conventional vs. organic potatoes. When measured on a fresh mass basis, no difference in Cd levels by farming type; when measured on a dry mass basis, organic potatoes had less Cd than conventional (p < .05).
Rodriguez et al. (240)	Spain	National Program for Scientific Research and Technological Development (Spain)	Tomatoes	EEC	RFT	Vitamin C, phenols, ash	64 O, 70 C	Organic tomatoes had less vitamin C and total phenolic compounds than conventional tomatoes (p < .05). No differences were found in ash content by farming type.
Rossi et al. (244)	Italy	Catholic University of the Sacred Heart (Italy)	Tomatoes	EEC	RFT	Pesticides, Cu, Cd, Pb, ergosterol, vitamin C, lycopene, beta-carotene, crude protein	10 O, 10 C	Organic tomatoes had less vitamin C, Cu and lycopene, and more crude protein, Cd and Pb, than conventional tomatoes (p < .05). No difference was found in beta-carotene levels by farming type. No ergosterol was detected in any tomato samples.
Søltoft et al. (65)	Denmark	Danish Ministry of Food, Agriculture and	Carrots	Denmark	RFT	Carotenoid	Not stated	No differences in carotenoid levels between organic vs. conventional carrots.

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
Sousa et al. (257)	Portugal	Fisheries --	Cabbage	--	RFT	Phenolics, ascorbic acid	12 O, 12 C	No statistical difference in levels of ascorbic acid between organic vs. conventional cabbage. Generally, organic cabbages had higher phenol content than conventional cabbages collected in the same period (statistical tests not provided).
Stracke et al. (69)	Germany	German Federal Agency for Agriculture and Food	Carrots	EEC	FS	Beta-carotene	5 O, 5 C	No significant differences in carotene content between organic vs. conventional carrots.
Tasiopoulou et al. (263)	Italy	Not stated	Cereals, citrus fruits, other fruits, legumes, potatoes, other vegetables	--	FS, R	Pesticides	266 O, 3242 C	Organic food samples had a lower prevalence of pesticide residues than conventional food samples (2.6% vs. 27.0%).
Tran thi Ngoc et al. (266)	Vietnam	Not stated	Soybeans	--	RFT	N, P, K	3 O, 3 C	Organic soybeans had significantly more N and K than conventional soybeans; but statistically the same levels of P.
Warman and Havard (276)	Canada	Canada/Nova Scotia Agri-Food Development Agreement	Potatoes	OCIA	RFT	Vitamin C, alpha-tocopherol, gamma-tocopherol, N, P, K, Na, Ca, Mg, S, B, Fe, Mn, Cu, Zn	10 O, 10 C	Organic potatoes had more P and Mg than conventional potatoes (p < .05). No difference in levels of N, K, B, Fe, Na, Ca, Mn, Cu, Zn, S, or vitamin C in potatoes by farming type.
Warman and Havard (274)	Canada	Canada/Nova Scotia Agri-Food Development Agreement	Carrots, cabbage	OCIA	RFT	Vitamin C, alpha-tocopherol, gamma-tocopherol, alpha-carotene, beta-carotene, beta-carotene equivalents,	10 O, 10 C	No differences in vitamin content, micro-nutrients or macro-nutrients in carrots and cabbages by farming type.

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
Warman and Havard (275)	Canada	Canada/Nova Scotia Agri-Food Development Agreement	Carrots, cabbage, potatoes	OCIA	RFT	N, P, K, Na, Ca, Mg, S, B, Fe, Mn, Cu, Zn Vitamin C, vitamin E, alpha-carotene, beta-carotene, N, P, K, Na, Ca, Mg, S, B, Fe, Mn, Cu, Zn	5 O, 5 C for each of 3 years	No differences in vitamin content for any of the three foods examined. Few differences in mineral content, except that organic carrots had more B and S and less Mn than conventional (p .05), and organic potatoes had more Mg than conventional (p<.05).
Wszelaki et al. (277)	USA	USDA	Potatoes	Certified	RFT	Ca, K, Mg, P, S, B, Cu, Fe, Mn, Mo, Zn, solanidine	20 O, 20 C	Organic potatoes had higher levels of solanidine, K, Mg, P, S, and Cu in both skin and flesh than conventional potatoes, and higher levels of Fe and Mo in the flesh than conventional potatoes (p < .05). Organic potatoes had lower levels of Mn and Fe in their skins than conventional potatoes (p < .05).
Wunderlich et al. (278)	USA	Not stated	Broccoli	--	R	Vitamin C	Not stated	No differences in vitamin C content of organic vs. conventional broccoli. Vitamin C content did vary by season, but not by farming type.
Young et al. (279)	USA	Organic Farming Research Foundation, USDA	Lettuce, collard greens, pac choi	USDA	RFT	Flavonoids, phenolic acids, total phenolics	6 O, 6 C	No statistical difference in phenolic content of organic vs. conventionally grown lettuce and collard greens. Organic pac choi had more total phenolic content than conventional (p < .01).
Zhao et al. (280)	USA	Organic Farming Research Foundation, USDA	Lettuce	--	RFT	Phenolics (6 compounds)	9 O, 9 C for each of 2 cultivars	No difference in phenolics levels in organic vs. conventional lettuce.
Zhao et al. (281)	USA	Not stated	Pac choi	--	RFT	Phenolics	9 O, 9 C	Organic pac choi had more total phenolics

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
						(chlorogenic acid, ferulic acid, sinapic acid, total phenolics), P, K, Ca, Mg, Cu, Fe, Mn, Zn		(p < .01), P (p < .01), and Mg (p < .01) and less Cu (p < .05), Mn (p < .05) and Zn (p < .01) than conventional pac choi. No difference in levels of K, Ca, and Fe by farming type.
GRAINS AND NUTS								
Asami et al. (77)	USA	Not stated	Corn	USDA	FS	Vitamin C, total phenolic content	100 g fresh weight O, 100 g fresh weight C	Statistically higher levels of total phenols and vitamin C in organically grown corn vs. conventional.
Beretta et al. (84)	Italy	Ministry for University and Scientific and Technological Research (MURST, Italy)	Cereal-based baby foods	--	R	OTA	Semolina: 30 O, 30 C; rice: 33 O, 33 C; maize/tapioca: 30 O, 30 C	Organic semolina baby cereals and multigrain baby cereals had less OTA than their conventional counterparts. Organic rice-based baby cereals had more OTA than their conventional counterparts. No OTA was detected in either conventional or organic maize/tapioca baby cereals.
Berhnoft et al. (86)	Norway	Norwegian Research Council	Barley, oats, wheat	Norway	FS	DON, fungal contamination, other fungal toxins	301 O, 301 C	Fusarium infestation and mycotoxin levels were generally lower in organically grown grains than in conventional, though differences in DON concentration differed significantly only in 1 year and in 1 grain.
Bicanova et al. (87)	Czech Republic	Czech Ministry of Agriculture; Ministry of Education, Youth and Sports (Czech Republic)	Wheat	IFOAM	RFT	Protein	Not stated	Organic wheat had less protein than conventional (p < .05).
Biffi et al. (88)	Italy	Italian Ministry	Flour and	--	MW, R	OTA	77 C, 96 O	For commercial flours and derivatives, no

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
		of Agriculture (MIPAF)	cereals (corn, wheat, spelt, oats, barley, rye, rice), including commercial flours and derivatives and baby foods					significant difference in OTA contamination by farming type. For baby foods, organic semolina had less OTA than conventional and rice cereals had more OTA than conventional ($p < .01$); no differences in OTA by farming type for corn-based and multigrain baby foods.
Carcea et al. (97)	Italy	National Institute for Research on Food and Nutrition (Italy)	Wheat	--	RFT	Ash, protein	6 O, 6 C	Organic wheat had less protein than conventional ($p < .01$), for all 6 cultivars examined. Ash differences, although in some cases statistically significant, were not consistent by production type (for some cultivars, organic had more ash; for other cultivars, conventional had more ash).
Champagne et al. (100)	USA	USDA	Rice	--	RFT	Ca, P, K, Mg, Mn, Fe, Zn, protein	4 O, 4 C for each of 5 cultivars	Organic rice had less protein than conventional ($p < .05$). No consistent trend in mineral content by farming type: for some cultivars, and some minerals, there were differences by farming type, but these differences were not consistent across cultivars.
Chang and Salomon (101)	USA	Not stated	Barley, brown rice, cornmeal	--	R	Cd, Cu, Fe, Pb, Zn	2 O, 2 C	Few differences in levels of Cd, Cu, Fe, Pb, Zn between organic vs. conventional grains examined. Sample sizes too small to make statistical inferences.
Cirillo et al. (103)	Italy	Not stated	Corn-based foods (popcorn, flour, couscous, polenta,	--	R	DON, FB1, FB2	Wheat-based foods: 36 O, 44 C;	No significant difference in contamination with DON, FB1, and FB2 in conventional vs. organic cereal products.

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
			breakfast products), wheat-based foods (wheat grains, flour, bran, biscuits, bread, pasta), rice-based foods (rice, biscuits, rice flakes), mixed-grain foods (rye, barley, spelt, wheat, oats, cereals, soups)				corn-based foods: 27 O, 27 C; mixed-grain based foods: 29 O, 17 C; rice-based foods: 11 O, 13 C	
Czerwiecki et al. (111)	Poland	State Committee for Scientific Research (KBN, Poland)	Rye, wheat, barley	--	FS	OTA, Aspergillus, Penicillium	Wheat: 34 O, 37 C; rye: 46 O, 37 C; barley: 17 O, 36 C	Organic wheat had lower prevalence of OTA, Aspergillus and Penicillium contamination, and lower OTA levels in contaminated samples than conventional. For rye and barley, no differences in OTA, Aspergillus, and Penicillium contamination by farming type.
Doll et al. (121)	Germany	Federal Agricultural Research Center (FAL, Germany), Thuringian State Institute of Agriculture	Wheat, rye	--	FS	DON, ZEA	Wheat: 46 O, 150 C; rye: 19 O, 50 C	Incidence and level of contamination with DON was lower in organic wheat than conventional (p < .05) and lower in organic rye than in conventional (no p-value due to small sample sizes). No difference in incidence and level of ZEA contamination in wheat by farming type.

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
Edwards (122)	UK	(Germany) UK Food Standards Agency	Oats	--	FS	DON, other mycotoxins	115 O, 343 C	Organic oats had significantly lower levels of some mycotoxins than conventional oats.
Eurola et al. (126)	Finland	Agrifood Research Finland (MTT), Satafood Development Association (Finland)	Oats	--	RFT	Cd	91 O, 163 C	No statistical difference in Cd content of organic vs. conventional oats.
Fjelkner-Modig et al. (127)	Sweden	Findus Foods AB	Wheat, barley	EEC	RFT	Pesticides, vitamin C, 25 minerals and trace elements	38 O, 38 C	No pesticide residues detected in any samples. No significant differences in vitamin C content for organic vs. conventional wheat and barley. Significant differences found for only 4 trace elements, but not for the other 21 minerals and trace elements tested.
González et al. (133)	Spain	Spanish Ministry of Science and Technology, National Science and Technology Foundation (CONACyT, Mexico)	Basmati rice, bomba rice, parboiled rice, puffed rice, red rice, white rice, brown rice, riced flour, semolina, wild rice	--	R	OTA	20 O, 64 C	A higher incidence of OTA was found in organic rice than in conventional (30% of organic samples vs. 7.8% of conventional).
Griesshaber et al. (135)	Switzerland	Not stated	Wheat	IFOAM	RFT	DON, NIV, HT-2	8 O, 8 C for each of 2 years	No difference in trichothecene contamination between organic vs. conventional wheat.
Hamouz et al. (144)	Czech	Czech Ministry	Potatoes	IFOAM	RFT	Polyphenols,	2 O, 2 C	No significant difference in glycoalkaloid

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
	Republic	of Agriculture; Ministry of Education, Youth and Sports (Czech Republic)				glycoalkaloids, reducing sugar content	for each of 7 cultivars	content, polyphenol content, or reducing sugars between conventional vs. organic potatoes.
Hanell et al. (147)	Sweden	Not stated	Wheat	IFOAM	RFT	Amino acids (18 examined), protein	3 O, 3 C for each of 2 cultivars and 3 years	Organic spring wheat had less protein than conventional spring wheat (p=.05); no statistical difference in protein content for winter wheat by farming type. Total essential amino acids and total amino acids were not statistically different between conventional vs. organic, for either spring wheat or winter wheat. Amino acids differed more between years than by farming type.
Harcz et al. (150)	Belgium	Belgian Federal Public Planning Service (BELSPO)	Wheat cereals	--	RFT, FS, MW, R	Hg, Pb, Cd, DON, ZEA	DON - 52 O, 65 C; ZEA - 47 O, 68 C; Cd - 37 O, 189 C; Pb - 37 O, 189C; Hg - 18 O, 150 C	No significant differences in Cd, Hg, DON, and ZEA by farming type. Organic wheat cereal had more Pb than conventional (p < .05).
Hietaniemi et al. (154)	Finland	Finnish Ministry of Agriculture and Forestry, Suomen Viljava Ltd. (Finland),	Oats	--	RFT	Trichothecenes (e.g., DON, NIV, T-2, HT-2)	8 O, 2 C for each of 7 cultivars and 2 years	No difference in DON contamination between organic vs. conventional oats.

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
Hildermann et al. (155)	Switzerland	Kemira Ltd. (Finland), Raisio Group (Finland) Swiss Federal Office for Agriculture	Wheat	IFOAM	RFT	P, N	40 O, 40 C	Cultivar and system of cultivation were both found to significantly affect levels of P and N. Organic wheat, averaged across examined cultivars, had less P and N than conventional wheat (p < .05).
Hoogenboom et al. (159)	Netherlands	Dutch Ministry of Agriculture, Nature and Food Quality; Food and Consumer Products Safety Authority (Netherlands)	Wheat	--	FS, MW, R	Hg, Pb, Cd, As, DON, ZEA	30 O, 30 C	No differences in DON, ZEA, Pb, Hg, Cd, or As between conventional vs. organic wheat.
Jorgensen and Jacobsen (164)	Denmark	Danish Veterinary and Food Administration, Regional Veterinary and Food Control Authority (Denmark)	Rye, wheat	--	MW, R	OTA	Wheat kernels: 14 O, 405 C; rye kernels: 17 O, 405 C; wheat flour: 120 O, 156 C; rye flour: 155 O, 165 C	Organic rye had more OTA than conventional. No difference in OTA levels in wheat by farming type.
Jorhem and Slanina (165)	Sweden	National Food Administration (Sweden)	Wheat, rye	--	RFT	Pb, Cd, Cr, Zn	Wheat: 3 O, 3 C; rye: 1 O, 1 C	No differences in Cd, Pb, Cr, or Zn were detected in organic vs. conventional wheat and rye.

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
Juan et al. (166)	Spain, Portugal	Integrated Actions Programmes (Portugal, Spain), Spanish Ministry of Science and Technology	Cereal products: Wheat, corn, oats, barley, rice, rye, spelt	--	R	OTA	Wheat: 11 O, 11 C; corn: 5 O, 6 C; oats: 5 O, 7 C; barley: 4 O, 4 C; rice: 9 O, 12 C; spelt: 2 O, 1 C	Organic cereal products had a higher incidence of OTA contamination than conventional cereal products (31.7% vs. 11.9%), and a higher mean level of contamination.
Krejcirova et al. (170)	Czech Republic	Czech University of Life Sciences; Czech Ministry of Agriculture	Wheat	IFOAM	RFT	Crude protein	6 O, 6 C	Organic wheat had less protein than conventional (p < .01).
L-Baekstrom et al. (178)	Sweden	Orebro County Council and Orebro Urban Council, Sweden	Wheat	IFOAM	RFT	Protein	Not stated	Organic wheat had less protein than conventional (p < .05).
La Torre et al. (172)	Italy	Plant Pathology Research Institute (CRA, Italy)	Wheat	--	FS	Fungal pathogens	Not stated	No difference in fungal contamination by farming type. For wheat, some organic cultivars had more fungal contamination than their conventional counterpart; for other cultivars, the opposite was true.
Langenkamper et al. (175)	Switzerland	Swiss Federal Program for Ecologic Agriculture	Wheat	IFOAM	RFT	Protein, phosphates, antioxidative capacity, phenols, fiber, fructan, oxalate, phytic acid, oxalic acid	Not stated	Organic wheat had less crude protein than conventional wheat that had received mineral fertilizer (p < .05), but more protein than wheat that had never been fertilized (p < .05). No significant differences in phosphate levels, antioxidative capacity, phenols, fiber, fructan, or oxalate.

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
Mader et al. (187)	Switzerland	Swiss Federal Office of Agriculture	Wheat	IFOAM	RFT	DON, NIV, crude protein, ash, P, K, Ca, Mg, Mn, Zn, Cu, Mo, Co, amino acids (18 tested for)	24 O, 24 C	No difference in any of the outcomes measured (mycotoxins, protein, amino acids, mineral content) between conventional vs. organic wheat.
Malmauret et al. (189)	France	Ministry for Food (DGAL, France), Dannon Foods, Regional Council of Brittany	Buckwheat, barley, wheat	--	FS	As, Cd, Hg, Pb, DON, NIV, HT-2	Buckwheat, barley: 5 O, 5 C; wheat: 11 O, 11 C	No difference in levels of As, C, Hg, Pb, DON, ZEA, and HT-2 by farming type.
Mason et al. (194)	Canada	Canadian Wheat Board, Organic Agriculture Center of Canada, Alberta Crop Industry Development Fund (Canada), Alberta Agricultural Research Institute (Canada)	Wheat	OCIA	RFT	Protein	20g O, 20g C for each of 5 cultivars	No difference in protein content between conventional vs. organic wheat.
Mazzoncini et al. (195)	Italy	Not stated	Wheat	--	RFT	N, P, protein, ash	Not stated	Organic wheat had less protein than conventional (p < .05). Levels of phenols, ash content, and gluten index were not statistically different in organic vs. conventional wheat. Organic wheat bran and wheat flour had less N than conventional wheat bran and wheat flour (p

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
								< .05). Organic wheat bran had less P than conventional wheat bran (p < .05), but organic wheat flour had more P than conventional wheat flour (p < .05). Levels of phenols in wheat bran and wheat flour did not vary by farming type.
Nitika et al. (209)	India	Not stated	Wheat	--	RFT	Ca, P, Mg, Fe, Zn, Cu, Mn, protein, gluten, albumin, globulin, prolamin, glutelin, ash, sugars, polyphenols	15 O, 15 C	Organic wheat had less protein than conventional (12.5% vs. 13.6%, significance not stated), and less polyphenols, phytic acid, albumin, globulin, prolamin, glutelin, P, Mg, Cu, and Mn than conventional (p<.05). Ash content, sugar levels, Fe, Zn, and Ca did not differ by farming type.
Perkowski et al. (224)	Poland	Scientific and Technical Cooperation Program (OEAD, Austria)	Wheat	Poland	FS	Fusarium mycotoxins (HT-2, DON, 3-AcDON, NIV, ZEA), trichodiene, ergosterol, ATP	12 O, 20 C	Organic wheat had higher levels of ergosterol and ATP than conventional wheat. Organic and conventional wheat contained similar amounts of Fusarium toxins and trichodiene.
Petr (225)	Czech Republic	Czech Ministry of the Environment	Triticale	IFOAM, Czech Republic	RFT	Protein	Not stated	In one cultivation year, organic triticale had less protein than conventional; in the second cultivation year, there was no difference in protein levels by farming type.
Pussemier et al. (235)	Belgium	Belgian Federal Public Planning Service (BELSPO)	Wheat, wholemeal wheat flour	--	FS, R	DON, OTA, ZEA	Wheat grain: 20 O, 20 C in 2002; 26 O, 22 C in 2003; wheat flour: 40 O,	Higher prevalence of OTA and lower prevalence of ZEA in organic wheat grain (p < .05). No difference in DON in wheat grains by farming type. Organic wheat flour had less DON than conventional wheat flour (p < .001), but no difference in OTA by farming type.

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
Rossi et al. (243)	Italy	Italian National Research Council	Wheat	--	MW	Pb, Cd, OTA, trichothecenes (e.g., DON, NIV), protein, ash	40 C 20 O, 15 C	Organic wheat had less crude protein ($p < .01$), Cd ($p < .01$), and DON ($p < .01$) and more Pb ($p < .05$) than conventional wheat. No difference in OTA prevalence by farming type, nor in prevalence of trichothecenes other than DON, and no difference in ash content.
Ryan et al. (246)	Australia	New South Wales Agriculture (Australia), Australian National University, Grains Research and Development Corporation (Australia)	Wheat	--	FS	N, K, Mg, Ca, S, Fe, Zn, Cu, Mn, P	16 O, 16 C	Organic wheat had more Zn and Cu and less Mn and P than conventional ($p < .05$). For all other minerals tested, no statistically significant difference by farming type.
Schollenberger et al. (249)	Germany	Not stated	Wheat	--	MW, R	DON	24 O, 36 C	DON was found in 25% of organic vs. 36% of conventional wheat samples. DON levels in contaminated samples were lower in organic than conventional wheat ($p < .05$).
Shier et al. (252)	USA	Not stated	Wheat	--	FS	Protein, ash	9 O, 9 C	No difference in crude protein by farming type. No significant difference in ash when the wheat was heated to 700 degrees C, but when the wheat was heated to only 500 degrees C, organic wheat had significantly less ash than conventional ($p < .05$).

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
Srikumar and Ockerman (258)	Sweden	Swedish Council for Forestry and Agricultural Research	Wheat, oats	--	RFT	Zn, Cu, Fe, Mn, Se	4 O, 4 C	Organically fertilized wheat had more Cu and less Zn, Fe, and Mn than conventionally fertilized wheat ($p < .05$); no differences in levels of Se. Organically fertilized oats had more Mn and Se and less Zn and Fe than conventionally fertilized oats ($p < .05$); no differences in levels of Cu.
Stracke et al. (259)	Germany, Switzerland	German Federal Agency for Agriculture and Food	Wheat	--	RFT	Total phenolics	20 O, 20 C	No significant differences in phenolics or carotenoid content between organic vs. conventional wheat. Climate and year-to-year differences were more important in determining phytochemical content than farming type.
Tasiopoulou et al. (263)	Italy	Not stated	Cereals, citrus fruits, other fruits, legumes, potatoes, other vegetables	--	FS, R	Pesticides	266 O, 3242 C	Organic food samples had a lower prevalence of pesticide residues than conventional food samples (2.6% vs. 27.0%).
Vanova et al. (270)	Czech Republic	Czech Ministry of Agriculture	Wheat	IFOAM	RFT	DON, protein	4 O, 4 C for each of 9 cultivars	Organic wheat had less protein and less contamination with DON than conventional wheat ($p < .05$).
Warman and Havard (276)	Canada	Canada/Nova Scotia Agri-Food Development Agreement	Corn	OCIA	RFT	Vitamin C, alpha-tocopherol, gamma-tocopherol, N, P, K, Na, Ca, Mg, S, B, Fe, Mn, Cu, Zn	10 O, 10 C	No statistical differences in any of the examined vitamins or minerals between organic vs. conventional corn.
Warman and Havard (275)	Canada	Canada/Nova Scotia Agri-Food Development Agreement	Corn	OCIA	RFT	Vitamin C, vitamin E, alpha-carotene, beta-carotene, N, P, K, Na, Ca, Mg, S, B,	5 O, 5 C for each of 3 years	No differences in vitamin or mineral content between organic vs. conventional corn.

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
Zörb et al. (284)	Switzer-land	Research Institute of Organic Agriculture (Switzerland)	Wheat	IFOAM	RFT	Fe, Mn, Cu, Zn Total protein content, metabolite concentrations	4 O, 4 C	Organic wheat had significantly less protein than conventional (p < .05). Marginal or non-significant differences between organic vs. conventional wheat were found for 62 metabolite concentrations in mature grains.
Zörb et al. (283)	Switzerland	Research Institute of Organic Agriculture (Switzerland)	Wheat	IFOAM	RFT	Total protein content	3 O, 3 C	Organic wheat had less protein than conventional (statistical significance not stated).
Zuchowski et al. (285)	Poland	Not stated	Wheat	--	RFT	Protein, total phenolics	12 O, 12 C	Organic wheat had significantly less protein than conventional (p < .05). Organic wheat had higher concentrations of total phenolic acid than conventional wheat, though the differences were not large.
OILS								
Amvrazi and Albanis (74)	Greece	European Union, European Social Fund	Olive oil	--	MW, R	Pesticides (35 examined)	10 O, 90 C	Organic olive oils had lower incidence of pesticide residues than conventional (4/10 O samples, 81/90 C samples; no statistical tests provided).
Gutierrez et al. (137)	Spain	Interministerial Commission on Science and Technology (CICYT, Spain), Andalusian Committee for Organic	Olive oil	--	RFT	Alpha-tocopherol, alpha-diphenols, polyphenols, sterols, fatty acids (7 examined)	4 O, 4 C	Organic olive oil contained significantly more alpha-tocopherol (p<.001), o-diphenols (p<.01), and polyphenols (p<.001) than conventional olive oil. No significant difference in levels of plant sterols by farming type. Organic olive oil had less palmitic acid (p<.05), palmitoleic acid (p<.05), and linoleic acid (p<.05) than

Author	Country	Funding Source	Food Studied	Organic Standard Used ^b	Sample Setting ^c	Outcomes Measured ^d	Sample Sizes ^e	Key Findings
		Agriculture (CAAE, Spain)						conventional, but more oleic acid (p<.01). No significant differences in the levels of the other 3 fatty acids examined.
Ninfali et al. (208)	Italy	Not stated	Olive oil	--	FS	Total polyphenols, tocopherols, total antioxidant capacity	3 O, 3 C for each of 2 cultivars and 3 years	No statistically significant difference in phenols, tocopherols, or total antioxidant activity between conventional vs. organic olive oil.
Tsatsakis et al. (267)	Greece	Not stated	Olive oil	EEC, Greece	FS	Pesticides	53 O, 50 C for each of 3 years	Organic olive oil had lower levels of the 2 examined pesticides than conventional, for all 3 years examined.

^a223 produce and meat publications met our inclusion criteria. The number of human, produce, and meat studies does not sum to 240 (= 223+17) because 3 studies included data on both the human subjects and the food they consumed.

^bOrganic standards abbreviations: Country Name (e.g., Sweden) = Organic farming standards for that country (e.g., Sweden); APB = A.Pro.Bio, Association of Organic Producers in Friuli–Venezia Giulia Region of Italy; APROBA = Association of Organic Producers of Buenos Aires Province (Argentina); BOAM = Board of Organic Agriculture of the Murcia Region (Spain); CCOF = California Certified Organic Farmers; Certified = Study stated that the food was organically certified, but did not name standard used; Ecovida = Ecovida agriculture network (Brazil); EEC = European Economic Community Regulation on Organic Production; EKOLAND = Association of Ecological Food Producers (Europe); IFOAM = International Federation of Organic Agriculture Movements; OCIA = Organic Crop Improvement Association; Soil Association = Soil Association (United Kingdom) organic farming standards; USDA = United States Department of Agriculture National Organic Program standards; WSDA = Washington State Department of Agriculture Organic Food Program

^cSample setting abbreviations: FS = farm survey; MW = mill or wholesaler; R = retailer or market; RFT = research field trial

^dOutcomes abbreviations: EHEC = enterohemorrhagic *E. coli* (*E. coli* O157:H7), MUFA = monounsaturated fatty acid(s), PUFA= polyunsaturated fatty acid(s), SFA = saturated fatty acid(s), DHAA = dehydroascorbic acid, OCP = organochlorine pesticide, OTA = ochratoxin A, DON = deoxynivalenol, NIV = nivalenol, FB1 = fumonisin B1, FB2 = fumonisin B2, ATP – adenosine 5’-triphosphate, ZEA - zearalenone, MRL = maximum residue level

^eSample type abbreviations: O = organic, C = conventional

^fUnpublished data obtained from author.

B. Description of Included Studies of Animal Products

Author	Country	Funding Source	Food (Body Part) Studied	Organic Standard Used ^g	Sample Setting	Outcomes Measured ^h	Sample Sizes ⁱ	Key Findings
MEATS								
Blanco-Penedo et al. (89)	Spain	Xunta de Galicia (Government Ministry of Galicia, Spain), Ministry of Science of Spain	Beef (diaphragm muscle)	Spain	Cattle farms	Levels of trace elements including As, Cd, Hg, and Pb	166 samples from 9 farms (data only abstracted from the 3 O and 3 C farms)	No significant differences in contamination with heavy metal residues between O and C samples. Most of the heavy metal residues were below detection limits; those above detection limits were still below national safety standards.
Ghidini et al. (131)	Italy	Not stated	Beef (Longissimus dorsi muscle)	--	Retailers	Levels of organochlorine pesticides, PCBs, Pb, Cd, and mycotoxins	10 samples each of C and O beef	Pesticides and PCB residues were lower than legal limits in both organic and conventional samples. Pb and Cd residues were at very low levels and did not differ by production type.
Olsson et al. (216)	Sweden	MISTRA (Foundation for Strategic Environmental Research, Sweden)	Beef (kidney, liver, muscle tissue, mammary tissue)	Sweden	Dairy farms	Cd and Zn levels in tissues	Samples of kidney, liver, muscle tissue, and mammary tissue from 29 O cows and 67 C cows	Significantly lower levels of Cd in kidneys, livers, and mammary tissue of organic cows; no difference in Cd levels in muscle tissue by farming type. Significantly lower levels of Zn in organic cow kidneys, and significantly higher levels of Zn in organic cow muscles; no difference in Zn levels in livers and mammary tissue.
Walshe et al. (272)	Ireland	Irish Government	Beef (Longissimus dorsi muscle)	Organic Trust	Slaughter-house	Fat, protein, ash, beta-carotene, vitamin E, and vitamin A content, fatty acid composition	Samples from 6 O cows and 6 C cows	No differences in protein, ash, beta-carotene, vitamin E and vitamin A by production type. Organic beef had more fat (p < .05) than conventional beef. No significant difference in fatty acid profile by production system.
Hansen et al.	Denmark	Structure Directorate	Pork (loin	Denmark	Experimental	Vitamin E levels in	39 O samples, 39	No significant difference in levels of

Author	Country	Funding Source	Food (Body Part) Studied	Organic Standard Used ^g	Sample Setting	Outcomes Measured ^h	Sample Sizes ⁱ	Key Findings
(149)		(Strukturdirektoratet, Denmark)	muscle, liver, back fat)		farm	loin muscle and liver, vitamin A levels in liver, Fatty acid composition (SFA, MUFA, PUFA) in back fat	C samples	vitamin E. Conventional pork liver had more vitamin A than organic pork liver ($p < .05$). No statistical difference in levels of SFA. Organic pork fat had less MUFA ($p < .05$) and more PUFA ($p < .05$) than conventional pork fat.
Hogberg et al. (156)	Sweden	Not stated	Pork (Longissimus dorsi muscle)	KRAV	Experimental farm	Level of alpha-tocopherol and beta-tocopherol in meat and back fat, and fatty acid composition (numerous components measured)	21 O pigs, 23 C pigs	No statistically significant differences in levels of tocopherol between organic and conventional pigs, and few statistically significant differences in fatty acid composition.
Laukkanen et al. (177) and Hellström et al. (152)	Finland	Finnish Ministry of Agriculture and Forestry	Pork (intestines, tonsils, lung, heart, liver, kidney, thoracic cavity, pelvic cavity)	EEC	Pig farms and slaughter-houses	<i>Y. pseudotuberculosis</i> and <i>L. monocytogenes</i> prevalence in pigs at time of slaughter	120 O pigs, 239 C pigs from 5 O and 10 C farms	Prevalence of <i>Y. pseudotuberculosis</i> was higher in all sampled body parts from organically raised pigs than in corresponding samples from conventionally raised pigs ($p < .01$). Prevalence of <i>L. monocytogenes</i> was higher in rectal swabs of O vs. C (4/121 vs. 0/243) but not in cut meat samples (2/60 vs. 3/80).
Lindén et al. (184)	Sweden	Swedish Council for Forestry and Agricultural Research, Foundation for Strategic Environmental Research	Pork (kidney, liver)	KRAV	Experimental farm	Level of Cd in kidney, liver	40 O samples, 40 C samples	No significant difference in liver Cd levels between organic and conventional pigs. Organic pigs had significantly higher levels of Cd in kidneys ($p = .005$) than conventional pigs.
Millet et al. (200)	Belgium	Belgian Ministry of Small Enterprises, Traders and Agriculture	Pork (muscle and fat)	Belgium	Experimental farm	Intramuscular fat content (percentage)	16 O samples, 15 C samples	No difference in intramuscular fat content between organically and conventionally raised pigs.

Author	Country	Funding Source	Food (Body Part) Studied	Organic Standard Used ^g	Sample Setting	Outcomes Measured ^h	Sample Sizes ⁱ	Key Findings
Miranda et al. (201)	Spain	Xunta de Galicia (Government Ministry of Galicia, Spain)	Pork (loin muscle)	Spain	Retailers	Prevalence of <i>E. coli</i> , Resistance of <i>E. coli</i> isolates to 9 antimicrobial agents	90 <i>E. coli</i> isolates from O pork meat, 90 isolates from C pork meat	<i>E. coli</i> was more prevalent in organic than conventional pork samples (65% vs. 48%). Isolates from organic pork meat were statistically less resistant to 4 of the 9 tested antibiotics than isolates from conventional meat; no differences were found for the other 5 tested antibiotics. Isolates from organic pork were less likely to be multidrug-resistant than isolates from conventional pork (41% vs. 90%, $p < .0001$).
Nowak et al. (210)	Germany	Fritz-Ahrberg Foundation (Hannover, Germany)	Pork (tonsils, lymph nodes)	--	Pig farms	Prevalence of <i>Y. enterocolitica</i>	200 O pigs and 210 C pigs, each sampled 3 times (tonsils, lymph nodes)	<i>Y. enterocolitica</i> was more prevalent in conventional pigs than in organic pigs (29% vs. 18%, $p = .014$).
Olsson et al. (218)	Sweden	MISTRA (Foundation for Strategic Environmental Research, Sweden)	Pork (Longissimus dorsi muscle)	KRAV	Experimental farm	Lean meat content (percentage), crude protein levels, ash content	40 O pigs, 40 C pigs	Conventional pork had a higher lean meat percentage ($p = .0007$) and lower crude protein levels ($p = .0001$) and ash content ($p = .028$) than organic pork.
Pozzo et al. (232)	Italy	University of Torino, Ministry of Education, University and Research (MIUR, Italy), Piedmont Region Health Research Program (Italy)	Pork (serum)	--	Pig farms	Prevalence of OTA contamination in serum	11 C and 4 O farms	All serum samples were contaminated with OTA (80/80 O samples and 205/205 C samples). However, the mean amount of contamination was significantly higher among O samples (1.32 µg/kg vs. 0.16 µg/kg; $p < 0.001$).
Zheng et al. (282)	Denmark	European Commission, Danish Institute of Food and Veterinary Research	Pork	--	Pig farms	<i>Salmonella</i> in meat juice samples from frozen meat samples	Approximately 45 pigs from each farm: 11 O farms, 12 C (outdoor)	No significant differences in the prevalence of <i>Salmonella</i> detected by production type.

Author	Country	Funding Source	Food (Body Part) Studied	Organic Standard Used ^g	Sample Setting	Outcomes Measured ^h	Sample Sizes ⁱ	Key Findings
Angood et al. (76)	United Kingdom	Not stated	Lamb (loin muscle)	--	Retailers	Total fat, total fatty acids, SFA, MUFA, PUFA, n-3 PUFA, n-6 PUFA, linoleic acid	farms, 11 C (indoor) farms 180 O and 180 C lamb chops	Organic lamb chops contained more total fatty acids (p < .05), SFA (p < .05) and n-3 PUFA (p < .01) than conventional, and less linoleic acid than conventional (p < .05). No differences were detected in levels of total fat, MUFA, PUFA, and n-6 PUFA by farming type.
Pla et al. (229)	Spain	Not stated	Rabbits (hind leg)	Spain	Experimental farm	Levels of SFA, MUFA, and PUFAs, n-6 fatty acid, n-3 fatty acid	26 O samples, 26 C samples	No statistical difference in levels of SFA between conventional and organic rabbit meat. Organic rabbit meat had less MUFA (p < .0001) and more PUFA (p < .05), n-3 FA (p < .01), and n-6 FA (p < .01) than organic rabbit meat.
Pla (228)	Spain	Not stated	Rabbits (hind leg)	Spain	Experimental farm	Protein levels, lipid levels, SFA, MUFA, PUFA, n-6 fatty acid, n-3 fatty acid	50 O and 50 C rabbits	Meat from organic rabbits had lower protein content (p < .001), lipid content (p < .001), SFA (p < .05), and MUFA (p < .001) than meat from conventional rabbits, but more PUFA (p < .001), n-6 FA (p < .001) and n-3 FA (p < .001).
POULTRY								
Castellini et al. (98)	Italy	University of Perugia	Chicken (breast, leg)	EEC	Experimental farm	Protein, lipid and ash content (percentage), iron content, fatty acid composition (SFA, MUFA, PUFA)	20 O and 20 C chickens slaughtered on each of two slaughtering dates	No statistical differences in protein content. Conventional breasts and drumsticks had higher lipid content (p < .01) and lower total iron content (p < .05) than their organic counterparts. No differences in ash content of organic and conventional chicken breasts, but

Author	Country	Funding Source	Food (Body Part) Studied	Organic Standard Used ^g	Sample Setting	Outcomes Measured ^h	Sample Sizes ⁱ	Key Findings
								organic drumsticks had statistically more ash than conventional (p < .05). Conventional breasts and drumsticks had less SFA (p < .05), more MUFA (p < .05), and less PUFA (p < .001) than their organic counterparts.
Cui et al. (51)	USA	Not stated	Chicken (whole chicken)	--	Retailers	Percent of samples contaminated with <i>Salmonella</i> , percent of samples contaminated with <i>Campylobacter</i> , percent of <i>Campylobacter</i> isolates resistant to 4 tested antimicrobial agents, percent of <i>Salmonella</i> isolates resistant to 17 tested antimicrobial agents	198 O chickens, 61 C chickens; 150 O samples with <i>Campylobacter</i> , 45 C samples with <i>Campylobacter</i> ; 121 O samples with <i>Salmonella</i> , 27 C samples with <i>Salmonella</i>	No difference between level of <i>Campylobacter</i> contamination in organic vs. conventional chickens. Organic chickens were more likely to be contaminated with <i>Salmonella</i> than conventional chickens (61% O vs. 44% C). Few differences in antibiotic resistance of <i>Campylobacter</i> by production type, though <i>Campylobacter</i> in organic chicken was statistically more likely to be resistant to ciprofloxacin and less likely to be resistant to erythromycin than isolates from conventional chicken. Few statistically significant differences in antimicrobial resistance of <i>Salmonella</i> isolates by antimicrobial agent and production type. However, <i>Salmonella</i> isolates from organic chicken were more likely to be susceptible to all 15 tested microbials than isolates from conventional chicken.
Han et al. (146)	USA	Louisiana Board of Regents Support Fund Research and Development Program	Chicken (whole chicken from retail stores)	--	Retailers	Prevalence of <i>Campylobacter</i> and resistance of isolates to antimicrobial agents	141 O chicken carcasses, 53 C chicken carcasses	No statistical difference in prevalence of <i>Campylobacter</i> between organic and conventional chicken. No statistical difference in resistance of

Author	Country	Funding Source	Food (Body Part) Studied	Organic Standard Used ^g	Sample Setting	Outcomes Measured ^h	Sample Sizes ⁱ	Key Findings
								<i>Campylobacter</i> to gentamicin and tetracycline, but isolates from conventional chicken had statistically higher rates of resistance to ciprofloxacin and erythromycin ($p < .05$) than isolates from organic chicken.
Husak et al. (160)	USA	Leopold Center for Sustainable Agriculture (Iowa)	Chicken (breast, thigh, skin)	--	Retailers	Fat and protein content of breast, thigh and skin; Levels of SFA, MUFA, and PUFA	60 O chickens, 60 C chickens, each yielding a breast, thigh and skin sample	Organic breast meat, thigh meat, and skin had more protein than conventional counterparts ($p < .05$). Organic breast and thigh meat had more fat than conventional counterparts ($p < .05$), but skin from organic chickens had less fat than skin from conventional chickens ($p < .05$). Organic chicken had less SFA and less MUFA but more PUFA than conventional chicken ($p < .05$).
Izat et al. (161)	USA	USDA	Chicken (whole chicken)	--	Retailers	Prevalence of <i>Salmonella</i> , mean counts of <i>Salmonella</i>	24 O chickens, 48 C chickens	<i>Salmonella</i> prevalence was higher in organic than conventional chickens (10/24 O samples vs. 11/48 C samples). No difference in <i>Salmonella</i> counts between contaminated O vs. C chickens.
Jahan and Paterson (162)	United Kingdom	Government of Bangladesh, University of Strathclyde	Chicken (breast)	--	Retailers	Levels of neutral lipids (NL), phospholipids (PL), and free fatty acid (FFA)	5 O chicken breast products, 7 C chicken breast products	No statistically significant differences in fatty acid composition between organic and conventional chicken breasts.
Jahan et al. (163)	United Kingdom	University of Strathclyde, Government of Bangladesh	Chicken (breast)	--	Retailers	Total fat (percentage), cholesterol content, content of SFA, MUFA, PUFA, n-3, n-6	6 O and 6 C chicken breasts	Organic chicken breasts contained less fat than conventional. No difference in level of cholesterol, SFA MUFA, n-3, and n-6. Organic chicken breasts contained more PUFA than

Author	Country	Funding Source	Food (Body Part) Studied	Organic Standard Used ^g	Sample Setting	Outcomes Measured ^h	Sample Sizes ⁱ	Key Findings
Lestari et al. (181)	USA	Louisiana Board of Regents Support Fund Research and Development Program	Chicken (whole chicken from retail stores)	--	Retailers	Prevalence of <i>Salmonella</i> and resistance of isolates to antimicrobial agents	141 O chicken carcasses, 53 C chicken carcasses	conventional chicken breasts (p < .05). No statistical difference in prevalence of <i>Salmonella</i> between organic and conventional chicken. Isolates from conventional chicken had statistically higher rates of resistance to streptomycin, tetracycline, and trimethoprim-sulfamethoxazole (p < .05) than isolates from organic chicken. No statistical difference in rates of resistance to other antibiotics tested.
Martino et al. (192)	Italy	Not stated	Chicken (breast)	--	Not stated	Protein content, ash content, total fat, levels of SFA, MUFA and PUFA	12 O and 12 C chicken breasts	Organic chicken breasts had more total fat (p < .01) than conventional chicken breasts. No statistically significant differences in levels of protein, ash, SFA, MUFA, or PUFA.
Miranda et al. (52)	Spain	Not stated	Chicken (leg)	Spain	Retailers	Resistance of <i>Enterococcus spp.</i> isolates to 8 antimicrobials	60 isolates from O chicken, 60 isolates from C chicken	<i>Enterococcus</i> mean counts were statistically higher in organic chicken meat than in conventional. <i>Enterococcus</i> isolates from organic chicken were statistically less resistant to 6 of the tested antimicrobials than isolates from conventional chicken.
Miranda et al. (50)	Spain	Xunta de Galicia (Government Ministry of Galicia, Spain)	Chicken (leg)	Spain	Retailers	Prevalence of <i>E. Coli</i> , <i>S. aureus</i> , and <i>L. monocytogenes</i> , resistance of <i>E. coli</i> to 10 antimicrobial agents, resistance of <i>S. aureus</i> to 9 antimicrobial agents,	55 O samples, 61 C samples; <i>E. coli</i> isolates from 105 O chickens, 115 C chickens; <i>S. aureus</i> isolates from 91 O chickens, 101 C	Organic chicken was more likely to be contaminated with <i>E. coli</i> than conventional chicken (82% vs. 63%). No difference in prevalence of <i>S. aureus</i> and <i>L. monocytogenes</i> between organic and conventional chicken. Resistance of <i>E. coli</i> isolates to 7 of 10 tested antibiotics was higher for conventional

Author	Country	Funding Source	Food (Body Part) Studied	Organic Standard Used ^g	Sample Setting	Outcomes Measured ^h	Sample Sizes ⁱ	Key Findings
						resistance of <i>L. monocytogenes</i> to 6 antimicrobial agents	chickens; <i>L. monocytogenes</i> isolates from 39 O chickens, 32 C chickens	than organic chicken ($p < .002$); no differences found for the other 3 antibiotics tested. Resistance of <i>S. aureus</i> isolates was statistically different only for 1 of 9 tested antibiotics: isolates from conventional chicken were more likely to be resistant to doxycycline than isolates from organic chicken ($p = .0001$). No differences between organic and conventional chicken in susceptibility of <i>L. monocytogenes</i> isolates to all 6 tested antibiotics.
Miranda et al. (53)	Spain	Xunta de Galicia (Government Ministry of Galicia, Spain)	Chicken (leg)	--	Retailers	Mean counts of Enterobacteriaceae and resistance of isolates to 8 antimicrobial agents	30 O samples, 30 C samples; Enterobacteriaceae isolates from 60 O samples, 60 C samples	Mean counts of Enterobacteriaceae were significantly higher in organic than conventional chicken (3.81 log CFU/g vs. 2.66 log CFU/g; $p < .001$). Resistance of Enterobacteriaceae isolates to 6 antimicrobials (ampicillin, chloramphenicol, doxycycline, ciprofloxacin, gentamicin, sulfisoxazole) was significantly lower in organic than conventional chicken ($p < .05$). No difference for the other 2 antimicrobials tested (cephalothin, nitrofurantoin).
Soonthornchai et al. (256)	United Kingdom	Not stated	Chicken (whole chickens)	--	Retailers	Prevalence of <i>Campylobacter</i> and resistance of <i>Campylobacter</i> isolates to 3 antimicrobials	30 O chickens, 30 C packaged chickens, 30 C fresh butcher chickens	<i>Campylobacter</i> prevalence did not differ significantly between organic vs. conventional packaged chickens (80% of O chickens vs. 83% of C chickens), but was found in 100% of fresh butcher conventional chickens. <i>Campylobacter</i>

Author	Country	Funding Source	Food (Body Part) Studied	Organic Standard Used ^g	Sample Setting	Outcomes Measured ^h	Sample Sizes ⁱ	Key Findings
						(ciprofloxacin, erythromycin, nalidixic acid)		isolates from conventional chicken were more likely to be resistant to ciprofloxacin than isolates from organic chicken (2.9% of C samples vs. 0% of O samples; $p < .05$). No difference between <i>Campylobacter</i> isolates from C vs. O chickens in resistance to ciprofloxacin and nalidixic acid: 100% of chickens harbored resistant <i>Campylobacter</i> .
EGGS								
Giannenas et al. (132)	Greece	Not stated	Eggs	--	Poultry farms	Concentrations of 12 trace minerals (Se, Zn, Mn, Co, Cu, Mo, V, Cr, Ni, Tl, As, Cd)	48 O eggs, 48 C eggs	Only small differences were found in the trace mineral contents of organic vs. conventional eggs.
Messens et al.- (198)	Belgium	Commission of the European Communities	Eggs	--	Poultry farms	Fraction of eggshells with <i>Salmonella</i> penetration	20 O eggs, 20 C white eggs, 20 C brown eggs	No difference in chance of <i>Salmonella</i> penetration as a function of raising system (organic vs. conventional).
Schwaiger et al. (250)	Germany	Bavarian State Ministry of the Environment, Public Health and Consumer Protection (Germany)	Eggs	--	Poultry farms	Prevalence of <i>Salmonella spp.</i> , <i>E. coli</i> , and <i>Campylobacter spp.</i> in eggs, and resistance of the bacterial isolates to 27 different antibiotics	800 O and 800 C eggs	Number of bacterial isolates from eggs was too small to draw conclusions.
Schwaiger et al. (251)	Germany	Bavarian State Ministry of the Environment, Public Health and Consumer Protection	Eggs	--	Poultry farms	Prevalence of <i>Listeria</i> and <i>Enterococcus</i> in eggs, and resistance of the bacterial isolates	40 O and 40 C eggs	Number of bacterial isolates from eggs was too small to draw conclusions.

Author	Country	Funding Source	Food (Body Part) Studied	Organic Standard Used ^g	Sample Setting	Outcomes Measured ^h	Sample Sizes ⁱ	Key Findings
						to 27 different antibiotics		
MILK								
Bennesdgaard et al. (83)	Denmark	Danish Dairy Board, Danish Ministry for Food, Agriculture and Fisheries, Research Center for the Management of Animal Production and Health	Raw cows' milk	--	Dairy farms	Percent of cows with <i>Staphylococcus aureus</i> , and percent of <i>Staphylococcus aureus</i> -infected cows with penicillin-resistant <i>Staphylococcus aureus</i>	Milk tested from 391 O cows, 493 C cows	No difference in prevalence of <i>Staphylococcus aureus</i> in milk from conventionally and organically raised cows, nor in the prevalence of penicillin-resistant <i>Staphylococcus aureus</i> among infected cows.
Bergamo et al. (85)	Italy	European Union	Pasteurized cows' milk, Raw water buffalo milk	Italy	Dairy farms, retailers	Fat content (percentage), levels of 9 fatty acids including trans-11 octadecenoic acid (TVA), linoleic acid (LA), conjugated linoleic acid (CLA), and alpha-linoleic acid (LNA), beta-carotene	Raw water buffalo milk samples from 3 O dairies, 8 C dairies collected during a 3-month period; retail cows' milk samples from 2 O brands, 2 C brands	Total fat content did not differ by farming type for either type of milk. Some statistical differences in fatty acid composition between organic and conventional: for example, organic milk had more TVA (p < .05), CLA (p < .01) and LNA (p < .05) than conventional, but less LA (p < .05). Organic cows' milk had significantly more beta-carotene than conventional (p = .004).
Bombyk et al. (91)	USA	University of Minnesota	Raw cows' milk	USDA	Dairy farms	Isolates of <i>Staphylococcus</i> distinguished by three categories (CP - coagulase positive, NSCNS - novobiocin-sensitive coagulase-negative, NRCNS -	239 <i>Staphylococcus</i> isolates from O cows, 166 from C cows	Organic milk was more likely to harbor NSCNS (p = .004), while conventional milk was more likely to harbor NRCNS (p < .0001). <i>Staphylococcus</i> isolates from organic and conventional milk were equally susceptible to erythromycin and penicillin, while isolates from organic milk were more

Author	Country	Funding Source	Food (Body Part) Studied	Organic Standard Used ^g	Sample Setting	Outcomes Measured ^h	Sample Sizes ⁱ	Key Findings
						novobiocin-resistant coagulase-negative), susceptibility of <i>Staphylococcus</i> isolates to 4 tested antibiotics		susceptible to pirlimycin (p < .001) and tetracycline (p = .04) than isolates from conventional milk.
Butler et al. (94)	United Kingdom	Greek State Scholarship Foundation, European Union, Yorkshire Agricultural Society	Pasteurized cows' milk	--	Retailers	Levels of a variety of fatty acids and protein in milk	48 samples from 12 C brands, 40 samples from 10 C brands	Organic brands of milk were 7% higher in total fat content than conventional brands (p<0.01) and had more PUFA, CLA, and linoleic acid than conventional milk brands; however, there were no differences in protein or total SFAs or MUFAs. There were differences in individual fatty acids by O vs. C brands. There were considerable statistically significant differences in all of these outcomes by season, year of testing, and specific brand of organic milk.
Butler et al. (92)	United Kingdom	European Union	Raw cows' milk	UK	Dairy farms	Levels of total CLA and 14 isomers	20 O samples, 16 high-input C samples, 10 low-input C samples	Total CLA and levels of 7 isomers were significantly higher in organic milk and milk from conventional low-input systems compared to milk from conventional high-input systems.
Butler et al. (93)	United Kingdom	European Community, UK Red Meat Industry Forum	Raw cows' milk	UK	Dairy farms	Protein content, fat content, levels of SFA, MUFA, PUFA, conjugated linoleic acid (CLA), alpha-linoleic acid (ALA), alpha-tocopherol,	34 O samples, 20 samples from low-input C farms, 24 samples from high-input C farms	Organic milk had more protein than either type of conventional milk (p < .0001). Compared to milk from high-input conventional dairies (which follow the most common conventional production practices), organic milk had statistically more fat (p = .0004), MUFA

Author	Country	Funding Source	Food (Body Part) Studied	Organic Standard Used ^g	Sample Setting	Outcomes Measured ^h	Sample Sizes ⁱ	Key Findings
						carotenoids, lutein, zeaxanthin		(p = .017), PUFA (p = .0017), ALA (p < .0001), CLA (p < .0001), alpha-tocopherol (p < .0001), carotenoids (p < .0001), lutein (p < .0001), and zeaxanthin (p < .0001), and less SFA (p = .042).
Collomb et al. (107)	Switzerland	Not stated	Raw cows' milk	--	Dairy farms	Levels of SFA, MUFA, PUFA, trans fatty acid, branched fatty acid, n-3 fatty acid, n-6 fatty acid, and conjugated linoleic acid (CLA)	36 O samples, 36 C samples	No difference in levels of SFA or trans FA. Organic milk had more PUFA, CLA, n-3 FA and branched FA than conventional (p < .0001), but less MUFA (p < .05) and n-6 FA (p < .01) than conventional.
Coorevits et al. (108)	Belgium	Ministry of the Flemish Community	Raw cows' milk	--	Dairy farms	Total aerobic spore counts, presence of different species of aerobic spore-forming bacteria	10 O and 10 C raw milk samples	No significant difference between total aerobic spore counts in organic vs. conventional raw milk. The overall diversity of aerobic spore-forming bacteria between organic and conventional milk was similar. A higher number of thermotolerant organisms was found in conventional milk compared to organic milk (41% vs. 26%).
Cubon et al. (110)	Slovak Republic	VEGA (Scientific Grant Agency, Slovak Republic)	Raw cows' milk	Slovakia	Dairy farms	Somatic cell count (SCC), ^j total bacterial count, number of coliform bacteria, fat content, protein content, Ca content	10 O samples, 10 C samples	No significant difference in SCC, fat content, or protein content. Total bacterial count, number of coliform bacteria, and Ca content were statistically higher in organic than conventional milk.
Dahl et al. (112)	Norway	Norwegian Research Council	Cows' milk ^k	Norway	Dairy farms	Iodine concentration in milk samples	14 O milk samples, 37 C	For summer season milk samples, median iodine concentration in organic

Author	Country	Funding Source	Food (Body Part) Studied	Organic Standard Used ^g	Sample Setting	Outcomes Measured ^h	Sample Sizes ⁱ	Key Findings
							milk samples	milk was lower than in conventional milk (p = .006); no statistical difference in median iodine concentration by farming type for winter season milk samples.
D'Amico and Donnelly (113)	USA	USDA	Raw cows' milk	US	Dairy farms	<i>Listeria monocytogenes</i> , <i>Staphylococcus aureus</i> , <i>Salmonella spp.</i> , and <i>Escherichia coli</i> O157:H7	6 O farms, 14 C farms	No difference in contamination with any of the pathogens evaluated between O and C samples.
Ellis (123) and Ellis et al. (124)	United Kingdom	Organic Milk Suppliers Cooperative, Wellcome Trust	Raw cows' milk	--	Dairy farms	MUFA, PUFA, SFA, n-3 and n-6 fatty acids	17 O farms and 19 C farms tested monthly for a year; 430 milk samples (O vs. C breakdown not specified)	Organic milk contained higher levels of PUFA and n-3 fatty acids and lower levels of MUFA compared to conventional milk. Levels of SFA and n-6 fatty acid were similar.
Ellis (123) and Ellis et al. (125)	United Kingdom	Organic Milk Suppliers Cooperative, Wellcome Trust	Raw cows' milk	--	Dairy farms	Vitamin A content, vitamin E content, beta-carotene content	17 O dairy farms and 19 C dairy farms, each visited and sampled 6 times	Conventionally produced milk had higher mean content of vitamin A than organically produced milk (p < .05). No significant differences in levels of vitamin E and beta-carotene by farming system.
Gabryszuk et al. (129)	Poland	Not stated	Raw cows' milk	--	Dairy farms	Levels of 29 elements, including heavy metals	20 O samples, 30 C samples	Few significant differences in levels of macro- and microelements by farming type. No differences in levels of Ca, As, and Cd between conventional vs. organic milk. Organic milk had

Author	Country	Funding Source	Food (Body Part) Studied	Organic Standard Used ^g	Sample Setting	Outcomes Measured ^h	Sample Sizes ⁱ	Key Findings
Garmo et al. (130)	Norway	Not stated	Raw cows' milk	Norway	Dairy farms	Contamination with common pathogens associated with mastitis, penicillin resistance of those pathogens	24 O and 25 C herd	significantly less Pb and more Hg than conventional milk ($p < .05$). No difference in the rate of bacterial contamination of milk samples with pathogens associated with mastitis (17.2% O vs. 15.5% C). 81/167 isolates (48.5%) of coagulase-negative <i>Staphylococci</i> (CNS) and 6/68 isolates (8.8%) of <i>S. aureus</i> collected from C samples were penicillin resistant compared to 93/200 (46.5%) CNS and 9/64 (14%) of <i>S. aureus</i> .
Ghidini et al. (131)	Italy	Not stated	Raw cows' milk	--	Dairy farms	Levels of organochlorine pesticides, PCBs, Pb, Cd, and mycotoxins	78 O and 78 C milk samples	Pesticides and PCB residues were lower than legal limits in both organic and conventional milk. Pb and Cd residues were at very low levels and did not differ by production type. Mean levels of aflatoxin M1 were higher in organic milk than in conventional milk.
Halbert et al. (142)	USA	USDA, Michigan Agricultural Experiment Station, Michigan State University	Raw cows' milk	US	Dairy farms	Resistance of <i>Campylobacter</i> isolates to 20 antimicrobials	2 O samples, 12 C samples	No significant differences in antibiotic resistance could be detected, due to the low number of samples in which <i>Campylobacter</i> was detected.
Halbert et al. (141)	USA	USDA, Michigan Agricultural Station, Michigan State University	Raw cows' milk	US	Dairy farms	Resistance of <i>Campylobacter</i> isolates to 8 antimicrobials	304 isolates from O dairy farms, 912 isolates from C dairy farms	Resistance to 7 of 8 drugs (excluding tetracycline) was very low and did not differ by farm type. Tetracycline resistance was common in <i>Campylobacter</i> isolated from conventional and dairy farms, but did not differ statistically by farm type.

Author	Country	Funding Source	Food (Body Part) Studied	Organic Standard Used ^g	Sample Setting	Outcomes Measured ^h	Sample Sizes ⁱ	Key Findings
Hermansen et al. (153)	Denmark	Not stated	Raw cows' milk	--	Dairy farms	Level of 6 major elements and 45 trace elements, including heavy metals	Approximately 850 milk samples analyzed for most elements	Organic milk contained a significantly higher concentration of Mo and significantly lower concentrations of Ba, Eu, Mn, and Zn. No difference in levels of Ca.
Hoikkala et al. (158)	Finland	Not stated	Pasteurized cows' milk	--	Retailers	Levels of six phytoestrogens	12 O and 12 C cartons of milk	Organic milk contained significantly higher levels of equol than conventional milk. No differences in the levels of the other phytoestrogens examined.
Larsen et al. (176)	Sweden	European Community	Raw cows' milk	--	Dairy farms	Levels of fatty acids	5 O and 15 C dairy farms	The composition of fatty acids in milk was greatly affected by feed and season but not consistently affected by method of farming (O vs. C).
Malmauret et al. (189)	France	French Ministry of Agriculture, Regional Council of Brittany	Raw cows' milk	--	Dairy farms	Level of Cd and Pb	11 O milk samples, 11 C milk samples	No difference in levels of Cd or Pb by farming type.
Molkentin and Gieseemann (286)	Germany	Not stated	Pasteurized cows' milk	EEC	Retailers, dairy farms	Conjugated linoleic acid (CLA)	17 O, 18 C	Organic milk contained more CLA than conventional in spring and summer. No difference in CLA content between organic and conventional milk in winter.
Olivo et al. (215)	Brazil	Research Foundation of the State of Rio Grande do Sul (FAPERGS, Brazil)	Raw cows' milk	Brazil	Dairy farms	Total solids, fat, protein, lactose, and somatic cell counts (a measure of mastitis)	102 samples from 3 agro-ecological (O) farms, 120 samples from 5 C farms	Organic milk had less fat and protein and a lower somatic cell count than conventional milk (p < .05). No difference in lactose between milk from O vs. C farms.
Prandini et al. (233)	Italy	Not reported	Raw cows' milk	--	Dairy farms	Fatty acids	Not reported	Organic milk samples had lower linoleic acid levels but higher vaccenic acid levels than conventional milk samples (p<0.05). No difference in MUFA or PUFA between O vs. C milk.

Author	Country	Funding Source	Food (Body Part) Studied	Organic Standard Used ^g	Sample Setting	Outcomes Measured ^h	Sample Sizes ⁱ	Key Findings
Roesch et al. (241)	Switzerland	Swiss Federal Veterinary Office, Swiss Federal Agricultural Office, UFA Med AG, Migros Cooperatives	Raw cows' milk	BioSwiss	Dairy farms	Fat, protein, lactose, urea concentrations, and somatic cell counts (SCC)	28 O farms, 60 C farms	No difference in fat, lactose, urea concentrations, and SCC between O vs. C milk. Organic milk had significantly lower protein content than conventional milk.
Roesch et al. (242)	Switzerland	Swiss Federal Veterinary Office, Swiss Federal Agricultural Office, UFA Med AG, Migros Cooperatives	Raw cows' milk	BioSwiss	Dairy farms	Resistance of <i>Staphylococcus aureus</i> , <i>Staphylococcus spp.</i> , <i>Streptococcus uberis</i> , and <i>Streptococcus dysgalactiae</i> isolates to 12, 12, 11, and 11 antibiotics, respectively	46 O and 33 C <i>S. aureus</i> isolates, 19 O and 19 C <i>Staphylococcus spp.</i> isolates, 19 O and 9 C <i>Streptococcus uberis</i> isolates, 9 O and 4 C <i>Streptococcus dysgalactiae</i> isolates	Levels of bacterial resistance were not statistically different between the organic and conventional isolates.
Sato et al. (248)	USA, Denmark	USDA, CDC	Raw cows' milk	USDA, Denmark	Dairy farms	Prevalence of <i>S. aureus</i> , and resistance of <i>S. aureus</i> isolates to 15 antimicrobials	79 bulk tanks (30 O and 30 C dairy farms in Wisconsin, 20 O and 20 C dairy farms in Denmark; 2 visits to each farm)	No statistically significant difference in the prevalence of <i>S. aureus</i> between conventional and organic milk. Few significant differences in resistance to 15 antibiotics tested. Significant differences in resistance to antibiotics between organic and conventional milk were only found for ciprofloxacin in Wisconsin (isolates from conventional milk were more resistant) and avilamycin in Denmark (isolates from conventional milk were more resistant).
Skaug (253)	Norway	Not stated	Pasteurized cows' milk	--	Retailers (conventional	Prevalence of OTA in milk samples	47 O samples, 40 C samples	No significant difference in prevalence of OTA contamination between organic

Author	Country	Funding Source	Food (Body Part) Studied	Organic Standard Used ^g	Sample Setting	Outcomes Measured ^h	Sample Sizes ⁱ	Key Findings
					samples), dairy farms (organic samples)			and conventional milk samples.
Slots et al. (255)	Denmark	Danish Dairy Research Foundation, Research School for Organic Agriculture and Food Systems (SOAR, Denmark)	Raw cows' milk	Denmark	Dairy plant	Level of 6 antioxidants (lutein, zeaxanthin, beta-carotene, alpha-tocopherol, RRR-alpha-tocopherol, synthetic 2R-alpha-tocopherol), level of 14 fatty acids	12 O samples, 12 C samples	Organic milk had more alpha-tocopherol, carotenoids, and alpha-linoleic acid than conventional milk (p < .02), but less synthetic 2R-alpha-tocopherol and oleic acid than conventional milk (p < .02).
Slots et al. (254)	Denmark	European Community	Raw cows' milk	--	Dairy farms	Level of fat soluble antioxidants (beta-carotene, alpha-tocopherol, lutein, zeaxanthin), level of fatty acids	10 O samples, 15 C samples	Organic milk had more alpha-tocopherol, beta-carotene, lutein, zeaxanthin, linoleic acid and vaccenic acid than conventional milk (p < .0001 for each), but less synthetic MUFA and PUFA (p < .0001 and 0.0003, respectively).
Tikovsky et al. (264)	USA	Organic Farming Research Foundation	Raw cows' milk	US	Dairy farms	<i>S. aureus</i> prevalence in milk samples, resistance of <i>S. aureus</i> isolates to 9 antimicrobials	903 milk samples from 22 O herds and 535 milk samples from 16 C herds; 144 <i>S. aureus</i> isolates from O milk and 177 isolates from C milk	No statistically significant difference in the prevalence of <i>S. aureus</i> between conventional and organic milk. For 7 of the 9 antimicrobials tested, <i>S. aureus</i> isolates from organic milk had statistically lower resistance than isolates from conventional milk; for the other 2 antimicrobials tested, there was no difference in resistance between organic and conventional isolates.
Toledo et al.	Sweden	Swedish Dairy	Raw cows'	KRAV	Dairy farms	Protein, fat and lactose	31 O farms, 19 C	No statistical differences in composition

Author	Country	Funding Source	Food (Body Part) Studied	Organic Standard Used ^g	Sample Setting	Outcomes Measured ^h	Sample Sizes ⁱ	Key Findings
(265)		Association, Farmers Research Foundation (SLF, Sweden), MISTRA (Foundation for Strategic Environmental Research, Sweden)	milk			content (percentage), somatic cell count, urea content	farms, each sampled monthly for 12 months	of organic and conventional milk, except for urea, which was found at higher levels in conventional milk than in organic milk (p < .01).
Tsiplakou et al. (268)	Greece	Not stated	Raw sheep milk, raw goats' milk	Greece	Dairy farms	Fats, fatty acids, protein, milk solids	162 samples taken from 4 O sheep farms, 4 C sheep farms, 4 O goat farms, and 4 C goat farms	The conventional sheep milk had higher fat and total solids than organic sheep milk (p <0.05) but no difference in protein, lactose, or non-fat solids. There was higher milk fat in conventional goat milk than organic (p<0.05) but no differences in any other outcomes evaluated. Some specific fatty acids (e.g., MUFA, PUFA) were significantly higher among O sheep milk samples than C samples, but there were no consistent differences in specific goat milk samples between O vs. C.
Vicini et al. (271) and O'Donnell et al. (212)	USA	Monsanto Company	Pasteurized cows' milk	USDA	Retailers	Fat, protein, and antibiotic, hormone, and bacterial contamination	334 samples of pasteurized milk from retail stores from 48 states (111C, 99 O samples)	No samples had detectible antibiotic residues. The O samples had significantly greater bacterial contamination than C samples (22 ± 8.1 1000CFU/mL vs. 11 ± 4.0 1000CFU/mL, p<0.0001). The O samples had significantly higher protein levels than C samples (3.22 ± 0.012 % vs. 3.14 ± 0.012 %, p<0.001). No difference in fat content, fatty acids, lactose, or milk solids between O vs. C samples.

^gOrganic standards abbreviations: Country Name (e.g., Sweden) = Organic farming standards for that country (e.g., Sweden); BioSwiss – Certification standards of the BioSwiss organic farmers association; EEC = European Economic Community Regulation on Organic Production; KRAV – Certification standard of an association of farmers and processors in Sweden; Organic Trust = standards of an organic certification association in Ireland; USDA = United States Department of Agriculture National Organic Program standards

^hOutcomes abbreviations: HCA – heterocyclic amine, ALA – alpha linoleic acid, CLA – conjugated linoleic acid, LA – linoleic acid, TVA – trans-11 octadecenoic acid, FA – fatty acid(s), MUFA – monounsaturated fatty acid(s), PUFA– polyunsaturated fatty acid(s), SFA – saturated fatty acid(s), OTA – ochratoxin A, PCB – Polychlorinated biphenyl, STEC – Shiga toxin-producing *E. coli*, STB – Shiga toxin-encoding bacteria, SCC – somatic cell count

ⁱSample type abbreviations: O – organic, C – conventional

^jA common measure of mastitis among dairy cows is their milk’s somatic cell count.

^kThe study did not specify whether the milk was raw or pasteurized.

Supplement 5. Summary Results: Comparisons of Vitamin, Protein, and Fats Levels in Organic vs. Conventional Milk^a

Nutrient	Standardized Mean Difference^b	95%CI		p-value^c	I²	No. of Studies	Studies
Beta-carotene	1.50	0.40	2.60	0.22	94	4	(93, 125, 254, 255)
Alpha-tocopherol	0.78	-0.03	1.55	0.84	88	4	(93, 125, 254, 255)
Protein	0.306	-0.45	1.06	1.00	91	6	(94, 110, 129, 265, 268, 271)
Fat	-0.65	-2.94	1.65	1.00	99	6	(85, 94, 254, 265, 268, 271)

^aAll included studies sampled raw milk from farms. Among protein and fat studies, all sampled raw milk except three studies, which sampled pasteurized milk (85, 94, 271). All summary effect measures reported are results of random effects models. $I^2 > 25$ suggests heterogeneity. All results were robust to removal of 1 study at a time.

^bStandardized mean difference (SMD) is the difference between mean nutrient level in organic minus mean nutrient level in conventional divided by the pooled standard deviation; thus, a positive (negative) number indicates higher (lower) nutrient levels in organic.

^cAll p-values are adjusted p-values.

Supplement 6. Summary Results: Comparisons of 8 Fatty Acids in Organic vs. Conventional Milk and Chicken^a

Fatty Acid	Standardized Mean Difference^b	95%CI	p-value^c	I²	No. of Studies	Studies
Milk						
CLA	8.68	2.73	14.63	0.117	98	3 (85, 107, 124)
Linoleic acid	1.71	-2.39	5.82	1.00	99	4 (176, 212, 254, 268)
MUFA	-3.65	-7.10	-0.20	0.70	99	6 (93, 107, 124, 212, 254, 268)
Omega-3	11.17	5.93	16.41	<0.001	98	5 (93, 107, 124, 212, 268)
Omega-6	-3.17	-5.84	-0.49	0.47	99	5 (93, 107, 124, 212, 268)
PUFA	4.04	1.16	6.92	0.170	99	6 (93, 107, 124, 212, 254, 268)
SFA	4.29	1.16	7.42	0.196	98	4 (93, 107, 124, 212)
Vaccenic acid	2.62	1.04	4.19	0.031	97	5 (93, 124, 212, 254, 268)
Chicken						
MUFA	-0.12	-3.96	3.73	1.00	96	4 (98, 160, 162, 192)
Omega-3	5.48	2.19	8.76	0.031	90	3 (98, 160, 162)
PUFA	-3.66	-7.66	0.35	0.90	97	4 (98, 160, 162, 192)
SFA	0.16	-2.95	3.28	1.00	96	4 (98, 160, 162, 192)

^aCLA = conjugated linoleic acid, MUFA= monounsaturated fatty acid, PUFA = polyunsaturated fatty acid, SFA = saturated fatty acid, omega-3 = omega-3 fatty acid, omega-6 = omega-6 fatty acid. All summary effect measures reported are results of random effects models. I²> 25 suggests heterogeneity. Results for linoleic acid (milk), omega-3 (milk), PUFA (milk), SFA (milk), vaccenic acid (milk), PUFA (chicken), SFA (chicken) were robust to removal of 1 study at a time. Results for CLA (milk), MUFA (milk), omega-6 (milk), omega-3 (chicken) were no longer significant when 1 study was removed. The synthesis of MUFA (chicken) became significant with the removal of 1 outlier (192) (SMD -3.61, 95%CI: -5.4 to -1.9; p<0.001). Funnel plots suggest publication bias for omega-3 (milk), PUFA (milk), SFA (milk), vaccenic acid (milk) and omega-3 (chicken).

^bStandardized mean difference (SMD) is the difference between mean nutrient level in organic minus mean nutrient level in conventional divided by the pooled standard deviation; thus, a positive (negative) number indicates higher (lower) nutrient levels in organic.

^cAll p-values are adjusted p-values.

Supplement 7. Difference in Risk of Isolating Multidrug-Resistant *E. coli*, *Salmonella*, and Enterobacteriaceae in Organic vs. Conventional Chicken and Pork^a

Type of Organism	Risk Difference ^b	95%CI		p-value ^c	I ²	No. of Studies	Country
Resistant to							
≥1 antibiotic	-17%	-30%	-4%	0.192	78	5	U.S. (51, 181), Spain (50, 53, 201)
≥ 2 antibiotics	-33%	-46%	-19%	<0.001	73	5	U.S. (51, 181), Spain (50, 53, 201)
≥ 3 antibiotics	-33%	-45%	-21%	<0.001	62	5	U.S. (51, 181), Spain (50, 53, 201)

^aNumber of antibiotics tested in the included studies ranged from 8-15 (median 9.5). All summary effect measures reported are results of random effects models. $I^2 > 25$ suggests heterogeneity. Funnel plots did not suggest publication bias for any of these analyses. One study (50) examined drug resistance patterns for three organisms (*E. coli*, *Listeria*, and *Staphylococcus aureus*) identified on organic and conventional products. To avoid entering the same study twice in the analyses, we only included the resistance patterns reported for *E. coli*. However, in sensitivity analysis, we included the results for *Listeria* instead of *E. coli*. Results did not substantially change for ≥3 antibiotics but the p-values were less significant for syntheses of ≥2 antibiotics (p=0.01) and ≥1 antibiotic (p=0.09). Two studies (52, 53) reported antibiotic resistance patterns for different bacteria (Enterobacteriaceae (53) and *Enterococcus spp.* (52)) obtained from the same population of retail packaged chicken. So that the same chickens do not enter the synthesis twice, we included Enterobacteriaceae results in the syntheses (reported above) as Enterobacteriaceae is the family to which *E. coli* and *Salmonella* belong. In sensitivity analysis, we used the *Enterococcus* results, which did not substantially change findings for ≥ 3 antibiotics, but yielded more significant p-values for the remaining analyses (e.g., for ≥1 antibiotic, p<0.001).

^bRisk Difference (RD) is calculated as the risk of contamination in the organic group minus the risk of contamination in the conventional group; thus, a positive (negative) number indicates more (less) contamination in organic. All risk differences are absolute risk differences.

^cAll p-values are adjusted p-values.

Supplement 8. Difference in Risk of Isolating Antibiotic-Resistant Bacteria in Organic vs. Conventional Chicken, Pork, and Raw Milk^a

Antibiotic	Bacteria Tested For	Food	Risk Difference ^b	95%CI		p-value ^c	I ²	No. of Studies ^d	Country
Ampicillin	<i>E. coli</i> , <i>Salmonella</i> , Enterobacteriaceae	Chicken, pork	-34.8%	-56.1%	-13.5%	0.031	90	5	U.S. (51, 181), Spain (50, 53, 201)
Cephalothin	<i>E. coli</i> , <i>Salmonella</i> , Enterobacteriaceae	Chicken, pork	-24.0%	-44.4%	-3.6%	0.48	90	4	U.S. (51), Spain (50, 53, 201)
Chloramphenicol	<i>E. coli</i> , Enterobacteriaceae	Chicken, pork	-1.6% ^e	-7.0%	3.8%	1.00	60	3	Spain (50, 53, 201)
Ciprofloxacin	<i>E. coli</i> , <i>Campylobacter</i> , Enterobacteriaceae	Chicken	-5.8% ^f	-16.7%	5.1%	1.00	87	5	U.S. (51, 146), Spain (50, 53), U.K. (256)
Erythromycin	Enterobacteriaceae, <i>Enterococcus</i> , <i>Listeria</i> , <i>Campylobacter</i>	Chicken	-3.8% ^e	-14.6%	6.9%	1.00	78	5	U.S. (51, 146), Spain (50, 52), U.K. (256)
Nitrofurantoin	<i>E. coli</i>	Chicken, pork	-2.4%	-7.1%	2.3%	1.00	52	3	Spain (50, 53, 201)
Streptomycin	<i>E. coli</i> , <i>Salmonella</i>	Chicken, pork	-3.1%	-24.4%	18.2%	1.00	88	4	U.S. (51), Spain (50, 52, 201)
Sulfisoxazole	<i>E. Coli</i> , Enterobacteriaceae	Chicken, pork	-27.3% ^e	-51.1%	-3.5%	0.53	89	3	Spain (50, 53, 201)
Tetracycline	<i>Salmonella</i> , <i>Campylobacter</i>	Chicken	15.2% ^g	4.4%	26.0%	0.170	0	3	U.S. (51, 146, 181)
Penicillin	<i>Staphylococcus aureus</i>	Raw milk	-1.0%	-7.7%	5.7%	1.00	63	5	U.S. (91, 248, 264), Denmark (248), Norway (130), Switzerland (242)

^aAll summary effect measures reported are results of random effects models. $I^2 > 25$ suggests heterogeneity. No analysis suggested publication bias. Results for cephalothin, erythromycin and nitrofurantoin were robust to removal of 1 study at a time; all other results were sensitive to removal of 1 study at a time. Three or four studies examined resistance to doxycycline and gentamicin though data were sparse (zero cells) so results were not synthesized. Only 1 or 2 studies reported prevalence of resistance for the following antibiotics and hence results for these antibiotics could not be synthesized: amoxicillin/clavulanic acid, cefoxitin, clindamycin, enrofloxacin, fosfomycin, nalidixic acid, oxacillin, trimethoprim/sulfamethoxazole, and vancomycin.

^bRisk Difference (RD) is calculated as the risk of contamination in the organic group minus the risk of contamination in the conventional group; thus, a positive (negative) number indicates more (less) contamination in organic. All risk differences are absolute risk differences.

^cAll p-values are adjusted p-values. The following unadjusted p-values are significant: cephalothin (p=0.021); sulfisoxazole (p=0.024); tetracycline (p=0.006).

^d**Supplement 2** lists the studies included for each statistical analysis.

^eEach study population is only represented once in each analysis. One study (50) examined 3 bacteria (*E. coli*, *Listeria*, and *Staphylococcus aureus*) for the same antibiotics. To avoid entering the same study population twice, we used results for *E. coli*. In sensitivity analysis, we re-ran analyses using results for *Listeria* instead of *E. coli*. The RD and p-value were not substantially different for analyses of chloramphenicol, doxycycline, erythromycin, and gentamicin. For sulfisoxazole the RD changed little, but the p-value was rendered no longer significant.

^fTwo studies (146, 256) had zero events in one arm and we applied a continuity correction of 0.5 so that all studies could be included. In sensitivity analysis, we removed these studies in which 1 arm did not detecting any ciprofloxacin resistant bacteria; results were essentially unchanged (RD -4% [95%CI -25% to 17%], p=1.00, $I^2 = 93$).

[§]One study (51) examined both *Campylobacter spp.* and *Salmonella spp.* for tetracycline resistance. The table reports the results using *Salmonella*. In sensitivity analysis we re-ran analyses using results for *Campylobacter*; conclusions did not change (RD 0.149; 95%CI: 0.055 to 0.243; p=0.06; I²=0).

Supplement 9. Supplemental Information Regarding Statistical Analyses and Outcomes That Could Not be Synthesized

Continuity correction

In an effort to include all eligible studies, a continuity correction was applied for studies with zero events in 1 or more arms. In practice, we applied the continuity correction in 2 analyses: contamination with any pesticide residues (Figure 1); and contamination of chicken/pork with bacteria resistant to ciprofloxacin.

Among the pesticide contamination studies, 2 of the 9 studies had zero events (Figure 1). These were small, single-food studies. Removal of the small studies with zero events did not substantially change results (Figure 1).

Among the contamination of chicken/pork with bacteria resistant to ciprofloxacin, removal of the 2 studies with zero cells (146, 256) did not substantially change results though only 3 studies remained for analysis (RD -4% (95%CI -25% to 17%, $p=0.70$, $I^2=93$ – random effects).

Results were not synthesized if, when the studies with zero events were removed, the resulting number of studies was < 3 . This was the case with pesticide residues exceeding maximum allowed limits (we report a range); contamination of milk with *S. aureus* resistant to erythromycin, oxacillin, and tetracycline; and contamination of chicken and pork with bacteria resistant to doxycycline and gentamicin.

Other nutrients in produce

Too few studies evaluated selenium, manganese, zinc, and vitamins B, D, and K to be synthesized (Appendix Table 2).

Other nutrients in animal products

Only 3 studies (110, 129, 153) evaluated the calcium content of milk: 2 studies (129, 153) reported no difference by farming method; the other (110) reported significantly higher levels of calcium in organically produced milk ($p<0.01$). Two studies evaluated the lutein and zeaxanthin content of milk (93, 255), finding statistically higher levels of both antioxidants in organic than conventional milk. Two studies examined the zinc content of eggs (132) and beef products (216), finding significantly less zinc in organic egg yolks and beef kidney, and significantly more zinc in beef muscle than their conventional counterparts.

Two studies compared protein content of chicken: one found significantly more protein in organic than conventional chicken (160); the other found no difference (192).

Botanical pesticides in produce

Two studies (95, 172) tested for 2 botanical pesticides allowed in organic cultivation: neither pesticide was detectable in organic or conventional produce samples.

Antibiotic resistance of bacteria in produce

Only 1 study examined the prevalence of antibiotic resistance in bacteria in produce, finding no difference between organic and conventional produce (245).

Subgroup analyses of DON and OTA in produce

In subgroup analyses, we found a higher risk of OTA contamination in organically grown rice (84, 133, 166) (RD 35%; 95%CI: 17% to 53%; $p<0.001$; $I^2=22$) but not in wheat (84, 111, 164, 166, 189, 235) compared with conventional alternatives. Seven studies examined DON levels in wheat (135, 150, 224, 235, 243, 249, 270), finding significantly lower levels of DON in organic wheat (SMD -0.94; 95%CI: -1.27 to -0.62; $p<0.001$; $I^2=63$), though one large study, not reporting sufficient detail to be included in summary effect size calculations, found no significant differences in DON concentrations (122).

Other fungal toxin results in milk and meats

Two studies evaluated mycotoxin contamination of milk: one study found significantly higher levels of aflatoxin in organic than conventional milk (131) while another study found no difference in ochratoxin A (OTA) contamination (253). One study found that OTA contamination of porcine serum samples was significantly higher among organic than conventional samples (1.32 $\mu\text{g/kg}$ versus 0.16 $\mu\text{g/kg}$; $p<0.001$) (232).

Two studies evaluated mycotoxin contamination of milk: one study found significantly higher levels of aflatoxin in organic than conventional milk (131) while another study found no difference in OTA contamination (253). One

study found that OTA contamination of porcine serum samples was significantly higher among organic than conventional samples (1.32 µg/kg versus 0.16 µg/kg; $p < 0.001$) (232).