Nutritional quality of organic foods: a systematic review[1–4]

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ABSTRACT

Background: Despite growing consumer demand for organically produced foods, information based on a systematic review of their nutritional quality is lacking.

Objective: We sought to quantitatively assess the differences in reported nutrient content between organically and conventionally produced foodstuffs.

Design: We systematically searched PubMed, Web of Science, and CAB Abstracts for a period of 50 y from 1 January 1958 to 29 February 2008, contacted subject experts, and hand-searched bibliographies. We included peer-reviewed articles with English abstracts in the analysis if they reported nutrient content comparisons between organic and conventional foodstuffs. Two reviewers extracted study characteristics, quality, and data. The analyses were restricted to the most commonly reported nutrients.

Results: From a total of 52,471 articles, we identified 162 studies (137 crops and 25 livestock products); 55 were of satisfactory quality. In an analysis that included only satisfactory quality studies, conventionally produced crops had a significantly higher content of nitrogen, and organically produced crops had a significantly higher content of phosphorus and higher titratable acidity. No evidence of a difference was detected for the remaining 8 of 11 crop nutrient categories analyzed. Analysis of the more limited database on livestock products found no evidence of a difference in nutrient content between organically and conventionally produced livestock products.

Conclusions: On the basis of a systematic review of studies of satisfactory quality, there is no evidence of a difference in nutrient quality between organically and conventionally produced foodstuffs. The small differences in nutrient content detected are biologically plausible and mostly relate to differences in production methods. *Am J Clin Nutr* doi: 10.3945/ajcn.2009.28041.

INTRODUCTION

The demand for organically produced food is increasing. In 2007 the organic food market in the United Kingdom was estimated to be worth >£2 billion, an increase of 22% since 2005 (1), and the global estimate was £29 billion (2). Organic foodstuffs are produced according to specified standards, which, among other factors, control the use of chemicals in crop production and medicines in animal production and emphasize a minimal environmental impact (3, 4). Previous nonsystematic reviews have concluded that organically produced foods have a nutrient composition superior to that of conventional foods (5–7), although this finding has not been consistent (8, 9). To date, there has been no systematic review of the available published literature on this topic.

All natural products vary in their composition of nutrients and other nutritionally relevant substances (10). Different cultivars of the same crop may differ in nutrient composition, which can also vary depending on fertilizer and pesticide regimen, growing conditions, season, and other factors. The nutrient composition of livestock products can similarly be affected by factors such as the age and breed of the animal, feeding regimen, and season. This inherent variability in nutrient content may be further affected during the storage, transportation, and preparation of the foodstuffs before they reach the plate of the consumer. (*See* Supplemental Figure 1 under "Supplemental data" in the online issue.) An understanding of the factors that affect nutrient variability in crops and livestock products is important for the design and interpretation of research on differences in the nutrient content of organically produced and conventionally produced foodstuffs.

Notwithstanding the current uncertainty in the available evidence on the nutrient composition of foods produced under different agricultural regimens, consumers appear willing to pay a higher price for organic foods based on their perceived health and nutrition benefits (11, 12). Establishing the strength of existing evidence relating to the nutrient content of organic food will enable the development of evidence-based statements on content and potential nutrition-related public health gains or risks resulting from its consumption, which will allow consumers to make informed choices.

We present the results of a systematic review of studies that report the chemical analysis of foodstuffs produced under organic or conventional methods. The outcome was restricted to the nutrient and nutritionally relevant content of foodstuffs. We did not address differences in contaminant contents (eg, herbicide,

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[2] The funding organization had no role in the study design, data collection, analysis, interpretation, or writing of the report. The review team held 6 progress meetings with the funding organization.

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pesticide, or fungicide residues) or the possible environmental consequences of organic and conventional agricultural practices because this was beyond the scope of our review.

METHODS

The quality and heterogeneity of the available data meant that we could not undertake a formal meta-analysis of the reported numerical results. We adhered, as much as possible, to the guidelines for the reporting of systematic reviews of observational studies (13).

Search strategy

We developed a search strategy in PubMed (http://www.ncbi.nlm.nih.gov/pubmed/) using Medical Subject Heading [MeSH] and title abstract [tiab] terms. The exposure terms searched (including all MeSH, headings, subheadings, and tiab terms) were "organic," "health food," and "conventional" combined with "food," "agricultural crop," and "livestock," and "agriculture." These terms were combined with terms for nutrients and nutritionally relevant substances from a recent global report on diet, nutrition, and prevention of cancer (14). (*See* Supplemental Table 1 under "Supplemental data" in the online issue.) The databases PubMed, Web of Science (http://isiwebofknowledge.com/products_tools/multidisciplinary/webofscience/), and CAB Abstracts (http://www.cabi.org/cababstracts) were searched for a period of 50 y from 1 January 1958 to 29 February 2008. Titles and available abstracts were scanned for relevance, and articles requiring further consideration were identified. Reference lists of relevant articles were hand-searched to identify additional publications. Subject experts (n = 40) identified from relevant publications were contacted by E-mail; we received 29 responses and were sent 36 publications, 25 of which were either not relevant or had previously been identified.

Selection criteria and data extraction

Studies with an English abstract published in peer-reviewed journals in any language were included if they reported a direct comparison of the composition of nutrients or nutritionally relevant substances in foodstuffs from organic (reported by authors as organic, ecologic, and bioorganic) and conventional (reported by authors as conventional and intensive) farming systems. Studies reporting comparisons of organic with either integrated (n = 10) or biodynamic (n = 1) farming practices were excluded, because these farming practices are specifically not conventional. Studies were also excluded if they were primarily concerned with the impact of different fertilizer regimens (n = 6) or nonnutrient (eg cadmium, lead, and mercury) contaminant content (n = 37) or were authentication studies describing techniques to identify the agricultural production method of the foodstuffs (n = 11). Gray literature (conference abstracts and unpublished studies) was not included.

All searching and data extraction were conducted by 2 research assistants (SKD and AH), and any disagreement resolved in discussion with the project lead (ADD). Data were extracted into separate databases for studies reporting on crops and livestock products. Data from foreign language articles were extracted by native speakers using a standardized template in discussion with the review team. Data extraction was performed in duplicate for the first 10 included articles, and inconsistencies were noted and corrected. For the remaining articles, one reviewer entered the data and the other checked all entries; any differences were discussed and a consensus was reached.

Study designs

Studies investigating the nutrient content of organically and conventionally produced foods were based on 3 distinct study designs: field trials, which compare samples originating from organic and conventional agricultural methods on adjacent parcels of land (fields); farm surveys, which compare samples originating from organic and conventional farms that may be matched for selected variables; and basket studies, which compare samples of organically and conventionally produced food as available to the consumer from retail outlets.

Study quality

The quality of research and reporting in this area is extremely variable. Each study included in the review was graded for quality based on 5 criteria addressing key components of study design: a clear definition of the organic production methods, including the name of the organic certification body; specification of the cultivar of crop or breed of livestock; a statement of which nutrient or other nutritionally relevant substance was analyzed; a description of the laboratory analytic methods used; and a statement of the methods used for statistical analyses. Studies were defined as being of satisfactory quality if they met all 5 criteria. We did not grade further the quality of organic certifying bodies or analytic methods used.

Quantitative data synthesis

To assess the totality of evidence, all study designs and all foodstuffs (agricultural produce, livestock products, foods, and drinks) were included in the analysis. The articles reported a chemical analysis on 100 distinct foodstuffs and presented data on 455 nutrients and nutritionally relevant substances, which we grouped into 98 nutrient categories to facilitate the analysis. (*See* Supplemental Tables 2 and 3 under "Supplemental data" in the online issue.) There was an insufficient number of studies on comparable foodstuffs to permit direct analysis by foodstuff; therefore, the analysis was conducted by nutrient category across all study designs. Given the large number of possible nutrients that could be analyzed, an a priori pragmatic decision was made to conduct statistical comparisons on nutrient categories reported in $\geq$10 studies on crops and $\geq$4 studies on livestock products for which there were considerably fewer studies.

A small number of included studies reported some (n = 5) or all (n = 1) relevant data only in graphic format; only numerical data were extracted for use in the analysis. All remaining studies presented levels of nutrients as mean values. When the results consisted of more than one mean (eg, by month of harvest), the mean of the means was calculated. Most of the studies contained no information on sample size or variability around central estimates. The analysis presented is therefore a pragmatic choice that permitted the available data to be used to its fullest extent.

We calculated the standardized percentage difference in the reported mean nutrient content, as follows:

$$[(\text{Content of nutrient in organically produced foodstuff} - \text{content of nutrient in conventionally produced foodstuff}) / \text{content of nutrient in conventionally produced foodstuff}] \times 100 \quad (1)$$

Positive differences suggested that there might be more of particular nutrients in organically produced foodstuffs, whereas negative differences suggested that there might be more of particular nutrients in conventionally produced foodstuffs. Given the intrinsic differences in the design of studies included in the analyses, the percentage differences are not translatable into specific nutrient differences. We used *t* tests with robust SEs (to account for clustering caused by multiple nutrient comparisons within studies) and a significance level of 5% to interpret the results. Extreme values thought to be unlikely (n = 3) and defined as values for which the absolute difference from the next largest value was ≥1 SD were excluded from the analyses. The analyses were conducted by using STATA version 10 (2007, *Stata Statistical Software: release 10*; StataCorp LP, College Station, TX).

External review

An independent expert review panel was constituted to oversee and advise on the conduct of the review. The panel comprised a subject expert (Julie Lovegrove, University of Reading, United Kingdom) and an expert in public health nutrition with systematic review experience (Martin Wiseman, University of Southampton, United Kingdom, and World Cancer Research Fund International, United Kingdom). The expert independent review panel provided feedback on the review protocol, which was incorporated into the final protocol posted online on 18 April 2008 at http://www.lshtm.ac.uk/nphiru/research/organic/. Relevant subject experts and external bodies were informed about the availability of the review protocol. Comments from the expert panel were incorporated into the final report, which was also sent by the funder for external peer review by 5 subject experts. Relevant peer review comments were incorporated into this report.

RESULTS

Overview of studies identified

Of the 52,471 articles included in the search, 292 with potentially relevant titles were identified. Full copies of 281 of these articles were obtained, and, after scrutiny, 145 (52%) were excluded. Full copies of the remaining 11 articles [6 (2%) potentially eligible and 5 (2%) of unknown peer review status] were unobtainable despite numerous attempts. (*See* Supplemental Table 4 under "Supplemental data" in the online issue.) An additional 15 relevant articles were identified through a hand-search and 11 through direct author contact, which resulted in a final list of 162 articles that were assessed for study quality (**Figure 1**).

Quality of the studies

More than one-half of the studies identified (n = 87; 54%) failed to specify the organic certifying body [in 12 cases (7.5%) for which no certifying body was specified, we inferred a body from the Methods section of the report], 20% of the studies (n = 33) failed to state the plant cultivar or livestock breed, all studies stated the nutrients analyzed, 1% of studies (n = 2) failed to state laboratory methods, and 14% of studies (n = 22) failed to state statistical methods (*see* Supplemental Table 5 under "Supplemental data" in the online issue). One-third (n = 55; 34%) of the studies identified were of satisfactory quality (*see* Supplemental Table 6 under "Supplemental data" in the online issue), consisting of 46 reports (20 field trials, 22 farm surveys, and 4 basket surveys) on the composition of crops (*see* Supplemental Table 7 under "Supplemental data" in the online issue) and 9 reports (4 field trials and 5 farm surveys) on the composition of livestock products (*see* Supplemental Table 8 under "Supplemental data" in the online issue).

Comparison of content of nutrients and other substances

We extracted 1149 nutrient content comparisons from 46 satisfactory quality-crop studies, and data on 11 nutrient categories were reported in ≥10 studies. Analysis of satisfactory quality-crop studies found no evidence of a difference in 8 of the 11 nutrient categories (vitamin C, phenolic compounds, magnesium, potassium, calcium, zinc, copper, and total soluble solids) (**Table 1**). Nitrogen contents were significantly higher in conventionally produced crops, and contents of phosphorus and titratable acidity were significantly higher in organically produced crops. We extracted 125 nutrient comparisons from 9 satisfactory quality-livestock-product studies, and data on only 2 nutrient categories were reported in ≥4 studies. Analysis of the very limited database found no evidence of a difference between production method in either fats (unspecified) or ash (**Table 2**).

DISCUSSION

This report presents the results of the first published systematic review investigating differences in nutrient content of organically and conventionally produced foodstuffs. The review includes peer-reviewed publications published with an English abstract over the past 50 y. The organic movement has a long history (15), and the large proportion of articles identified in this review published after 2000 highlights the high level of current scientific interest.

The analysis presented suggests that organically and conventionally produced foods are comparable in their nutrient content. For 10 of 13 nutrient categories analyzed, there were no significant differences between production methods. Differences that were detected in crops were biologically plausible and were most likely due to differences in fertilizer use (nitrogen and phosphorus) (3) and ripeness at harvest (titratable acidity) (16). It is unlikely that consumption of these nutrients at the levels reported in organic foods in this study provide any health benefit. An important corollary is that organically produced foods are not inferior to conventionally produced foods with respect to their nutrient content.

Unlike all previous reviews that were nonsystematic, we conducted a rigorous literature search and identified a large

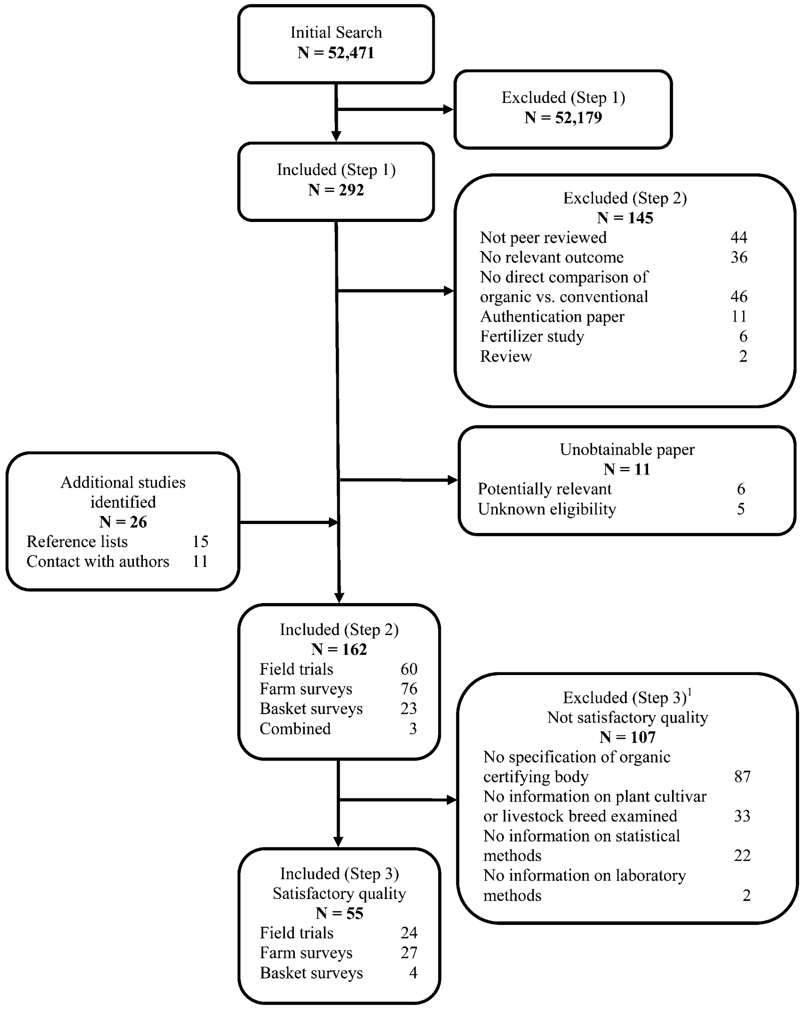

FIGURE 1. Study selection process for systematic review of the nutrient content of organic foodstuffs. [1]Reasons for exclusion at step 3 were not mutually exclusive.

number of studies conducted over the past 50 y. Our systematic approach, which focused on studies of satisfactory quality, agrees with some (higher contents of phosphorus in organic foods) but not all (higher contents of vitamin C and magnesium in organic foods) findings from previous reviews (5, 7, 9).

Results of analyses on >450 different nutrients or nutritionally relevant substances were identified in our review, and, whereas many articles appeared to have focused objectives guiding the analysis conducted and presented, others reported information on a considerable number of disparate substances. Given the large number of nutrients reported, we decided to group them into distinct nutrient categories for further analysis. We provided the totality of the data extracted from all satisfactory quality studies as a future resource for nutrition and agricultural researchers. (*See* Supplemental Tables 7 and 8 under "Supplemental data" in the online issue.)

Our review again highlighted the heterogeneity and generally poor quality of research in this area (11). The criteria we used to assess publication quality were identified as key methodologic components of study design, specifically relating to exposure (certification of organic production and definition of foodstuff) and outcome (statements on laboratory and statistical analysis methods). We attempted no further gradings within each quality criterion; eg, organic certifying bodies have differing production regulations, and laboratory methods have different sensitivities (17). Despite the relatively low threshold used in this review to define satisfactory quality studies, a disappointingly low number of studies was graded as being of satisfactory quality. We urge researchers investigating nutritional characteristics of organic food to improve the scientific quality of their work and propose our 5 criteria as the bare minimum when reporting studies. To enable assessment of the nutritional quality of the foodstuffs in relation to their growing environment and mode of production, well-controlled long-term field trials, which provide explicit and detailed information on production methods, would be particularly valuable. An additional analysis including all 162 studies identified, irrespective of quality, similarly concluded that there was no evidence of important differences in nutrient content between organically and conventionally produced foodstuffs (data not shown).

This review had several strengths, such as its systematic and exhaustive nature, its broad inclusion criteria, and its methodologic rigor. However, because of the limitations of the extracted data, no formal meta-analysis was possible. To make best use of the available data, we elected to combine results from different study designs and calculated standardized differences across foods by

TABLE 1
Comparison of content of nutrients and other nutritionally relevant substances in organically and conventionally produced crops as reported in satisfactory quality studies

Nutrient category[1]	No. of studies	No. of comparisons	Results of analysis: Standardized difference[2]	Results of analysis: P	Higher levels in organic or conventional crops?
			%		
Nitrogen	17	64	6.7 ± 1.9	0.003	Conventional
Vitamin C	14	65	2.7 ± 5.9	0.84	No difference
Phenolic compounds	13	80	3.4 ± 6.1	0.60	No difference
Magnesium	13	35	4.2 ± 2.3	0.10	No difference
Calcium	13	37	3.7 ± 4.8	0.45	No difference
Phosphorus	12	35	8.1 ± 2.6	0.009	Organic
Potassium	12	34	2.7 ± 2.4	0.28	No difference
Zinc	11	30	10.1 ± 5.6	0.11	No difference
Total soluble solids	11	29	0.4 ± 4.0	0.92	No difference
Copper	11	30	8.6 ± 11.5	0.47	No difference
Titratable acidity	10	29	6.8 ± 2.1	0.01	Organic

[1] Nutrient categories are listed by numeric order of the included studies.
[2] All values are means ± SEs (robust).

nutrient category. This will have resulted in the loss of the more nuanced findings from individual studies on specific foods but was chosen to be the most effective method for including and reporting all available data in a standardized form.

This review also had some limitations, which relate more specifically to the review process. We excluded gray literature and foreign language publications without English abstracts, and we were unable to locate a small number (n = 11) of potentially relevant publications, which may have resulted in us not including some relevant data in the review. Reporting bias, which occurs when authors do not report all analyses conducted in their research, and publication bias, which occurs when journal editors favor the publication of statistically significant findings are also potential limitations of systematic reviews (18). We are aware of 2 studies (19, 20) published after the review cutoff date.

All natural products vary in their composition of nutrients and other nutritional relevant substances for a wide variety of reasons (10), including production method. Production methods, especially those that regulate the use of chemical fertilizer, herbicides, and pesticides may also affect the chemical content of foodstuffs. Certified organic regimens specify the production of foodstuffs with the strictly controlled use of chemicals and medicines. The potential for any benefits to public and environmental health of these actions would certainly warrant further systematic review, but was beyond the scope of the current report.

The current analysis suggests that a small number of differences in nutrient content exist between organically and conventionally produced foodstuffs and that, whereas these differences in content are biologically plausible, they are unlikely to be of public health relevance. One broad conclusion to draw from this review is that there is no evidence to support the selection of organically produced foodstuffs over conventionally produced foodstuffs to increase the intake of specific nutrients or nutritionally relevant substances. It is also clear that research in this area would benefit considerably from greater scientific rigor and a better understanding of the various factors (apart from production regimen) that determine the nutrient content of foodstuffs.

We gratefully acknowledge technical support from Andrea Aikenhead. The funding organization had no role in study design, data collection, analysis, interpretation, or writing of the report. The review team held 6 progress meetings with the funding organization. The corresponding author had full access to all data and had final responsibility for the decision to submit for publication.

The authors' responsibilities were as follows—ADD, EA, KL, and RU: participated in the design of the study; ADD: managed the study, had full access to all of the data, and had final responsibility for the decision to submit for publication; EA: conducted the statistical analysis; and SKD and AH: conducted the literature search and data extraction. All authors contributed to the first and subsequent drafts of the report and approved the submitted version. All authors stated that they had no conflicts of interest to declare.

TABLE 2
Comparison of content of nutrients and other nutritionally relevant substances in organically and conventionally produced livestock products as reported in satisfactory quality studies

Nutrient category[1]	No. of studies	No. of comparisons	Results of analysis: Standardized difference[2]	Results of analysis: P	Higher levels in organic or conventional livestock products?
			%		
Fats (unspecified)	6	13	13.0 ± 14.6	0.42	No difference
Ash	4	8	13.7 ± 7.8	0.18	No difference

[1] Nutrient categories are listed by numeric order of the included studies.
[2] All values are means ± SEs (robust).

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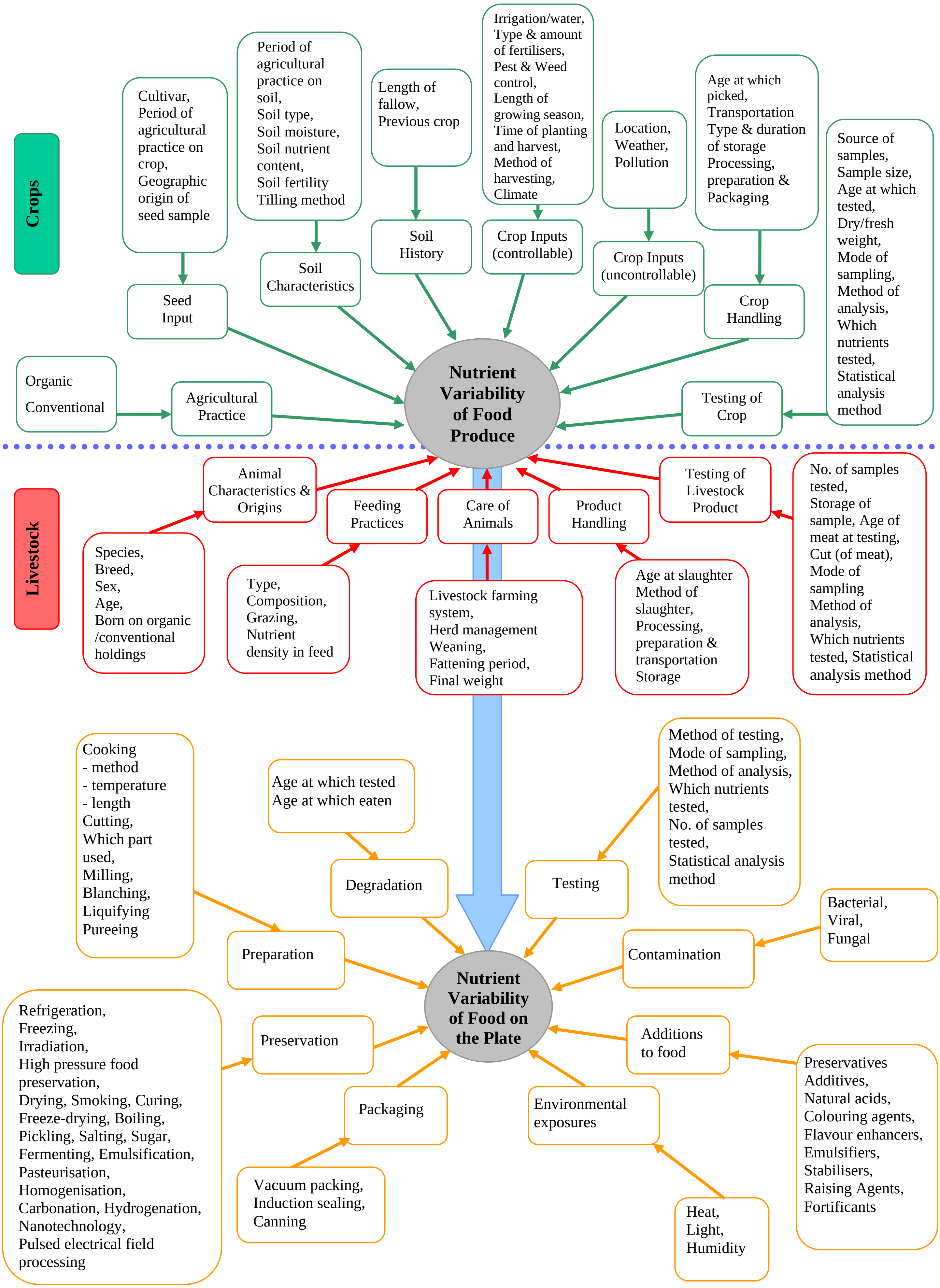

Crops
Cultivar, Period of agricultural practice on crop, Geographic origin of seed sample
Period of agricultural practice on soil, Soil type, Soil moisture, Soil nutrient content, Soil fertility Tilling method
Length of fallow, Previous crop
Irrigation/water, Type & amount of fertilisers, Pest & Weed control, Length of growing season, Time of planting and harvest, Method of harvesting, Climate
Location, Weather, Pollution
Age at which picked, Transportation Type & duration of storage Processing, preparation & Packaging
Source of samples, Sample size, Age at which tested, Dry/fresh weight, Mode of sampling, Method of analysis, Which nutrients tested, Statistical analysis method
Seed Input
Soil Characteristics
Soil History
Crop Inputs (controllable)
Crop Inputs (uncontrollable)
Crop Handling
Organic
Conventional
Agricultural Practice
Nutrient Variability of Food Produce
Testing of Crop
Livestock
Animal Characteristics & Origins
Feeding Practices
Care of Animals
Product Handling
Testing of Livestock Product
Species, Breed, Sex, Age, Born on organic /conventional holdings
Type, Composition, Grazing, Nutrient density in feed
Livestock farming system, Herd management Weaning, Fattening period, Final weight
Age at slaughter Method of slaughter, Processing, preparation & transportation Storage
No. of samples tested, Storage of sample, Age of meat at testing, Cut (of meat), Mode of sampling Method of analysis, Which nutrients tested, Statistical analysis method
Cooking - method - temperature - length Cutting, Which part used, Milling, Blanching, Liquifying Pureeing
Age at which tested Age at which eaten
Method of testing, Mode of sampling, Method of analysis, Which nutrients tested, No. of samples tested, Statistical analysis method
Degradation
Testing
Bacterial, Viral, Fungal
Preparation
Contamination
Nutrient Variability of Food on the Plate
Refrigeration, Freezing, Irradiation, High pressure food preservation, Drying, Smoking, Curing, Freeze-drying, Boiling, Pickling, Salting, Sugar, Fermenting, Emulsification, Pasteurisation, Homogenisation, Carbonation, Hydrogenation, Nanotechnology, Pulsed electrical field processing
Preservation
Additions to food
Packaging
Environmental exposures
Preservatives Additives, Natural acids, Colouring agents, Flavour enhancers, Emulsifiers, Stabilisers, Raising Agents, Fortificants
Vacuum packing, Induction sealing, Canning
Heat, Light, Humidity

Web Table 1: Search terms for systematic review on nutritional quality of organic foods

Modified terms for the search strategy for epidemiological literature as specified in the manual (World Cancer Research Fund / American Institute for Cancer Research 2003):

#1 diet therapy[MeSH Terms] OR nutrition[MeSH Terms]

#2 diet[tiab] OR diets[tiab] OR dietetic[tiab] OR dietary[tiab] OR eating[tiab] OR intake[tiab] OR nutrient*[tiab] OR nutrition[tiab] OR vegetarian*[tiab] OR vegan*[tiab] OR "seventh day adventist"[tiab] OR macrobiotic[tiab] OR breastfeed*[tiab] OR breast feed*[tiab] OR breastfed[tiab] OR breast fed[tiab] OR breastmilk[tiab] OR breast milk[tiab]

#3 food and beverages[MeSH Terms]

#4 food*[tiab] OR cereal*[tiab] OR grain*[tiab] OR granary[tiab] OR wholegrain[tiab] OR wholewheat[tiab] OR roots[tiab] OR plantain*[tiab] OR tuber[tiab] OR tubers[tiab] OR vegetable*[tiab] OR fruit*[tiab] OR pulses[tiab] OR beans[tiab] OR lentils[tiab] OR chickpeas[tiab] OR legume*[tiab] OR soy[tiab] OR soya[tiab] OR nut[tiab] OR nuts[tiab] OR peanut*[tiab] OR groundnut*[tiab] OR seeds[tiab] OR meat[tiab] OR beef[tiab] OR pork[tiab] OR lamb[tiab] OR poultry[tiab] OR chicken[tiab] OR turkey[tiab] OR duck[tiab] OR fish[tiab] OR fat[tiab] OR fats[tiab] OR fatty[tiab] OR egg[tiab] OR eggs[tiab] OR bread[tiab] OR oils[tiab] OR shellfish[tiab] OR seafood[tiab] OR sugar[tiab] OR syrup[tiab] OR dairy[tiab] OR milk[tiab] OR herbs[tiab] OR spices[tiab] OR chilli[tiab] OR chillis[tiab] OR pepper*[tiab] OR condiments[tiab]

#5 fluid intake[tiab] OR water[tiab] OR drinks[tiab] OR drinking[tiab] OR tea[tiab] OR coffee[tiab] OR caffeine[tiab] OR juice[tiab] OR beer[tiab] OR spirits[tiab] OR liquor[tiab] OR wine[tiab] OR alcohol[tiab] OR alcoholic[tiab] OR beverage*[tiab] OR ethanol[tiab] OR yerba mate[tiab] OR ilex paraguariensis[tiab]

#6 fertilizers[MeSH Terms] OR fertiliser*[tiab] OR fertilizer*[tiab]

#7 food preservation[MeSH Terms] OR pickled[tiab] OR bottled[tiab] OR bottling[tiab] OR canned[tiab] OR canning[tiab] OR vacuum pack*[tiab] OR refrigerate*[tiab] OR refrigeration[tiab] OR cured[tiab] OR smoked[tiab] OR preserved[tiab] OR preservatives[tiab] OR nitrosamine[tiab] OR hydrogenation[tiab] OR fortified[tiab] OR additive*[tiab] OR colouring*[tiab] OR coloring*[tiab] OR flavouring*[tiab] OR flavoring*[tiab] OR nitrates[tiab] OR nitrites[tiab] OR solvent[tiab] OR solvents[tiab] OR ferment*[tiab] OR processed[tiab] OR antioxidant*[tiab] OR genetic modif*[tiab] OR genetically modif*[tiab] OR vinyl chloride[tiab] OR packaging[tiab] OR labelling[tiab] OR phthalates[tiab]

#8 cookery[MeSH Terms]

#9 cooking[tiab] OR cooked[tiab] OR grill[tiab] OR grilled[tiab] OR fried[tiab] OR fry[tiab] OR roast[tiab] OR bake[tiab] OR baked[tiab] OR stewing[tiab] OR stewed[tiab] OR casserol*[tiab] OR broil[tiab] OR broiled[tiab] OR boiled[tiab] OR microwave[tiab] OR microwaved[tiab] OR re-heating[tiab] OR reheating[tiab] OR heating[tiab] OR re-heated[tiab] OR heated[tiab] OR poach[tiab] OR poached[tiab] OR steamed[tiab] OR barbecue*[tiab] OR chargrill*[tiab] OR heterocyclic amines[tiab] OR polycyclic aromatic hydrocarbons[tiab]

#10 dietary carbohydrates[MeSH Terms] OR dietary proteins[MeSH Terms] OR sweetening agents[MeSH Terms]

#11 salt[tiab] OR salting[tiab] OR salted[tiab] OR fiber[tiab] OR fibre[tiab] OR polysaccharide*[tiab] OR starch[tiab] OR starchy[tiab] OR carbohydrate*[tiab] OR lipid*[tiab] OR linoleic acid*[tiab] OR sterols[tiab] OR stanols[tiab] OR sugar*[tiab] OR sweetener*[tiab] OR saccharin*[tiab] OR aspartame[tiab] OR acesulfame[tiab] OR cyclamates[tiab] OR maltose[tiab] OR mannitol[tiab] OR sorbitol[tiab] OR sucrose[tiab] OR xylitol[tiab] OR cholesterol[tiab] OR protein[tiab] OR proteins[tiab] OR hydrogenated dietary oils[tiab] OR hydrogenated lard[tiab] OR hydrogenated oils[tiab]

#12 vitamins[MeSH Terms]

#13 supplements[tiab] OR supplement[tiab] OR vitamin*[tiab] OR retinol[tiab] OR carotenoid*[tiab] OR tocopherol[tiab] OR folate*[tiab] OR folic acid[tiab] OR methionine[tiab] OR riboflavin[tiab] OR thiamine[tiab] OR niacin[tiab] OR pyridoxine[tiab] OR cobalamin[tiab] OR mineral*[tiab] OR sodium[tiab] OR iron[tiab] OR calcium[tiab] OR selenium[tiab] OR iodine[tiab] OR magnesium[tiab] OR potassium[tiab] OR zinc[tiab] OR copper[tiab] OR phosphorus[tiab] OR manganese[tiab] OR chromium[tiab] OR phytochemical[tiab] OR allium[tiab] OR isothiocyanate*[tiab] OR glucosinolate*[tiab] OR indoles[tiab] OR polyphenol*[tiab] OR phytoestrogen*[tiab] OR genistein[tiab] OR saponin*[tiab] OR coumarin*[tiab]

#14 #1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13

KEY:

[tiab]	searches the title and abstract fields only
[MeSH Terms]	searches the Medical Subject Headings field only
	NB - explosion of MeSH terms is automatic
*	truncation symbol - searches all words with this combination of letters at the beginning

World Cancer Research Fund / American Institute for Cancer Research (2003). Second expert report. Food, nutrition, physical activity and the prevention of cancer:a global perspective. Systematic literature review specification manual (version 10). Washington DC, AICR.

Web Table 2: Nutrient category groupings based on reported nutrients and other nutritionally relevant substances in studies on composition of crops

Nutrient Grouping	Nutrient Category	Nutrients as Reported by Authors
Macronutrients	Alcohols	Alcohols, aldehydes
	Amino acids	Total amino acids, total essential amino acids, alanine, β-alanine, arginine, asparagine, aspartate, aspartic acid, cysteine, cystine, glutamate, glutamine, glutamic acid, glycine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, proline, serine, threonine, tryptophan, tyrosine, valine, allicin
	Carbohydrates	Carbohydrates, total carbohydrate, starch, pectin, hemicellulose, cellulose, starch index, total arabinoxylans, soluble arabinoxylans
	Cholesterol	Cholesterol
	Fats (unspecified)	Lipids, fats
	Fatty acids (unspecified)	Fatty acids, C18:3
	Monounsaturated fatty acids (cis)	C14:1, C16:1, C16:1 (n-7), C18:1, C18:1 (n-9), C20:1, C22:1, C24:1, monounsaturated fatty acids
	n-3 polyunsaturated fatty acids	C18:3 (n-3), C20:3 (n-3), C22:6 (n-3), n-3 fatty acids
	n-6 polyunsaturated fatty acids	C18:2 (n-6), C20:2 (n-6), C20:3 (n-6), C:20:4 (n-6), n-6 fatty acids
	Nitrogen	Crude protein, protein, nitrogen, total nitrogen, protein nitrogen, true protein
	Plant non-digestible carbohydrates	Fibre, dietary fibre, total fibre, total non-starch polysaccharides, insoluble fibre, soluble fibre, crude fibre, soluble dietary fibre, insoluble dietary fibre
	Polyalcohols	Glycerate, myo inolsitol, mannitol, sorbitol
	Polyunsaturated fatty acids	Polyunsaturated fatty acids
	Proteins (unspecified)	Proteins
	Ratio of n-3/n-6 fatty acids	Ratio of n-3/n-6 fatty acids
	Saturated fatty acids	C12:0, C14:0, C16:0, C18:0, C20:0, C22:0, C24:0, saturated fatty acids
	Specific proteins	Wholemeal protein, protein, total protein, wet gluten, glutelins, prolamins, albumins + globulins, residual albumins + globulins, low molecular weight & gliadins, gluten, globulins, albumins, glutenins - high molecular weight, glutenins - low molecular weight, Kolbach index

Nutrient Grouping	Nutrient Category	Nutrients as Reported by Authors
Macronutrients	Sugars	Sugars, total sugars, reducing sugars, fructose, glucose, maltose, sucrose, amylose, β-glucan, saccharose, fructan
	Triglycerides	Oleate, linoleate, palmitate
Minerals	Aluminium	Aluminium
	Boron	Boron
	Calcium	Calcium
	Carbon	Carbon
	Chloride	Chloride
	Chlorine	Chlorine
	Chromium	Chromium
	Cobalt	Cobalt
	Copper	Copper
	Iodine	Iodine
	Iron	Iron
	Lithium	Lithium
	Magnesium	Magnesium
	Manganese	Manganese
	Minerals	Total minerals
	Molybdenum	Molybdenum
	Nickel	Nickel
	Potassium	Potassium
	Phosphorus	Phosphorus

Nutrient Grouping	Nutrient Category	Nutrients as Reported by Authors
Minerals	Rubidium	Rubidium
	Selenium	Selenium
	Silicon	Silicon
	Sodium	Sodium
	Strontium	Strontium
	Sulphate	Sulphate
	Sulphur	Sulphur
	Vanadium	Vanadium
	Zinc	Zinc
Vitamins	Carotenes	Carotenes
	Carotenoids	Total carotenoids, α-carotene, capsanthin, cis-capsanthin, capsorubin, lutein, violaxanthin, zeaxanthin, β-cryptoxanthin,
	Lycopenes	Lycopenes, 15-cis-lycopene, 13-cis-lycopene, 9-cis-lycopene, all-trans- + 5-cis-lycopene
	Niacin	Niacin
	Pantothenic acid	Pantothenic acid
	Pyridoxine	Pyridoxine, pyridoxol
	Riboflavin	Riboflavin
	Thiamin	Thiamin
	Tocopherols	γ-tocopherol, total vitamin E
	Vitamin C	Vitamin C, ascorbic acid, dehydroascorbic acid, total vitamin C, ascorbate, dehydroascorbate
	Vitamin E	α-tocopherol, vitamin E
	Vitamin K1	Vitamin K1

Nutrient Grouping	Nutrient Category	Nutrients as Reported by Authors
Vitamins	β-carotene	β-carotene, 13-cis-β-carotene, All-trans-β-carotene, β-carotene equivalents
Other	Antioxidant activity	Antioxidant activity, total antioxidant activity, hydrophilic antioxidant activity, antioxidant capacity, relative antioxidant activity, total radical scavenging ability, lipophilic antioxidant activity
	Ash	Ash
	Dry matter	Dry matter
	Ethylene	Internal ethylene
	Flavonoids	Flavonoids, total flavanoids, flavonols, total flavanols, anthocyanins, total anthocyanins, total anthocyans, non-anthocyan flavonoids, naringenin, rutin, luteolin, quercetin, (+) catechin, cyanidin, delphynidin, (-) epicatechin, malvidin, peonidin, procyanidins B1, procyanidins B2, procyanidins B3, procyanidins B4, phloridzin, quercetin-3-rhamnozide, apigenin, luteolin-7-O-glucoside, hesperidin, myricetin, quercitrin, quercitin, hesperitin, baicalein, delfinidin 3-O-glucose, delfinidin 3-O-rutinoside, cyanidin 3-O-glucose, cyanidin 3-O-rutinoside, myricetin glucoside, myricetin rutinoside, myricetin malonylglucoside, aureusidin glucoside, quercetin glucoside, quercetin rutinoside, quercetin malonylglucoside, kaempferol, kaempferol glucoside, kaempferol rutinoside, kaempferol-3-O-glucoside, isorhamnetin rutinoside, desmethylxanthohumol, xanthohumol
	Glucosinolates	Total glucosinolates, sulforaphane, indole glucosinolates, alphatic glucosinolates, glucoraphanin, glucoberin, progoitrin, sinigrin, gluconapin, 4-OH-glucobrassicin, glucoerucin, glucobrassicin, 4-OCH3-glucobrassicin, neo-glucobrassicin
	Glycoalkaloids	Glycoalkaloids, total glycoalkaloids, solanidine
	Nitrates	Nitrate, nitrates, nitrate ions
	Nitrites	Nitrite, nitrites, nitrite ions
	Nitrogen-free extracts	Nitrogen-free extracts
	Organic acids	Total organic acids, aconitic acid, citric acid, fumaric acid, malic acid, oxalic acid, soluble oxalic acid, pyruvic acid, quinic acid, shikimic acid, hydroxygluterate
	Peroxide number	Peroxide number

Nutrient Grouping	Nutrient Category	Nutrients as Reported by Authors
Other	Phenolic compounds	Total phenolics, salicylic acid, total polyphenols, chlorogenic acid, polyphenols, gallic acid, p-coumaric acid, ellagic acid, polyphenol – naringin, polyphenol – bergamottin, polyphenol – bergaptol, phenolic acids, p-hydroxybenzoic acid, vanillic acid, syringic acid, 2,3-dihydroxybenzoic acid, ferulic acid, o-Diphenols, total phenols, protocatechuic acid, total phenolic compounds, total cinnamon acids, caffeic acid, sinapic acid, hydroxycinnamic acid, secoiridoid derivative: 3,4-DHPEA-EDA, 3-caffeolylquinic acid, p-coumaric acid derivative, caffeoylglucose, coumaric acid glucoisde, 3-p-coumaroyl-quinic acid, p-coumaroylglucose, ferulic acid glucoside, feruoylglucose, sinapic acid glucose derivative, hydroxycinnamic acid derviavtive a, hydroxycinnamic acid derviavtive b, soluble phenols, hydroxycinnamates, avenanthramide, truxinic acid sucrose ester, hydroxycinnamic acid f, hydroxycinnamic acid c, hydroxycinnamic acid p, avenanthramides 2f, avenanthramides 2p, avenanthramides 2c, trans-p-cumarico, neo-chlorogenic acid, catechol
	Phosphorus derivatives	Phytate-phosphorus, phytic acid
	Phosphate	Phosphate
	Phytoalexin	Resveratrol, trans-resveratrol glucoside
	Phytostanols	Campestanol
	Phytosterols	Total sterols, avenasterol, campesterol, clerosterol, β-sitosterol, stigmastadienol, stigmasterol, stigmastenol
	Titratable acidity	Titratable acidity, free acidity
	Total flavanols & phenols	Total flavanols & phenols
	Total soluble solids	Soluble solids (°Brix), total soluble solids, ripened soluble solids
	Volatile compounds	Volatile compounds, total volatile compounds
	Volatile esters	Esters
	α-acids	α-acids
	β-acids	β-acids

Web Table 3: Nutrient category groupings based on reported nutrients and other butritionally relevant substances in studies on composition of livestock products

Nutrient Grouping	Nutrient category	Nutrients as reported by authors
Macronutrients		
	Amino acids	Glutathione, isoleucine, glycine, proline, glutamic acid, serine, threonine, alanine, cystine, methionine, leucine, tyrosine, phenylalanine, lysine, histidine, arginine, valine, aspartic acid
	Carbohydrates	Residual glycogen
	Cholesterol	Cholesterol
	Fats (unspecified)	Total fat, fat, lipids, total lipids
	Fatty acids (unspecified)	Total fatty acids, branched fatty acids, linolenic acid, other fatty acids, C18:3
	Monounsaturated fatty acids (cis)	Monounsaturated fatty acids, C18:1 cis-9, C18:1 cis-11, C16:1 cis, C18:1, C16:1, C14:1 (n-5), C16:1 (n-7), C18:1 (n-9), C17:1 (n-8), C18:1 (n-3), C18:1 (n-7), C16:1 (n-9), C20:1, C14:1
	Nitrogen	Protein, caesin nitrogen, non-protein nitrogen, whey protein, crude protein
	n-3 polyunsaturated fatty acids	n-3 fatty acids (EPA), n-3 fatty acids (DHA), n-3 fatty acids, C18:3 (n-3), C20:5 (n-3), C22:5 (n-3), C22:6 (n-3)
	n-6 polyunsaturated fatty acids	n-6 fatty acids, C20:3 (n-6), C20:4 (n-6), C22:4 (n-6), C18:2 (n-6), linoleic acid, C22:5 (n-6), C20:2 (n-6), C18:3 (n-6), C18:2
	n-6/n-3 fatty acid ratio	n-6/n-3 fatty acid ratio
	Polyunsaturated fatty acids	Polyunsaturated fatty acids
	Proteins (unspecified)	Protein, total protein
	Ratio of fatty acids	C18:2/18:3, PUFA:SFA, ratio linoleic/linolenic, ratio PUFA/SFA, ratio MUFA/SFA
	Saturated fatty acids	Saturated fatty acids, C12:0, C18:0, C16:0, C14:0, C15:0, C17:0, C22:0, C4:0, C6:0, C8:0, C10:0, C20:0
	Specific proteins	True protein
	Sugars	Lactose

Nutrient Grouping	Nutrient category	Nutrients as reported by authors
Macronutrients		
	Trans fatty acids	C18:2 cis 9, trans-11, C18:1 trans, conjugated linoleic acid, TVA, CLA/LA, C18:1 t11, C16:1 t7, elaidic acid (C18:1 t9), C18:2 c9, t11 + C18:2 t9, c11, C18:1 c14+t16, C18:2 t9, 12 + C18:1 c16, C16:1 t9, myristelaidic acid (C14:1 t9), C18:2 t9, c12, C18:2 c9, t12, C18:1n-9trans
Minerals	Calcium	Calcium
	Copper	Copper
	Iron	Iron, haem iron
	Magnesium	Magnesium
	Manganese	Manganese
	Molybdenum	Molybdenum
	Niobium	Niobium
	Phosphorous	Phosphorous
	Potassium	Potassium
	Rhodium	Rhodium
	Sodium	Sodium
	Sulphur	Sulphur
	Zinc	Zinc
Vitamins	Riboflavin	Vitamin B2
	Thiamin	Vitamin B1
	Vitamin A	Vitamin A, retinol
	Vitamin C	Vitamin C
	α-tocopherol	α-tocopherol
	β-carotene	β-carotene
Other	Ammonia	Ammonia
	Antioxidant activity	Glutathione reducatase, Glutathione peroxidase, catalase activity
	Ash	Ash
	Dry matter	Dry matter, total solids
	Iodine	Iodine
	Lipid oxidation	Thiobarbituric acid-reactive substance, lipid oxidation (TBARS)

Nutrient Grouping	Nutrient category	Nutrients as reported by authors
Other	Nitrates	Nitrates
	Nitrites	Nitrites
	Phytoestrogens	Genistein, equol, formononetin, biochanin A, 0-demthylangolensin, daidzein
	Urea	Urea

Web Table 4: Excluded (n=145) and unobtainable (n=11) studies

Author	Year	Reason for Exclusion
Camin	2007	Authentication paper
Georgi	2005	Authentication paper
Molkentin	2007a	Authentication paper
Molkentin	2007b	Authentication paper
Ostermeyer	2004	Authentication paper
Pla	2007	Authentication paper
Rapisarda	2005	Authentication paper
Bahar	2008	Authentication paper (comparing isotopes)
Botrini	2004	Authentication paper (comparing fertilisers)
Bateman	2007	Authentication paper (uses N isotopes to discriminate organic vs conventional)
Schmidt	2005	Authentication paper (uses N isotopes to discriminate organic vs conventional)
Auclair	1995	Fertiliser study
Bateman	2005	Fertiliser study
Champagne	2007	Fertiliser study
Cürük	2004	Fertiliser study
del Amor	2007	Fertiliser study
Demir	2003	Fertiliser study
Burkitt	2007	No direct comparison of organic vs. conventional
Corbellini	2005	No direct comparison of organic vs. conventional
Daugaard	2001	No direct comparison of organic vs. conventional
Davis	2006	No direct comparison of organic vs. conventional
Ebbesvik	1993	No direct comparison of organic vs. conventional
Egerer	2008	No direct comparison of organic vs. conventional
Govasmark	2005	No direct comparison of organic vs. conventional
Grinder-Pedersen	2003	No direct comparison of organic vs. conventional
Gupta	1989	No direct comparison of organic vs. conventional
Hamilton	2002	No direct comparison of organic vs. conventional
Hansen	1981	No direct comparison of organic vs. conventional
Jahan	2006	No direct comparison of organic vs. conventional
Khalil	2007	No direct comparison of organic vs. conventional
Kienzle	1993	No direct comparison of organic vs. conventional
Lovatti	2003	No direct comparison of organic vs. conventional
Miceli	2003b	No direct comparison of organic vs. conventional
Oksberrg	2005	No direct comparison of organic vs. conventional
Olivio	2005	No direct comparison of organic vs. conventional
Partanen	2001	No direct comparison of organic vs. conventional
Perkins-Veazie	2006	No direct comparison of organic vs. conventional
Petr	1999	No direct comparison of organic vs. conventional
Petr	1999	No direct comparison of organic vs. conventional
Premuzic	1998	No direct comparison of organic vs. conventional
Singh	2007	No direct comparison of organic vs. conventional
Storey	1993	No direct comparison of organic vs. conventional
Sundrum	2000	No direct comparison of organic vs. conventional
Supradip	2007	No direct comparison of organic vs. conventional
Tamaki	1995	No direct comparison of organic vs. conventional
Thybo	2006	No direct comparison of organic vs. conventional
Thybo	2002	No direct comparison of organic vs. conventional
Toledo	2003	No direct comparison of organic vs. conventional

Urbanczyk	2005	No direct comparison of organic vs. conventional
Velisek	1995	No direct comparison of organic vs. conventional
Reeve	2005	No direct comparison of organic vs. conventional (biodynamic vs. organic)
di Candilo	2006	No direct comparison of organic vs. conventional (conversion study)
Nauta	2006a	No direct comparison of organic vs. conventional (organic in conversion)
Francakova	1996	No direct comparison of organic vs. conventional (ecological vs. integrated)
Fjelkner-Modig	2000	No direct comparison of organic vs. conventional (organic vs. integrated)
Hecke	2006	No direct comparison of organic vs. conventional (organic vs. integrated)
Roesch	2005	No direct comparison of organic vs. conventional (organic vs. integrated)
Roth	2007	No direct comparison of organic vs. conventional (organic vs. integrated)
Sansavini	2004	No direct comparison of organic vs. conventional (organic vs. integrated)
Tarozzi	2004	No direct comparison of organic vs. conventional (organic vs. integrated)
Tarozzi	2006	No direct comparison of organic vs. conventional (organic vs. integrated)
Veberic	2005	No direct comparison of organic vs. conventional (organic vs. integrated)
Weibel	2000	No direct comparison of organic vs. conventional (organic vs. integrated)
Fanatico	2005	No relevant outcome
Fanatico	2007	No relevant outcome
Nauta	2006b	No relevant outcome
Nunez-Delicado	2005	No relevant outcome
Nurnberg	2006	No relevant outcome
Petr	2004	No relevant outcome
Heinäaho	2006	No relevant outcome
Lehesranta	2007	No relevant outcome
Alvarez	1988	No relevant outcome (nutrients measured in inedible part)
Stalenga	2004	No relevant outcome (balance study)
Torstensson	2006	No relevant outcome (balance study)
Eurola	2003	No relevant outcome (cadmium)
Ghidini	2005	No relevant outcome (cadmium)
Karavoltsos	2008	No relevant outcome (cadmium)
Karavoltsos	2002	No relevant outcome (cadmium)
Linden	2001	No relevant outcome (cadmium)
Bergoglio	2004	No relevant outcome (comparing different housing conditions,)
Bengtsson	2003	No relevant outcome (field balance study)
Guzhis	2002	No relevant outcome (field balance study)
Gronowska-Senger	1997	No relevant outcome (health)
Ellis	2007a	No relevant outcome (no analysis of nutrient)
Hansson	2000	No relevant outcome (no analysis of nutrient)
Millet	2005	No relevant outcome (no analysis of nutrient)
Millet	2006	No relevant outcome (no analysis of nutrient)
Millet	2004	No relevant outcome (no analysis of nutrient)
Podwall	1999	No relevant outcome (no analysis of nutrient)
Stertz	2005a	No relevant outcome (no analysis of nutrient)
Woodward	1999	No relevant outcome (no analysis of nutrient)
Zhao	2007	No relevant outcome (no analysis of nutrient)
Jacob	2007	No relevant outcome (nutrient composition of livestock feedstuffs)
Karlen	1992	No relevant outcome (nutrients measured in inedible part)
Kristensen	2003	No relevant outcome (nutrients measured in inedible part)
Nakamura	2007	No relevant outcome (nutrients measured in inedible part)
Seidler	2006	No relevant outcome (nutrients measured in inedible part)
Stalenga	2007	No relevant outcome (nutrients measured in inedible part)

Tamaki	2002	No relevant outcome (nutrients measured in inedible part)
Allard	1998	Not peer reviewed
Anacker	2007	Not peer reviewed
Arenfalk	1996	Not peer reviewed
Bakutis	2007	Not peer reviewed
Besson	1988	Not peer reviewed
Buchberger	2001	Not peer reviewed
Buchberger	2001	Not peer reviewed
Carcea	2002	Not peer reviewed
Dahlstedt	1995	Not peer reviewed
D'Antuono	2004	Not peer reviewed
D'Egidio	2006	Not peer reviewed
Divis	2006	Not peer reviewed
Divis	1998	Not peer reviewed
Divis	2004	Not peer reviewed
Divis	2004	Not peer reviewed
Dustmann	2006	Not peer reviewed
Gaiani	2004	Not peer reviewed
Gravert	1989	Not peer reviewed
Gysi	1999	Not peer reviewed
Hansen	1976	Not peer reviewed
Hellenas	1995	Not peer reviewed
Heuberger	1993	Not peer reviewed
Hsieh	1996	Not peer reviewed
Kolsch	1991	Not peer reviewed
Kumpulainen	2001	Not peer reviewed
Lind	1990	Not peer reviewed
Lindner	1989	Not peer reviewed
Lumpkin	2005	Not peer reviewed
Molkentin	2007c	Not peer reviewed
Nielsen	1995	Not peer reviewed
Nogai	2003	Not peer reviewed
Pattono	2005	Not peer reviewed
Pattono	2004	Not peer reviewed
Reinken	1987	Not peer reviewed
Rembialkowska	2007	Not peer reviewed
Roth	2001	Not peer reviewed
Ruger	1984	Not peer reviewed
Staarup	2005	Not peer reviewed
Staffas	2002	Not peer reviewed
Stein-Bachinger	1997	Not peer reviewed
Stene	2002	Not peer reviewed
Weibel	1999	Not peer reviewed
Weibel	2004	Not peer reviewed
Weibel	2004	Not peer reviewed
Ristic	2004	Not relevant study type (review)
Vogtmann	1988	Not relevant study type (review)
Borówczak	2003	Unobtainable paper
Hallmann	2007d	Unobtainable paper
Jonsson	1996	Unobtainable paper

Keipert	1990	Unobtainable paper
Lazic	1992	Unobtainable paper
Meltsch	2007	Unobtainable paper
Pranckietien	2003	Unobtainable paper
Rembialkowska	1998	Unobtainable paper
Rembialkowska	2006	Unobtainable paper
Ren	2001	Unobtainable paper
Roesch	2006	Unobtainable paper

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Web Table 5: Assessment of quality criteria in studies identified in the systematic review of nutritional quality of organic foods

Study	Organic Definition	Cultivar/ Breed	Nutrients analysed	Laboratory methods	Statistical methods	Satisfactory Quality
Acharya, 2007	×	✓	✓	✓	✓	×
Açkay, 2004	×	✓	✓	✓	✓	×
Alvarez, 1993	×	✓	✓	✓	✓	×
Amodio, 2007	✓	✓	✓	✓	✓	✓
Angood, 2008	✓	×	✓	✓	✓	×
Annett, 2007	×	✓	✓	✓	✓	×
Anttonen, 2006	✓	✓	✓	✓	✓	✓
Arnold, 1984	×	×	✓	✓	✓	×
Asami, 2003	✓	✓	✓	✓	✓	✓
Barrett, 2007	✓	✓	✓	✓	✓	✓
Basker, 1991	×	✓	✓	✓	×	×
Baxter, 2001	×	×	✓	✓	✓	×
Benge, 2000	×	✓	✓	✓	✓	×
Bergamo, 2003	✓	×	✓	✓	✓	×
Bicanová, 2006	✓	✓	✓	✓	✓	✓
Borguini, 2005	✓	✓	✓	✓	✓	✓
Borguini, 2007	✓	✓	✓	✓	✓	✓
Briviba, 2007	✓	✓	✓	✓	✓	✓
Carbonaro, 2001	✓	✓	✓	✓	✓	✓
Carbonaro, 2002	✓	✓	✓	✓	✓	✓
Carcea, 2006	×	✓	✓	✓	✓	×
Caris-Veyrat, 2004	×	✓	✓	✓	✓	×
Castellini, 2002	✓	✓	✓	✓	✓	✓
Caussiol, 2004	×	✓	✓	✓	✓	×

Study	Organic Definition	Cultivar/ Breed	Nutrients analysed	Laboratory methods	Statistical methods	Satisfactory Quality
Cayuela, 1997	×	✓	✓	✓	✓	×
Chang, 1977	×	×	✓	✓	✓	×
Chassy, 2006	×	✓	✓	✓	✓	×
Clarke, 1979	×	✓	✓	✓	✓	×
Colla, 2000	✓	✓	✓	✓	✓	✓
Colla, 2002	✓	✓	✓	✓	✓	✓
Dani, 2007	×	✓	✓	✓	✓	×
Danilchenko, 2002	×	✓	✓	✓	✓	×
Daood, 2006	×	✓	✓	✓	×	×
De Martin, 2003	×	✓	✓	✓	✓	×
DeEll, 1992	✓	✓	✓	✓	✓	✓
DeEll, 1993	✓	✓	✓	✓	✓	✓
del Amor, 2008	×	✓	✓	✓	✓	×
Dimberg, 2005	✓	✓	✓	✓	✓	✓
Ellis, 2006	×	✓	✓	✓	✓	×
Ellis, 2007	×	✓	✓	✓	✓	×
Eltun, 1996	×	×	✓	✓	✓	×
Eurola, 2004	×	✓	✓	✓	✓	×
Ferreres, 2005	✓	✓	✓	✓	×	×
Fischer, 2007	×	✓	✓	✓	✓	×
Forster, 2002	✓	✓	✓	✓	✓	✓
Garnweidner, 2007	✓	×	✓	✓	✓	×
Guadagnin, 2005	✓	✓	✓	✓	✓	✓
Gunderson, 2000	✓	✓	✓	✓	✓	✓
Gutiérrez, 1999	×	✓	✓	✓	✓	×
Haglund, 1998	✓	✓	✓	✓	×	×

Study	Organic Definition	Cultivar/ Breed	Nutrients analysed	Laboratory methods	Statistical methods	Satisfactory Quality
Hajslova, 2005	✓	✓	✓	✓	✓	✓
Hakala, 2003	×	✓	✓	✓	✓	×
Häkkinen, 2000	×	✓	✓	✓	✓	×
Hallman, 2006	×	✓	✓	✓	✓	×
Hallman, 2007a	×	✓	✓	✓	✓	×
Hallman, 2007b	×	✓	✓	✓	✓	×
Hallman, 2007c	×	✓	✓	✓	✓	×
Hamouz, 1997	×	✓	✓	✓	✓	×
Hamouz, 1999a	×	✓	✓	✓	✓	×
Hamouz, 1999b	×	✓	✓	✓	✓	×
Hamouz, 2005	✓	✓	✓	✓	✓	✓
Hanell, 2004	✓	✓	✓	✓	✓	✓
Hansen, 2006	✓	✓	✓	✓	✓	✓
Hasey, 1997	×	×	✓	×	×	×
Hermansen, 2005	×	✓	✓	✓	✓	×
Hernández Suárez, 2007	×	✓	✓	✓	✓	×
Hernández Suárez, 2008a	×	✓	✓	✓	✓	×
Hernández Suárez, 2008b	×	✓	✓	✓	✓	×
Hidalgo, 2008	✓	×	✓	✓	✓	×
Hogstad, 1997	×	✓	✓	✓	✓	×
Hoikkala, 2007	×	×	✓	✓	×	×
Igbokwe, 2005	×	✓	✓	✓	✓	×
Ismail, 2003	×	×	✓	✓	✓	×
Jahan, 2004	×	×	✓	✓	✓	×

Study	Organic Definition	Cultivar/ Breed	Nutrients analysed	Laboratory methods	Statistical methods	Satisfactory Quality
Jahan, 2007	×	×	✓	✓	✓	×
Jahreis, 1997	×	✓	✓	✓	✓	×
Jorhem, 2000	×	✓	✓	✓	×	×
Keukeleire, 2007	✓	✓	✓	✓	✓	✓
Knöppler, 1986	×	×	✓	✓	✓	×
Koh, 2008	×	×	✓	✓	✓	×
Krejčířová, 2006	✓	×	✓	✓	✓	×
Krejčířová, 2007	✓	✓	✓	✓	✓	✓
Krejčířová, 2008	✓	×	✓	✓	✓	×
Langenkämper, 2006	×	✓	✓	✓	✓	×
Lanzanova, 2006	✓	✓	✓	✓	×	×
Lavrenčič, 2007	×	×	✓	✓	✓	×
L-Baeckström, 2004	✓	✓	✓	✓	✓	✓
L-Baeckström, 2006	✓	✓	✓	✓	✓	✓
Leclerc, 1991	×	✓	✓	✓	✓	×
Lester, 2007	✓	✓	✓	✓	✓	✓
Leszczyńska, 1996	✓	×	✓	✓	×	×
Lockeretz, 1980	×	✓	✓	✓	✓	×
Lombardi-Boccia, 2004	×	✓	✓	✓	✓	×
Ludewig, 2004	×	×	✓	✓	✓	×
Lund, 1996	✓	✓	✓	✓	✓	✓
Macit, 2007	✓	✓	✓	×	✓	×
Mäder, 1993	×	✓	✓	×	✓	×
Mäder, 2007	✓	✓	✓	✓	✓	✓
Malmauret, 2002	×	×	✓	✓	✓	×
Matallana González,	✓	✓	✓	✓	✓	✓

Study	Organic Definition	Cultivar/ Breed	Nutrients analysed	Laboratory methods	Statistical methods	Satisfactory Quality
1998						
Meyer, 2008	✓	✓	✓	✓	✓	✓
Micelli, 2003	×	×	✓	✓	✓	×
Mikkonen, 2001	×	✓	✓	✓	✓	×
Minelli, 2007	✓	✓	✓	✓	✓	✓
Mirzaei, 2007	×	✓	✓	✓	✓	×
Mitchell, 2007	×	✓	✓	✓	✓	×
Moreira, 2003	✓	✓	✓	✓	✓	✓
Nakagawa, 2000	✓	✓	✓	✓	✓	✓
Nguyen, 1995	×	×	✓	✓	×	×
Ninfali, 2008	×	✓	✓	✓	✓	×
Nyanjage, 2001	×	✓	✓	✓	✓	×
Olsson, 2001	✓	✓	✓	✓	✓	✓
Olsson, 2003	✓	✓	✓	✓	✓	✓
Olsson, 2006	×	✓	✓	✓	✓	×
Otreba, 2006	✓	✓	✓	✓	×	×
Peck, 2006	✓	✓	✓	✓	✓	✓
Pérez-Llamas, 1996	✓	✓	✓	✓	✓	✓
Péréz-López, 2007a	×	✓	✓	✓	✓	×
Péréz-López, 2007b	✓	✓	✓	✓	✓	✓
Péréz-López, 2007c	✓	✓	✓	✓	✓	✓
Perretti, 2004	✓	×	✓	✓	✓	×
Petr, 1998	✓	✓	✓	✓	×	×
Petr, 2000	✓	✓	✓	✓	✓	✓
Petr, 2006	✓	✓	✓	✓	✓	✓
Procida, 1998	✓	×	✓	✓	×	×

Study	Organic Definition	Cultivar/ Breed	Nutrients analysed	Laboratory methods	Statistical methods	Satisfactory Quality
Rembialowska, 1998	✓	×	✓	✓	✓	×
Rembialowska, 1999	✓	✓	✓	✓	✓	✓
Ren, 2001	×	✓	✓	✓	✓	×
Ristic, 2003	✓	✓	✓	✓	✓	✓
Ristic, 2007	✓	✓	✓	✓	✓	✓
Robbins, 2005	×	✓	✓	✓	✓	×
Rodríguez, 2006	✓	✓	✓	✓	✓	✓
Rutkowska, 2001	✓	✓	✓	✓	✓	✓
Ryan, 2004	×	✓	✓	✓	✓	×
Saastamoinen, 2004	×	✓	✓	✓	✓	×
Samman, 2008	×	×	✓	✓	✓	×
Santos, 2005	✓	×	✓	✓	✓	×
Seidler-Lożykowska, 2007	×	✓	✓	✓	×	×
Shier, 1984	✓	×	✓	✓	✓	×
Smith, 1993	×	×	✓	✓	×	×
Sousa, 2005	✓	✓	✓	✓	×	×
Starling, 1990	✓	✓	✓	✓	×	×
Starling, 1993	×	✓	✓	✓	×	×
Stertz, 2005	×	✓	✓	✓	✓	×
Stopes, 1988	×	×	✓	✓	×	×
Strobel, 2001	✓	✓	✓	✓	✓	✓
Toledo, 2002	✓	✓	✓	✓	✓	✓
Varis, 1996	×	✓	✓	✓	✓	×
Verde Mendéz, 2003	×	✓	✓	✓	✓	×
Vian, 2006	×	✓	✓	✓	×	×

Study		Organic Definition	Cultivar/ Breed	Nutrients analysed	Laboratory methods	Statistical methods	Satisfactory Quality
Walshe, 2006		×	×	✓	✓	✓	×
Wang, 1998		×	✓	✓	✓	✓	×
Warman, 1996		✓	✓	✓	✓	✓	✓
Warman, 1997		✓	✓	✓	✓	✓	✓
Warman, 1998		✓	✓	✓	✓	✓	✓
Wawrzyniak, 1997		×	×	✓	✓	×	×
Wolfson, 1981		×	✓	✓	✓	✓	×
Wszalaki, 2005		×	✓	✓	✓	✓	×
Wunderlich, 2008		×	×	✓	✓	×	×
Yildrim, 2004		✓	✓	✓	✓	✓	✓
Young, 2005		✓	✓	✓	✓	✓	✓
Zorb, 2006		×	✓	✓	✓	✓	×
Studies meeting criteria	**N**	75	129	162	160	140	**55**
	%	46	80	100	99	86	**34**

Citations for studies not meeting satisfactory quality:

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Web Table 6: Studies of satisfactory quality included in the systematic review of nutritional quality of organic foods

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