Comparison of composition (*nutrients and other substances*) of organically and conventionally produced foodstuffs: a systematic review of the available literature

Report for the Food Standards Agency

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1.0 EXECUTIVE SUMMARY

There is currently no independent authoritative statement on the nature and importance of differences in content of nutrients and other nutritionally relevant substances (*nutrients and other substances*) in organically and conventionally produced foodstuffs. This systematic review of the available published literature was designed to seek to determine the size and relevance to health of any differences in content of *nutrients and other substances* in organically and conventionally produced crops and livestock products. This review does not address contaminant content (such as herbicide, pesticide and fungicide residues) of organically and conventionally produced foodstuffs or the environmental impacts of organic and conventional agricultural practices.

The systematic review search process identified 162 relevant articles published, with an English abstract, in peer-reviewed journals since 1st January 1958 until 29th February 2008. A total of 3558 comparisons of content of *nutrients and other substances* in organically and conventionally produced foodstuffs were extracted for analysis.

Articles included in the review were assessed for study quality (satisfactory quality studies provided clear statements on material and nutrients analysed, laboratory and statistical methods and a clear definition of organic agricultural practices), and one third of all studies (n=55; 34%) met the pre-defined satisfactory quality criteria.

Analysis was conducted on nutrients or nutrient groups for which numeric data were provided in at least 10 of the 137 crop studies identified by the review. In analysis including all studies (independent of quality), no evidence of a difference in content was detected between organically and conventionally produced crops for the following *nutrients and other substances*: vitamin C, calcium, phosphorus, potassium, total soluble solids, titratable acidity, copper, iron, nitrates, manganese, ash, specific proteins, sodium, plant non-digestible carbohydrates, β-carotene and sulphur. Significant differences in content between organically and conventionally produced crops were found in some minerals (nitrogen higher in conventional crops; magnesium and zinc higher in organic crops), phytochemicals (phenolic compounds and flavonoids higher in organic crops) and sugars (higher in organic crops). In analysis restricted to satisfactory quality studies, significant differences in content between organically and conventionally produced crops were found only in nitrogen content (higher in conventional crops), phosphorus (higher in organic crops) and titratable acidity (higher in organic crops).

Analysis of differences in content of *nutrients and other substances* in livestock products (meat, dairy, eggs) was more limited given the smaller evidence base. Analysis was conducted on nutrients or nutrient groups for which numeric data were provided in at least 5 of the 25 livestock product studies identified by the review. In analysis including all studies (independent of quality), no evidence of a difference in content was detected between organically and conventionally produced livestock products for the following *nutrients and other substances*: saturated fatty acids, monounsaturated fatty acids (cis), n-6 polyunsaturated fatty acids, fats (unspecified), n-3 polyunsaturated fatty acids, nitrogen and ash. Significant differences in content between organically and conventionally produced livestock products were found in some fats (polyunsaturated fatty acids [unspecified], trans fatty acids and fatty acids [unspecified] higher in organic livestock products). In analysis restricted to satisfactory quality studies, significant differences in content of organically and conventionally produced livestock products were found only in nitrogen content (higher in organic livestock products).

No evidence of a difference in content of *nutrients and other substances* between organically and conventionally produced crops and livestock products was detected for the majority of nutrients assessed in this review suggesting that organically and conventionally produced crops and livestock products are broadly comparable in their nutrient content. The differences detected in content of *nutrients and other substances* between organically and conventionally produced crops and livestock products are biologically plausible and most likely relate to differences in crop or animal management, and soil quality. It should be noted that these conclusions relate to the evidence base currently available, which contains limitations in the design and in the comparability of studies. There is no good evidence that increased dietary intake, of the nutrients identified in this review to be present in larger amounts in organically than in conventionally produced crops and livestock products, would be of benefit to individuals consuming a normal varied diet, and it is therefore unlikely that these differences in nutrient content are relevant to consumer health.

2.0 CONTENTS

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3.0 INTRODUCTION

Currently there is uncertainty about the degree of difference in nutrient composition between conventionally and organically produced foodstuffs. Organic foodstuffs are those that are produced according to specified standards which, among other things, control the use of chemicals and medicines in crop and animal production, and emphasise protection of the environment. Recently published non-systematic reviews comparing nutrient composition of organically and conventionally produced foods have come to contrasting conclusions. Some have reported that organically produced foodstuffs have higher nutrient content than conventionally produced foodstuffs (1-3), while other reviews have concluded that there were no consistent differences in nutrient content between production method (4, 5).

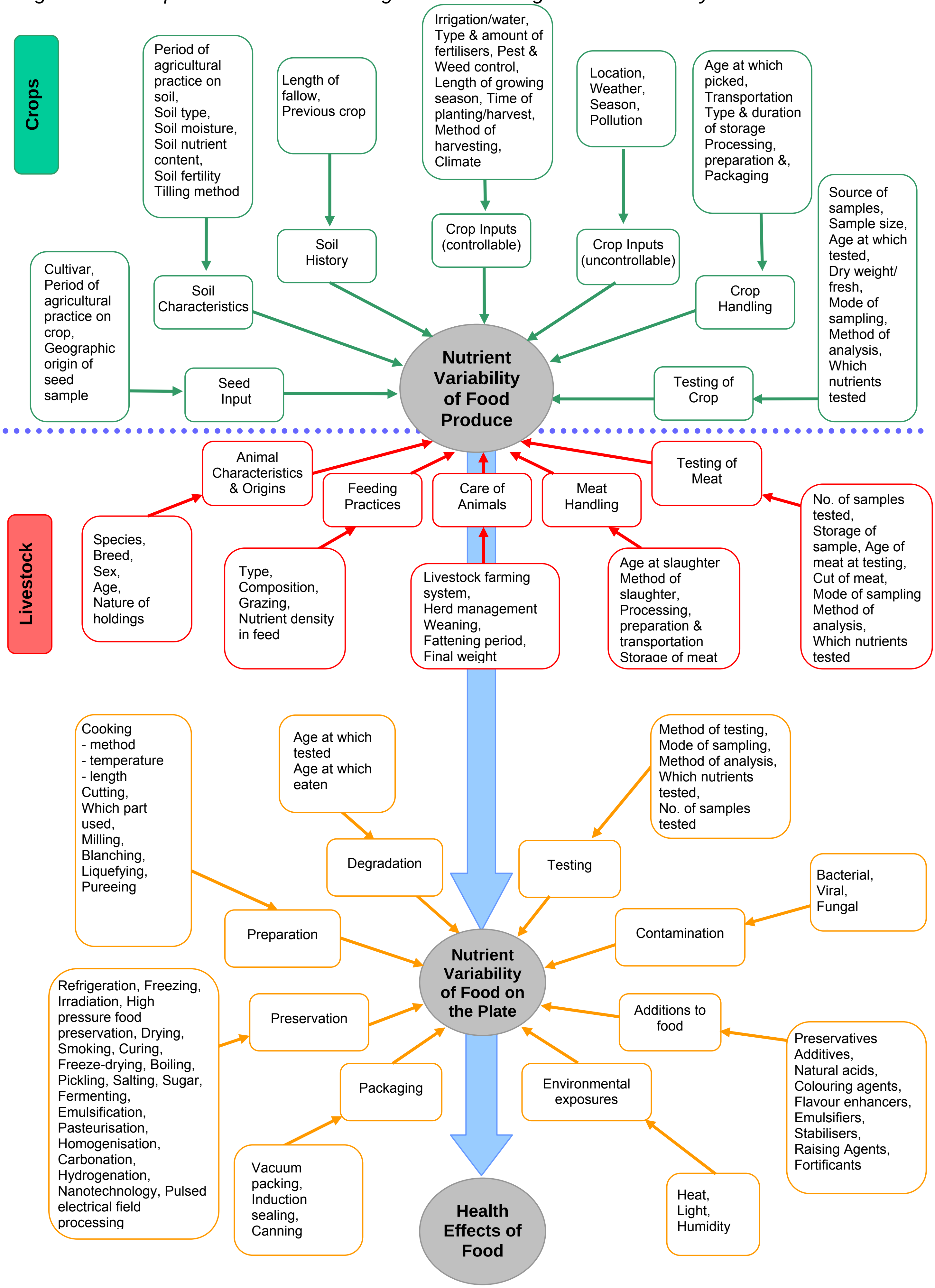
The global demand for organically produced food is rising. In 2007 the organic food market in the UK was estimated to be worth over £2 billion – an increase of 22% since 2005 (6). The UK organic market is now the third largest in Europe after Germany and Italy. Fruit and vegetables comprise the largest sector of organic foods in the UK, closely followed by dairy products. The shift in demand among consumers from conventionally to organically produced foodstuffs appears to have arisen at least in part from a belief that organically produced foodstuffs are healthier (7-10) and have a superior nutrient profile (11, 12) than conventionally produced foodstuffs.

To date, there has been no explicitly systematic review of the available literature on this topic. In contrast to non-systematic reviews which can be biased and incomplete, the prime purpose of systematic reviews of literature is to provide a comprehensive display of all available evidence in a common format. Systematic reviews have clear principles for their conduct. First, the process of the review should be carried out according to a pre-specified method. Second, the proposed method should be open to public scrutiny and peer review. Third, the review should be comprehensive within its pre-specified criteria. A systematic approach offers clear advantages in terms of reducing bias, where for instance inclusion or exclusion of studies may be influenced by preconceived ideas of the investigators. Systematic reviews cannot improve the quality of published data, but can provide details of the characteristics and quality of studies.

All natural products vary in their composition of nutrients and other nutritionally relevant substances depending on a wide range of factors (13). Different varieties of the same crop may differ in nutrient composition, and their nutrient content may also vary with fertiliser regime, growing conditions and season (among other things). Similarly, the nutrient composition of meat, milk and eggs is affected by several factors including age and breed of the animal, feeding regime and season. This inherent variability in nutrient content may then be further increased during the storage, transportation and preparation of the foodstuffs prior to reaching the plate of the consumer. An understanding of the various factors that affect nutrient variability in crops and livestock products is important for the design and interpretation of research in this area, and it should also serve to identify critical gaps in our knowledge and thus the intrinsic limitations of any analysis. An intuitive conceptual framework highlighting some of the factors that contribute to the variability in nutrient content in crops, livestock products and processed foods is presented in Figure 1.

Given the large and increasing demand for organic foodstuffs in the UK and elsewhere, an up-to-date objective independent statement on the nutrient and other nutritionally relevant substance composition of organically and conventionally produced foodstuffs is needed for both public policy and consumer advice. The aim of this report is to systematically review and compare the composition of organically and conventionally produced foodstuffs, focusing only on nutrients and other nutritionally relevant substances (*nutrients and other substances*). This review specifically does not address contaminant content (such as herbicide, pesticide and fungicide residues) of organically and conventionally produced foodstuffs or the environmental impacts of organic and conventional agricultural practices.

Figure 1: Conceptual framework outlining factors affecting nutrient variability



4.0 METHODS

4.1 Review process

In line with accepted guidelines, the review process was initiated by the preparation of a protocol which pre-specified the method to be used for the conduct of the review. The protocol was reviewed by an independent review panel. The review panel comprised a subject expert, Dr. Julie Lovegrove (University of Reading), and a public health clinician with systematic review expertise, Professor Martin Wiseman (World Cancer Research Fund International and University of Southampton). The review panel provided feedback on the protocol which was incorporated into a final version, posted on-line on 18th April 2008 at http://www.lshtm.ac.uk/nphiru/research/organic/. Relevant subject experts and external bodies were alerted to the review process and the availability of the review protocol. A draft of the final report was reviewed and approved by the independent review panel.

4.2 Search strategy

Search strategies were developed with PubMed using Medical Subject Heading [MeSH] and title abstract [tiab] terms to identify relevant exposures (organic vs. conventional production methods) and outcomes (composition of *nutrient and other substances*). The exposure terms searched (including all MeSH, headings, subheadings and tiab terms) were “organic”, “health food”, “conventional” combined with “food”, “agricultural crop”, “livestock”, “agriculture”. These were combined with a list of outcome terms for *nutrients and other substances* (see Appendix 1), modified from the World Cancer Research Fund specification manual (14).

Multi-database searching was used to ensure comprehensive article retrieval. Searches were conducted in PubMed, ISI Web of Science and CAB Abstracts[1]. The search period covered 50 years, from 1st January 1958 until 29th February 2008[2]. All languages were included in the searches but only publications with an English abstract were considered for inclusion in the review. Hand searching of the reference lists of studies included in the review was conducted to check the completeness of initial electronic searches. In-press articles were identified by direct contact with key authors. Forty authors were contacted by email; we received 29 responses and 36 papers as a result of this correspondence.

[1] The protocol proposed the use of 13 databases for the search. Upon closer inspection it was decided that the content of 10 of the databases were not directly related to this review.
[2] Fifty years was deemed an appropriate time period within which to retrieve all relevant literature.

4.3 Study designs

We identified three main study types for inclusion in the review:

Field trials

Comparisons between samples originating from organic and conventional agricultural methods on adjacent parcels of land (fields).

Strengths: adjacent land minimises variability between samples, greater control over agricultural inputs.

Weaknesses: expensive to conduct, time-consuming (especially if soil must go through a conversion period).

Farm surveys

Comparisons of samples originating from organic and conventional farms which may be matched for selected variables.

Strengths: makes use of existing agricultural infrastructure, large samples available.

Weaknesses: multiple farm sites introduce variability.

Basket surveys

Comparisons of samples of organically and conventionally produced food as available to the consumer from retail outlets.

Strengths: inexpensive to conduct, quick.

Weaknesses: no means of determining details of farming methods, little comparability between samples.

4.4 Publication selection

The titles and abstracts of all papers identified in the search process were assessed for relevance by two reviewers. Grey literature such as dissertations, conference proceedings (including peer-reviewed abstracts) and reports were excluded. Relevant in-press articles were reported in the review but excluded from the analysis. The full texts of all potentially relevant articles were retrieved and assessed for inclusion in duplicate by two independent reviewers. Articles were excluded if they:

- were not peer-reviewed
- did not have an English abstract
- did not address composition of *nutrients and other substances*
- did not present a direct comparison between organic and conventional production systems
- were primarily concerned with impact of different fertiliser regimes

- were primarily concerned with non-nutrient contaminant content (cadmium, lead and mercury)
- were authentication studies describing techniques to identify food production methods.

4.5 Data extraction

Data were extracted into separate databases for studies reporting on crops and livestock products (including meat, milk and eggs). Extracted data included all relevant information on study characteristics, methods and results. Data on factors outlined in the conceptual framework on nutrient variability (Figure 1) were also extracted when available. For the first 10 included articles, data extraction was performed in duplicate by two independent reviewers. Extracted data were compared and any inconsistencies noted and corrected as necessary. For the remaining articles, one reviewer entered the data and another checked all entries; any differences were discussed and a consensus agreed. The same two reviewers completed the entire data extraction process. See Appendices 2 and 3 respectively for a description of data extraction fields for crop and livestock product studies.

4.6 Study quality

Study quality was categorised based on concordance with five fundamental factors which were defined *a priori* as essential to answer the research question (i.e. comparison of *nutrient and other substance* composition of organically and conventionally produced foodstuffs). Study quality was grouped into two categories: satisfactory quality and unsatisfactory quality.

Satisfactory quality publications provided the following:

- a clear definition, in the Introduction or Methods section of the paper, of the organic production methods of the crop or livestock product analysed (including the name of any certifying body)
- specification of the cultivar of crop, or breed of livestock
- a statement of which *nutrient(s) and other substance(s)* were assessed for content
- a description of the laboratory analytical methods used to test for the content of the named *nutrients and other substances*
- a statement of the statistical methods used for data analyses.

Unsatisfactory quality publications were those that do not specify all of the above.

4.7 Nutrients and other substances

The publications included in the review reported chemical analyses on 100 distinct foodstuffs and presented data on 455 *nutrients and other substances*. Statistical analysis by foodstuff was impractical given the large array of different foods (and cultivars/breeds) presented in included publications. The review team therefore decided to facilitate analysis and interpretation of the available information by categorising the *nutrients and other substances* reported into nutrient groups or "families".

In some instances, such as minerals (e.g. zinc, magnesium etc.), analysis was conducted on the nutrient as reported. However, in other instances where this was not possible, the *nutrients and other substances* were categorised as follows:

- cognate groups i.e. the "vitamin C" group was formed from the amalgamation of the following nutrients as described in the respective publications: vitamin C, ascorbic acid, dehydroascorbic acid, total vitamin C, ascorbate, dehydroascorbate
- biological activity groups i.e. the "antioxidant activity" group was formed from the amalgamation of the following variables as described in the respective publications: antioxidant activity, total antioxidant activity, hydrophilic antioxidant activity, antioxidant capacity, relative antioxidant activity, total radical scavenging ability, lipophilic antioxidant activity
- method of analysis groups i.e. the "nitrogen" group was formed from the amalgamation of reports of nutrients whose content was assessed using a laboratory method reliant on estimation of nitrogen content reported in the respective publications as: crude protein, protein, nitrogen, total nitrogen, protein nitrogen, true protein.

The full list of nutrient groups and their constituent nutrients is reported in Appendix 4 for crop studies and in Appendix 5 for livestock product studies.

4.8 Data analysis

Comparisons of the content of *nutrient and other substances* available for analysis in this review derive from publications that differ in their study types, test foodstuffs and unit of measurement. For example, calcium was measured in crop studies with the following designs:

field trials, farm studies, basket surveys and combination designs;

on the following crops:

apple, banana, beetroot, cabbage, carrot, celeriac, grapefruit, kiwifruit, mandarin, oat, onion, pea, pear, plum, potato, pumpkin, rice, rye, savoury herb, strawberry, sweet pepper, sweet potato, sweet corn, tomato, wheat;

and reported in the following units:

% dry weight, parts per million (ppm), µg g^{-1}, mmol kg^{-1}, mg $100g^{-1}$, mg kg^{-1}, mg L^{-1}, g kg^{-1}.

Formal meta-analysis was not attempted due to the marked heterogeneity of study designs and outcome measures among the included studies. In order to examine differences between organically and conventionally produced foodstuffs in content of *nutrients and other substances* we therefore calculated the difference in the content reported, and expressed it as a percentage of the content in the conventionally produced foodstuffs, as follows:

$$\frac{(Content\ of\ nutrient\ in\ organically\ produced\ foodstuff - Content\ of\ nutrient\ in\ conventionally\ produced\ foodstuff)}{Content\ of\ nutrient\ in\ conventionally\ produced\ foodstuff} \times 100\%$$

This gave us the percentage of the *nutrients and other substances* found in the organically produced foodstuff above or below that found in the conventionally produced foodstuff, and enabled us to combine results from different studies for statistical analysis. Positive differences suggested that there might be more of particular *nutrients and other substances* in organically produced foodstuffs, negative differences suggested that there might be more of particular *nutrients and other substances* in conventionally produced foodstuffs. We represented the differences on dot plots by study type, omitting extreme values (defined as values where the absolute difference from the next largest value was at least 1 standard deviation). It is important to note that given the differences in the design of studies included in each analysis, the percent difference values are not translatable into specific nutrient differences.

We used t-tests with robust standard errors (to account for clustering caused by multiple nutrient comparisons within studies) to test the null hypothesis of no evidence of a difference between organically and conventionally produced food in content of *nutrients and other substances*. P-values were calculated to determine the significance of observed differences; p-values of less than 0.05 were used as a basis for evidence of significant differences between organically and conventionally produced foodstuffs. It should be noted that a large number of statistical tests were undertaken which increases the possibility of finding a significant difference where there is in fact no evidence of a difference between organically and conventionally produced food in content of *nutrients and other substances*.

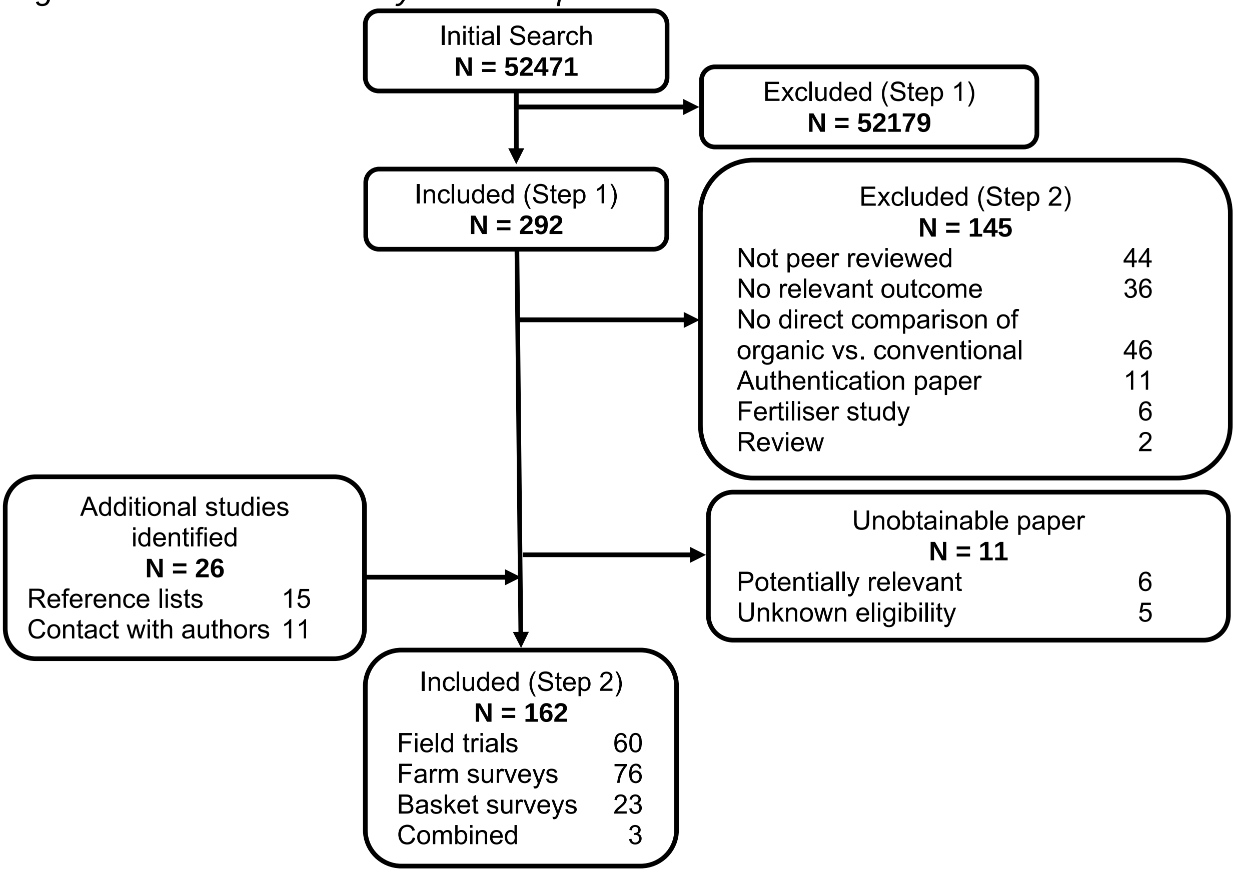
To convey the totality of evidence, primary analysis was based on all included studies. A subsequent analysis only considered satisfactory quality studies. Statistical analysis was conducted separately for crops and livestock products. A number of studies included in the review reported some (n=11) or all (n=24) relevant data only in graphical format; only numeric data were extracted for use in analysis.

5.0 RESULTS

5.1 Search results

The literature searches yielded 52,471 citations. Of these, 292 articles were identified as potentially relevant. Full copies of 281 of these papers were obtained; full copies of 6 (2%) potentially eligible publications and 5 (2%) of unknown eligibility (unknown peer review status) were unobtainable despite numerous attempts. Examination of full texts resulted in the exclusion of 145 studies for a variety of reasons including absence of peer review, no relevant outcome measure and lack of direct comparison of organic vs. other agricultural production method (see Appendix 6). A further 15 relevant papers were identified via hand searching of reference lists, and 11 relevant papers were identified by direct author contact. A total of 162 publications (60 field trials, 76 farm surveys, 23 basket surveys and 3 combination designs) were identified and included in the review (see Figure 2). Of the included publications, 137 reported on the composition of crops and 25 reported on the composition of livestock products. The list of publications included in this review is provided in Appendix 7, and their abstracts are provided in Appendix 8.

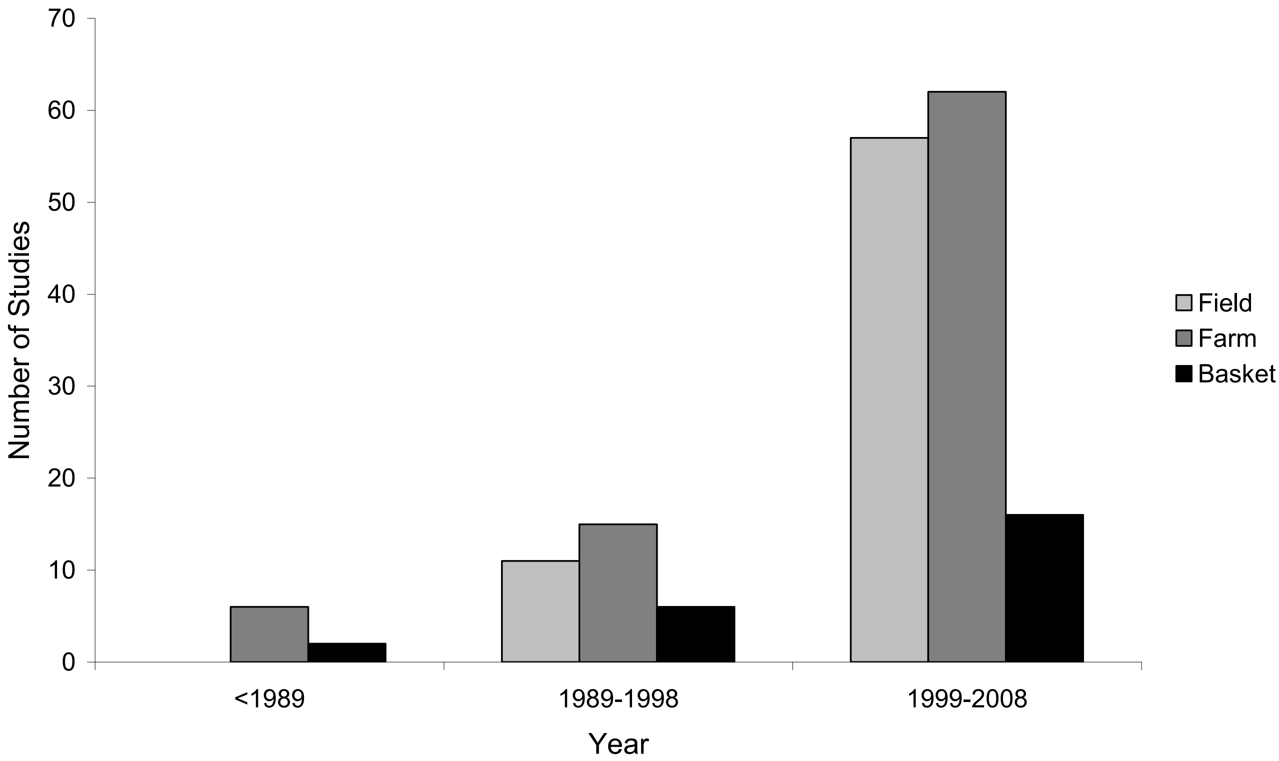
Figure 2: Flow chart of study selection process



(Step 1) – number of articles included/excluded after viewing title and abstract
(Step 2) – number of articles included/excluded after reading full text

Within the studies included in the review, there was a notable increase in the number of relevant papers published in the past 10 years (see Figure 3), and 120 (74%) of the papers were published after January 2000.

Figure 3: Distribution of publications included in the review by study type and year



5.2 Evidence base for analysis

In total we extracted 3558 nutrient content comparisons from 162 studies (3089 from 137 crop studies, 469 from 25 livestock product studies) which compared nutrient content in organically with conventionally produced foodstuffs.

5.3 Study quality

The 162 studies included in the review were assessed to determine whether they met the quality criteria. All studies (100%) stated which nutrients were analysed, and nearly all studies (99%) stated the laboratory methods used for the analyses. Fewer studies (86%) stated the methods used for statistical analysis, and one in five studies (20%) failed to state which plant cultivar or livestock breed was used for analysis. Finally, more than half the studies in the review (54%) failed to provide a clear definition of the organic production methods used (we required a statement of certifying body, although if no certifying body ear></dates><urls></urls></record></Cite></EndNote>¶ (16)⊥ . The differential use of cides and fus final quality criterion, largely due to the general lack of certifying bodies at that time, although even recent studies often failed to state the name of the organic production certifying body. In total, one third of studies included in the review (34%) met the pre-defined quality criteria (see Table 1). Information on the quality of each study included in the review is provided in Appendix 9.

Table 1: Number of studies included in the review meeting quality criteria

Criterion	N	%
Nutrients analysed	162	100
Laboratory methods	160	99
Statistical methods	140	86
Cultivar/ breed	129	80
Definition of organic	75	46
Satisfactory Quality	55	34

5.4 Comparison of content of *nutrients and other substances* in crops

Analysis was conducted on all nutrients or nutrient groups for which numeric data were provided in at least 10 of the 137 crop studies that reported comparisons between organic and conventional crops (see Appendix 10). The following 23 *nutrients and other substances* met this criterion (listed in order of number of studies reporting comparisons): nitrogen, vitamin C, phenolic compounds, magnesium, calcium, phosphorus, potassium, zinc, total soluble solids, titratable acidity[3], copper, flavonoids, iron, sugars, nitrates, manganese, ash, dry matter, specific proteins, sodium, plant non-digestible carbohydrates, β-carotene and sulphur. Given the reasonable amount of available data, and the hazards of conducting analyses on small datasets, it was deemed inappropriate to conduct analyses on nutrients or nutrient groups which were only reported in a small number of studies. Details of included studies, crops analysed, laboratory methods and units of measurement, and dot plots of results, are presented by nutrient category in Appendix 12. Analyses excluded extreme outliers and graphically reported data (listed in Appendix 14).

Summary results of the analysis comparing the content of *nutrients and other substances* from organically and conventionally produced crops are presented in Table 2 (results

[3] Titratable acidity measures the total amount of protons available in a solution, providing an approximate measure for the concentration of acidity.

presented for all studies and for satisfactory quality studies separately). The analyses comparing all available data suggest that there is no evidence of a difference between organically and conventionally produced crops in their content of 16 of the 23 nutrient categories analysed: vitamin C, calcium, phosphorus, potassium, total soluble solids, titratable acidity, copper, iron, nitrates, manganese, ash, specific proteins, sodium, plant non-digestible carbohydrates, β-carotene and sulphur. Conventionally produced crops were found to have significantly higher levels of nitrogen than organically produced crops. Organically produced crops were found to have significantly higher levels of sugars, magnesium, zinc, dry matter, phenolic compounds and flavonoids than conventionally produced crops.

Analysis including data only from satisfactory quality studies found no evidence of a difference in content for 20 of the 23 nutrient categories analysed. In these analyses, conventionally produced crops were found to have significantly higher levels of nitrogen than organically produced crops, while organically produced crops were found to have significantly higher levels of phosphorus and higher titratable acidity than conventionally produced crops.

5.5 Comparison of content of *nutrients and other substances* in livestock products

The small number of livestock product studies identified in the review necessitated the use of more modest criteria for nutrient selection. Analysis was conducted on all nutrients or nutrient groups for which numeric data were provided in at least 5 of the 25 livestock product studies which reported comparisons between organic and conventional livestock products (see Appendix 11). The following 10 *nutrients and other substances* met these criteria (listed in order of number of studies reporting comparisons): saturated fatty acids, monounsaturated fatty acids (cis), n-6 polyunsaturated fatty acids, fats (unspecified), n-3 polyunsaturated fatty acids, polyunsaturated fatty acids (unspecified), trans fatty acids, nitrogen, fatty acids (unspecified) and ash.

Details of included studies, livestock products analysed, laboratory methods and units of measurement, and dot plots of results, are presented by nutrient category in Appendix 13. Analyses excluded extreme outliers and graphically reported data (listed in Appendix 15).

Summary results of the analysis comparing the content of *nutrients and other substances* from organically and conventionally produced livestock products are presented in Table 3 (results presented for all studies and for satisfactory quality studies separately). The analyses comparing all available data suggest that there is no evidence of a difference between organically and conventionally produced livestock products in their content of 7 of the 10 nutrient categories analysed: saturated fatty acids, monounsaturated fatty acids (cis), n-6 polyunsaturated fatty acids, fats (unspecified), n-3 polyunsaturated fatty acids, nitrogen and ash. Organically produced livestock products were found to have significantly higher levels of polyunsaturated fatty acids, trans fatty acids and fatty acids (unspecified) than conventionally produced livestock products.

In analysis including data only from satisfactory quality studies, there was one *nutrient and other substance* that differed significantly in its content between organically and conventionally produced livestock products. In these analyses, organically produced livestock products were found to have significantly higher levels of nitrogen than conventionally produced livestock products.

Table 2: Comparison of content of nutrients and other substances in organically and conventionally produced crops[1]

	All Studies			Satisfactory Quality Studies Only		
Nutrient category	Studies (n)	Comparisons (n)	Statistically higher levels in	Studies (n)	Comparisons (n)	Statistically higher levels in
Nitrogen	42	145	**Conventional**	17	64	**Conventional**
Vitamin C	37	143	No difference	14	65	No difference
Phenolic compounds	34	164	**Organic**	13	80	No difference
Magnesium	30	75	**Organic**	13	35	No difference
Calcium	29	76	No difference	13	37	No difference
Phosphorus	27	75	No difference	12	35	**Organic**
Potassium	27	74	No difference	12	34	No difference
Zinc	25	84	**Organic**	11	30	No difference
Total soluble solids	22	81	No difference	11	29	No difference
Titratable acidity	21	66	No difference	10	29	**Organic**
Copper	21	62	No difference	11	30	No difference
Flavonoids	20	158	**Organic**	4	48	No difference
Iron	20	62	No difference	8	25	No difference
Sugars	19	95	**Organic**	7	32	No difference
Nitrates	19	91	No difference	7	23	No difference
Manganese	19	58	No difference	9	29	No difference
Ash	16	46	No difference	5	22	No difference
Dry matter	15	35	**Organic**	2	2	No difference
Specific proteins	13	127	No difference	7	43	No difference
Sodium	12	30	No difference	6	17	No difference
Plant non-digestible carbohydrates	11	40	No difference	3	18	No difference
β-carotene	11	32	No difference	3	9	No difference
Sulphur	10	28	No difference	6	17	No difference

[1]Standardised percentage difference and robust standard error are presented in Appendix 12

Table 3: Comparison of content of nutrients and other substances in organically and conventionally produced livestock products[1]

	All Studies			Satisfactory Quality Studies Only		
Nutrient category	Studies (n)	Comparisons (n)	Statistically higher levels in	Studies (n)	Comparisons (n)	Statistically higher levels in
Saturated fatty acids	13	61	No difference	3	10	No difference
Monounsaturated fatty acids (cis)	13	42	No difference	3	9	No difference
n-6 polyunsaturated fatty acids	12	42	No difference	2	3	No difference
Fats (unspecified)	12	20	No difference	6	13	No difference
n-3 polyunsaturated fatty acids	9	34	No difference	2	13	No difference
Polyunsaturated fatty acids (unspecified)	8	12	**Organic**	2	5	No difference
Trans fatty acids	6	48	**Organic**	0	0	N/A[2]
Nitrogen	6	13	No difference	3	10	**Organic**
Fatty acids (unspecified)	5	19	**Organic**	1	4	N/A[3]
Ash	5	9	No difference	4	8	No difference

[1]Standardised percentage difference and robust standard error are presented in Appendix 13

[2]No available data from satisfactory quality studies

[3]Statistical analysis not possible as all data from the same study

6.0 DISCUSSION

6.1 Review process

To the best of our knowledge, this is the largest and only systematic review ever conducted on the composition of *nutrients and other substances* in organically and conventionally produced foodstuffs. In all, we identified 162 relevant articles published, with an English abstract, in peer-reviewed journals over the past 50 years. The majority of publications in the review were written in English, 30 (19%) were written in other languages (Czech, German, Italian, Japanese, Polish, Portuguese, Russian, Slovakian, and Spanish). We are aware of a small number of potentially relevant papers (a total of 11) which we were unable to obtain despite repeated contacts with authors and publishers (see Appendix 6). Data extraction provided more than 3500 nutrient comparisons, with the largest evidence base coming from crop studies (87% of comparisons).

6.2 Study quality

The pre-specified quality criteria identified several weaknesses in publications on content of *nutrients and other substances* in organically and conventionally produced foodstuffs. While all or most publications cited the nutrients under investigation and the laboratory analysis methods used, several failed to describe their statistical analysis methods. Only 80% of studies reported the plant cultivar or the livestock breed from which the samples were obtained. Given the well known variation between cultivars and breeds in *nutrient and other substance* content, this is a significant omission. Finally, fewer than half the included studies provided a clear description of the organic regimen under which the crops or livestock products were produced. While many papers made no mention at all of certification or other descriptors of organic production methods, several papers stated that the produce was obtained from “certified” organic farms but did not specify a certifying body. In order fairly to compare organically with conventionally produced foodstuffs it is essential to have a clear definition of the “exposure”. We would urge all researchers conducting work in this area to pay special attention to our proposed minimum quality criteria to help enhance the quality of published work on this topic.

6.3 Findings from crop studies

In analyses based on the totality of the evidence, for 16 out of the 23 most commonly cited nutrient categories, no evidence of a difference was detected in content of between organically and conventionally produced crops. When study quality was taken into consideration, no evidence of a difference was detected in content for 20 of the 23 most commonly cited nutrients. The finding of no evidence of a difference in content for the majority of *nutrients and other substances* assessed in this review suggests that organically and conventionally produced crops are broadly comparable in their nutrient content.

Some statistically significant differences in the content of *nutrients and other substances* of organically and conventionally produced crops were found (see Table 2 and Appendix 12) and their relevance to human health is discussed below by broad nutrient group.

6.4 Minerals

Nitrogen

- Strength of evidence
  All available data: statistically higher in conventional crops
  Satisfactory quality data: statistically higher in conventional crops

- Biological plausibility
  Possibly due to the differential use of nitrogen containing fertilisers or nitrogen content of the soil.

- Relevance to health
  Unlikely to be relevant to health as nitrogen is present in all natural products.

Magnesium

- Strength of evidence
  All available data: statistically higher in organic crops
  Satisfactory quality data: no difference

- Biological plausibility
  Possibly due to the differential use of magnesium containing fertilisers or magnesium content of the soil.

- Relevance to health
  Magnesium is present in all plant and animal cells and dietary deficiency is unlikely among individuals consuming a normal varied diet. High levels of magnesium intake also appear not harmful to humans with normal renal function.

Phosphorus

- Strength of evidence
  All available data: no difference
  Satisfactory quality data: statistically higher in organic crops

- Biological plausibility
  Possibly due to the differential use of phosphorus containing fertilisers or phosphorus content of the soil.

- Relevance to health
  Phosphorus is present in all plant and animal cells and dietary deficiency is unlikely among individuals consuming a normal varied diet.

Zinc

- Strength of evidence
  All available data: statistically higher in organic crops
  Satisfactory quality data: no difference

- Biological plausibility
  Possibly due to the differential use of zinc containing fertilisers or zinc content of the soil.

- Relevance to health
  Zinc is present in reasonable amounts in most foodstuffs although the bioavailability of zinc is affected by the content of the diet. Zinc deficiency is unlikely in individuals consuming a typical Western diet (i.e. omnivorous diets with refined cereals). There is no known benefit from consumption above the requirement.

Dry matter

- Strength of evidence
  All available data: statistically higher in organic crops
  Satisfactory quality data: no difference

- Biological plausibility
  Possibly due to differences in total mineral content.

- Relevance to health
  While there is no requirement for dry matter, higher concentrations may provide health benefits by way of increased mineral content.

6.5 Overall summary for mineral differences in crops

Several biologically plausible differences in minerals exist which are most likely due to differences in fertiliser use and soil quality. Differences in the management of soil fertility affect soil dynamics and plant metabolism, which result in differences in plant composition and nutritional quality (3). Many of the differences in content were not present when only satisfactory quality studies were included in analysis. A health benefit of increased dietary intake of these minerals is unlikely in adequately nourished populations.

6.6 Phytochemicals

Phenolic compounds and Flavonoids

- Strength of evidence
  Phenolic compounds all available data: statistically higher in organic crops
  Phenolic compounds satisfactory quality data: no difference
  Flavonoids all available data: statistically higher in organic crops
  Flavonoids satisfactory quality data: no difference

- Biological plausibility
  The phenolic compound and flavonoid content of plants whether organically or conventionally cultivated is influenced by several factors such as variety, seasonal variation, light and climate, degree of ripeness, and food preparation and processing (15). Synthesis by plants of phytochemicals is also partly related to insect and microorganism pressures (16). The differential use of pesticides and fungicides may therefore influence phenolic compound and flavonoid content.

- Relevance to health
  Numerous health benefits have been ascribed to the actions of phytochemicals such as phenolic compounds and flavonoids, many of which related to their antioxidant activity. The recent World Cancer Research Fund report suggests that quercetin (a flavonol) may prevent lung cancer (although the strength of evidence for this relationship was graded as "Limited - suggestive"[4]) (17). There is also some evidence from cohort studies (although not from randomised controlled trials), that high flavonoid intake is associated with lower rates of coronary heart disease mortality (18).

6.7 Overall summary for phytochemical differences in crops

Biologically plausible differences in phytochemicals and associated antioxidant activity exist. The strength of evidence from satisfactory quality studies is much more limited. Absolute health benefits of increased dietary intake of these phytochemicals is currently unknown but an area of active research.

6.8 Other

Titratable acidity

- Strength of evidence
  All available data: no difference
  Satisfactory quality data: statistically higher in organic crops

- Biological plausibility
  Possibly related to fertiliser use, ripeness and growing conditions.

- Relevance to health
  Not relevant, except for sensory properties of foodstuffs.

Sugars

- Strength of evidence
  All available data: statistically higher in organic crops
  Satisfactory quality data: no difference

- Biological plausibility
  Possibly related to fertiliser use, ripeness and growing conditions.

- Relevance to health
  Not relevant, except for sensory properties of foodstuffs.

[4] "Limited – suggestive" is used where evidence is too limited to permit a probable or convincing causal judgement, but where there is evidence suggestive of a direction of effect. This almost always does not justify public health recommendations.

6.9 Findings from livestock product studies

In analyses based on the totality of the evidence, for 7 out of the 10 most commonly cited nutrient categories, no evidence of a difference in content was detected between organically and conventionally produced livestock products. When study quality was taken into consideration, no evidence of a difference in content was detected for 9 of the 10 most commonly cited nutrients. The finding of no evidence of a difference in content for the majority of *nutrients and other substances* assessed in this review suggests that organically and conventionally produced livestock products are broadly comparable in their nutrient content.

Some statistically significant differences in the content of *nutrients and other substances* of organically and conventionally produced livestock products were found (see Table 3 and Appendix 13) and their relevance to human health is discussed below by broad nutrient group.

6.10 Minerals

Nitrogen

- Strength of evidence
  All available data: no difference
  Satisfactory quality data: statistically higher in organic livestock products

- Biological plausibility
  Possibly due to differential use of nitrogen containing feeds and nitrogen content of the soil.

- Relevance to health
  Unlikely to be relevant to health as nitrogen is present in all natural products.

6.11 Fats

Trans fatty acids

- Strength of evidence
  All available data: statistically higher in organic livestock products
  Satisfactory quality data: no data

- Biological plausibility
  Analysis included a large number of different trans fatty acids from milk, cheese, eggs and meat. The fatty acid content of livestock products can be modified by feeding regime (19, 20) and organically reared animals may have greater access to α-linolenic acid-rich feed crops such as clover.

- Relevance to health
  The first two human feeding trials comparing ruminant trans fats with industrially produced trans fats have recently been published (21, 22). Both trials suggest that consumption of ruminant trans fats has similar adverse health effects to consumption of

industrially produced trans fats. The relatively low levels of ruminant trans fat found in natural products mean that consumption of these products are unlikely to be of significant health concern (23). We are aware of one study (24) published after the review cut-off date which suggests that there are higher levels of trans fatty acids in organically than conventionally produced livestock products (milk).

Polyunsaturated fatty acids

- Strength of evidence
  All available data: statistically higher in organic livestock products
  Satisfactory quality data: no difference

- Biological plausibility
  Nutrient category derived from studies that reported polyunsaturated fatty acids (unspecified), and the result of analysis is difficult to interpret as different classes of polyunsaturated fatty acids have different biological actions.

- Relevance to health
  No statement possible due to uncertainty in nutrient measured.

Fatty acids (unspecified)

- Strength of evidence
  All available data: statistically higher in organic livestock products
  Satisfactory quality data: no analysis possible

- Biological plausibility
  Nutrient category derived from studies that reported total fatty acids, branched fatty acids, linolenic acid, other fatty acids, C18:3, and the result of analysis is difficult to interpret as different classes of fatty acids have different biological actions.

- Relevance to health
  No statement possible due to uncertainty in nutrient measured.

6.12 Review limitations

Incomplete article retrieval

- The pre-defined literature search was conducted in the three most relevant scientific publication databases, and reference lists of relevant articles were further hand searched for potential papers. Despite these efforts it is possible that not all relevant articles were retrieved for inclusion in this review. We are aware of two potentially relevant reports published after the review cut-off date (24, 25).

Data extraction errors

- Significant efforts were made to ensure that data were accurately extracted. All data extracted from a publication by a member of the review team was checked by a second review team member. It is possible that small errors occurred in data extraction and that these errors have been incorporated in the analysis. The effect of small errors in the dataset are likely to have been minimised by restricting analysis to those nutrients reported in a reasonable number of studies.

Analyses and interpretation

- The construction of nutrient groups may have obscured findings for individual nutrients. Similarly, in using standardised percentage differences to determine the presence of overall differences in content of *nutrients and other substances*, the more nuanced findings from individual studies may have been lost. These analysis and interpretation decisions were applied as the review was designed to make the best use of all available data and to present the data in a standardised form.
- The authors understand that combining all crops and all animal products into single groups and analysing the results by nutrient category may have obscured possible nutrient differences within specific foodstuffs. Certain types of foodstuffs may be more responsive to organic or conventional production systems than others, and these differences may have been diluted or lost when all foodstuffs were combined in this manner. The decision to combine foodstuffs was made due to insufficient availability of data for specific crop cultivars or livestock breeds.
- A large number of statistical tests were undertaken which increased the possibility of finding a significant difference where there was in fact no evidence of a difference between organically and conventionally produced food in content of *nutrients and other substances*.

Quality criteria

- The quality criteria applied were identified as key methodological components of study design. We did not judge further factors such as the quality of laboratory methods or suitability of statistical analysis. In addition, it is important to note that although the EC regulations are most applicable to organic farming and foodstuffs in the UK, studies met quality criteria if they mentioned other organic certification bodies. No judgement was made on the quality of these organic definitions, which may be wide-ranging and thereby reduce comparability between organic samples.

Potential biases

- As per protocol, foreign language publications which did not have an English language abstract were excluded.
- As per protocol, grey literature was excluded from the review. Non-significant findings may be more likely to be available in grey literature.

- Despite considerable efforts, we were unable to locate a small number of potentially relevant publications.
- It is possible that authors did not report all laboratory analyses conducted in their research (reporting bias). Non-significant findings are more likely to be omitted from research papers (26).
- It is possible that journal publishers were less likely to publish papers reporting non-significant differences (publication bias) (26).

7.0 CONCLUSION

No evidence of a difference in content of *nutrients and other substances* between organically and conventionally produced crops and livestock products was detected for the majority of nutrients assessed in this review suggesting that organically and conventionally produced crops and livestock products are broadly comparable in their nutrient content. The differences detected in content of *nutrients and other substances* between organically and conventionally produced crops and livestock products are biologically plausible and most likely relate to differences in crop or animal management, and soil quality. There is no good evidence that increased dietary intake of the nutrients identified in this review which are present in larger amounts in organically than in conventionally produced crops and livestock products, would be of benefit to individuals consuming a normal varied diet, and it is therefore unlikely that these differences in nutrient content are relevant to consumer health.

It should be noted that these conclusions relate to the evidence base currently available, which contains limitations in the design and in the comparability of studies. The current evidence base is comprised of studies which investigate a wide variety of foodstuffs and nutrients, and which make use of many different agricultural practices and scientific methods. Examination of this scattered evidence indicates a need for further high-quality research in this field.

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Appendix 1: *Nutrient and Other Substances* Search Terms

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.

Appendix 2: Fields Used to Record Data from Crop Studies

Field	Description
Unique identifier	A unique code given to each study used throughout the review
Author	
Year	
Study Type	Field trial/Farm survey/Basket Study/Other study type
Production System	Organic/Ecological vs. Conventional/ Sustainable/Hydroponic/Bio-dynamic/ Integrated
Organic Regulation†	Certifying body or description of organic practices
Source of Funding	
Quality	Satisfactory/Unsatisfactory [based on 5 criteria (†)]
Cultivar†	
Common Name of Crop	
Period of Agricultural Practice on Crop	Time since organic certification introduced
Location of Study	City/Region, Country where experiment conducted
Climate	General climatic characteristics of region, as well as weather conditions during the experiment
Tilling	Description of tilling method, e.g. instrument, season, frequency
Irrigation	Description of irrigation method, e.g. instrument, water source, season, frequency
Soil Type	
Fertilisers & Soil Fertility	All information on crop rotation, cover crops, fertilisers (frequency & quantity)
Length of Fallow	Period which soil was unplanted prior to planting study crop
Previous Crop	Previous crop growing on soil used for study crop
Length of Growing Season	
Method of Harvesting	Description of harvest method, e.g. hand picking, plot harvesting, visually selected samples
Time of Planting & Time of Harvesting	Specification of month

Field	Description
Age at which Picked	Description of maturity, e.g. ripeness, size, time elapsed since planting
Transportation	Description of transportation between research site and laboratory for testing, including mode & time in transit
Cold Chain	Whether cold chain maintained for duration of transportation [Yes/No]
Processing & Preparation	Handling of samples prior to laboratory analysis
Packaging	Packaging of sample as available to consumer (basket studies)
Storage	Description of storage including temperature, duration, medium
Other	Additional information not covered previously
Source of Samples	Description of sample source e.g. controlled research plots, working farms, where purchased (basket surveys only)
Sample Size	Quantity of samples tested, e.g. number of fruit, weight, number of plots
Age at which Tested	Length of time between harvest and laboratory analysis
Preparation of Sample for Testing	Description of procedures prior to testing crop, e.g. drying, pressing, homogenising, peeling, grinding etc.
Nutrient†	As reported by authors
Nutrient Category	General category created for groups of nutrients, designed to synthesise results e.g. vitamins, organic acids
Dry/Fresh Weight	Hydration of sample [dry/fresh]
Laboratory Analysis†	Laboratory technique as reported by author
Unit of Analysis	As reported in results, e.g. $\mu g\ g^{-1}$, ppm, %.
Statistical Analysis†	Statistical tests as reported by author
Result	Organic & conventional values, means, SDs, ranges all recorded where presented.

† Refers to fields used for measuring quality

Appendix 3: Fields Used to Record Data from Livestock Product Studies

Field	Description
Unique identifier	A unique code given to each study used throughout the review
Author	
Year	
Study Type	Field trial/Farm survey/Basket Study
Production System	Organic/Ecological vs. Conventional/ Sustainable/Hydroponic/Bio-dynamic/ Integrated/Free-range
Organic Regulation†	Certifying body or description of organic practices
Source of Funding	
Quality	Satisfactory/Unsatisfactory (based on composite score of 5 criteria [†])
Species	A unique code given to each study used throughout the review
Breed†	
Sex	
Location of Study	City/Region, Country where experiment conducted
Born of Organic Holdings	Whether parents of tested livestock were reared organically [Yes/No]
Fodder	Description of animal feed, including quantity, nutrient composition
Animal Housing	Description of housing, including size, density of animals, free-range/barn (chickens)
Weaning/Starter Diet Period	Length of time fed starter diet
Fattening Diet	Length of time fed fattening diet
Final Weight	Weight at slaughter
Age at Slaughter	
Method of Slaughter	Description of slaughter, e.g. manual exsanguination, stunning
Type of Storage	Description of storage including temperature, duration, medium
Transportation	Description of transportation between research site and laboratory for testing, including mode & time in transit

Field	Description
Cold Chain	Whether cold chain maintained for duration of transportation [Yes/No]
Processing & Preparation	Handling of samples prior to laboratory analysis
Packaging	Packaging of sample as available to consumer (basket studies)
Other	Additional information not covered previously
Source of Samples	Description of sample source e.g. controlled research plots, working farms, where purchased (basket surveys only)
Sample Size	Quantity of samples tested, e.g. number of fruit, weight, number of plots
Age of Sample at Testing	Length of time between harvest and laboratory analysis
Preparation of Sample for Testing	Description of procedures prior to testing crop, e.g. drying, pressing, homogenising, peeling, grinding etc.
Nutrient†	As reported by authors
Nutrient Category	General category created for groups of nutrients, designed to synthesise results e.g. vitamins, organic acids
Cut/Type	Cut
Dry/Fresh Weight	Hydration of sample [dry/fresh]
Laboratory Analysis†	Laboratory technique as reported by author
Statistical Analysis†	As reported in results, e.g. $\mu g\ g^{-1}$, ppm, %.
Unit of Analysis	Statistical tests as reported by author
Result	Organic & conventional values, means, SDs, ranges all recorded where presented.

† Refers to fields used for measuring quality

Appendix 4: Nutrient Categories in Crop Studies

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
	β-carotene	β-carotene, 13-cis-β-carotene, All-trans-β-carotene, β-carotene equivalents

Nutrient Grouping	Nutrient Category	Nutrients as Reported by Authors
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

Appendix 5: Nutrient Categories in Livestock Product Studies

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

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

Appendix 6: 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

Author	Year	Reason for Exclusion
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)

Author	Year	Reason for Exclusion
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

Author	Year	Reason for Exclusion
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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Appendix 7: Studies Included in the Review

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Appendix 8: Abstracts of Included Studies

Acharya, T. and Vibha B.H. (2007). "Quality assessment of organic and conventional Nagpur mandarins (Citrus reticulata)." *Indian Journal of Nutrition and Dietetics* **44**(8): 403-406.

Mandarins were procured from Jhalawar district of Rajasthan (India) as it is the major district producing Nagpur mandarins in Rajasthan. Six orchards each of organic and conventionally grown mandarins were selected purposively in a single lot and used for the entire experimental work. Samples were analysed for nutritional and sensory qualities. The findings showed that organic and conventional mandarins contained moisture (87.51% and 86.75%), fibre (0.31% and 0.39%), ash (0.40% and 0.31%), total sugar (9.23% and 8.15%), vitamin C (57.33 mg% and 39.92 mg%), calcium (33.02 mg% and 24.15 mg%), magnesium (19.07 mg% and 8.19 mg%), sodium (8.07 mg% and 3.56 mg%) and potassium (11.13 mg% and 7.93 mg%), respectively. It is concluded that organic mandarins were superior to conventional mandarins. Organic mandarins also have a great potential for commercialization in view of its good nutritional and sensory qualities.

Akcay, Y. D., H. K. Yildirim, et al. (2004). "The effects of consumption of organic and nonorganic red wine on low-density lipoprotein oxidation and antioxidant capacity in humans." *Nutrition Research* **24**(7): 541-554.

It is known that moderate red wine consumption can reduce the risk of cardiovascular disease. The protective effects of wine have been attributed to phenolic compounds that are efficient scavengers of free radicals and breakers of lipid peroxidative chain reactions. Besides antioxidant activity, phenols also have anti-inflammatory effects and may protect low-density lipoproteins (LDL) against oxidative modification. The aim of this study was to determine the effects of the so-called "organic" wines (i.e., those that are produced from genetically nonmodified grapes and without fertilization) and "nonorganic" red wines (i.e., those that are produced in a conventional manner) on LDL oxidation, antioxidant activity, and other antioxidant enzymes such as catalase and superoxide dismutase. Male subjects (n = 6) drank 200 mL and female subjects drank (n = 2) 100 mL of red wine (the so-called organic wine) wine, and after 6 weeks the experiment was repeated with the nonorganic red wine. Blood samples were obtained at baseline and after 60 and 360 minutes. Total phenol, erythrocyte superoxide dismutase (e-SOD), erythrocyte catalase (e-CAT), erythrocyte thiobarbituric acid reactive substances (eTBARS), serum total antioxidant activity (AOA), LDL-TBARS, and Cu-stimulated LDL-TBARS levels were determined. Although the Cabernet Sauvignon wine caused a significant increase in eSOD activity during hour 1 (P = 0.046) and hour 6 (P = 0.028) of the experiment compared to the baseline levels, it led to an insignificant increase in eCAT activity in hour 1 (P = 0.08) and hour 6 (P = 0.069). There was no significant difference between two types of wines with respect to LDL-TBARS blood levels, and only the nonorganic wine led to a decrease in Cu-stimulated LDL-TBARS. There were noteworthy differences in the alcohol and phenol content of the organic and nonorganic wines.

Alvarez, C. E., Carracedo, A. E. et al. (1993). "Pineapples Cultivated by Conventional and Organic Methods in a Soil from a Banana Plantation - a Comparative-Study of Soil Fertility, Plant Nutrition and Yields." *Biological Agriculture & Horticulture* **9**(2): 161-171.

A comparative study on conventional and organically grown pineapples cultivated in a soil from a banana plantation has been carried out in the Canary Islands. Garden waste compost was used as fertilizer in the organic treatment and current NPK fertilization in the conventional one. Soil pH, and available Ca and Mg were higher with the compost. "D" leaf N, K, Ca and Mg levels of plants from the conventional treatment exceeded those from the organic one, but only N seemed to influence yields. Foliar Cu and Zn were higher in plants from the compost treatment, but apparently this did not affect pineapple production. Fruits from both treatments had similar size and total weight, and free acids and sugar contents. The weight without crown of the fruits from the conventional treatment was significantly higher.

Amodio, M. L., G. Colelli, et al. (2007). "A comparative study of composition and postharvest performance of organically and conventionally grown kiwifruits." *Journal of the Science of Food and Agriculture* **87**(7): 1228-1236.

Postharvest performance of organic and conventional Hayward kiwifruits grown on the same farm in Marysville, California, and harvested at the same maturity stage were compared in this study. Quality parameters monitored included morphological (shape index) and physical (peel characteristics) attributes of the initial samples. Maturity indices (CO_2 and C_2H_4 production, firmness, color, soluble solids content and acidity) and content of compounds associated with flavor and nutritional quality (minerals, sugars and organic acids, ascorbic acid, total phenolics, and antioxidant activity) were determined at 0, 35, 72, 90 and

120 days of storage at 0 deg C, and after 1 week of shelf-life simulation at 20 deg C, after each storage duration. Organically and conventionally grown kiwifruits had similar soluble solids content at harvest, but conventional kiwifruits had a higher firmness and *L** value, and a lower hue angle and chromaticity, resulting in a lighter green color when compared with the organic kiwifruits. These differences were maintained for all the storage durations, with the soluble solids content increasing more in conventionally grown kiwifruits. The two production systems resulted in different morphological attributes since organic kiwifruits exhibited a larger total and columella area, smaller flesh area, more spherical shape, and thicker skin compared to conventional kiwifruits. All the main mineral constituents were more concentrated in organic kiwifruits, which also had higher levels of ascorbic acid and total phenol content, resulting in a higher antioxidant activity. Sugars and organic acids composition was not affected by the production system.

Angood, K. M., J. D. Wood, et al. (2008). "A comparison of organic and conventionally-produced lamb purchased from three major UK supermarkets: Price, eating quality and fatty acid composition." *Meat Science* **78**(3): 176-184.

Organic and conventional lamb loin chops, labelled as British lamb, were bought from three major UK supermarket chains (designated A, B and C) in the Bristol area on 10 occasions over a six week period. Samples (n = 360) were from unknown production systems but representative of what is available to UK consumers. The nutritional quality of muscle was assessed in terms of its fatty acid composition and eating quality was assessed by a trained sensory panel. Lamb prices varied between 9 and 12.50 pound per kg, with a relatively modest price differential between organic and conventional lamb chops of 1.10 pound, 1.88 pound and 1.16 pound / kg pound for supermarkets A, B and C, respectively. On average, organic chops were 20 g heavier than conventional chops. Chops were relatively lean, having just 14% of subcutaneous fat, approximately half that of a similar survey 10 years ago. Organic lamb had a better eating quality than conventional lamb in terms of juiciness ($p < 0.05$), flavour ($p < 0.05$) and overall liking ($p < 0.05$) thus providing some evidence for the perception among consumers that organic products 'taste better'. Differences in juiciness were attributed to the higher intramuscular fat content of organic meat whilst differences in flavour were attributed to differences in fatty acid composition, in particular, the higher level of linolenic acid (18:3) and total n-3 PUFA in organic chops. Conventional chops had a higher percentage of linoleic acid (18:2). Chops from both productions systems had a favourable n-6:n-3 ratio. The most important difference between the three supermarkets was that lamb flavour was significantly lower in chops from supermarket A, probably due to differences in their 'display until' dates. Chops from supermarket A were also the cheapest.

Annett, L. E., D. Spaner, et al. (2007). "Sensory profiles of bread made from paired samples of organic and conventionally grown wheat grain." *Journal of Food Science* **72**(4): S254-S260.

The Canadian hard red spring wheat cultivar "Park" was grown in 2005 in Edmonton, AB, Canada on both conventionally and organically managed land, situated less than 1 km apart. Grains from the paired wheat samples were compared for cereal-grain-quality attributes. For sensory analysis, organically and conventionally produced wheat grains were milled into flour and baked into 60% whole wheat bread. Color, texture, taste, and aroma attributes of bread were compared using the sensory technique of descriptive analysis. Organic grain contained more wholemeal protein than conventional grain ($P <= 0.05$), but both were greater than 14% protein, indicating excellent grain quality for yeast-leavened bread. Mixograph analysis revealed that conventional flour produced stronger bread dough than organic flour ($P <= 0.05$). Visual observation confirmed these findings as conventional flour produced larger bread loaf volume. Fourteen sensory attributes were generated by the descriptive analysis panel. No differences were observed for flavor, aroma, or color attributes ($P > 0.05$), but the panel perceived the organic bread to be more "dense" in texture ($P <= 0.05$) with smaller air cells in the appearance of the crumb ($P <= 0.05$) than conventional bread.

Anttonen, M. J. and R. O. Karjalainen (2006). "High-performance liquid chromatography analysis of black currant (Ribes nigrum L.) fruit phenolics grown either conventionally or organically." *Journal of Agricultural and Food Chemistry* **54**(20): 7530-7538.

Black currants (Ribes nigrum L.) contain a diverse range of phenolics and possess a high antioxidant activity, which makes them an interesting target for the functional food industry. In this study, phenolic profiles of organically and conventionally grown black currant fruits, collected from commercial farms within a climatically similar area, were compared. Compounds were identified using UV/vis and mass spectroscopy techniques and quantified with high-performance liquid chromatography equipped with UV/vis detection. Several different conjugates of hydroxycinnamic acids, flavonols, and anthocyanins were quantified. Statistically significant differences between farms were found for almost all compounds. Differences between the highest and the lowest measured values of major phenolic compounds of different phenolic classes ranged from 24 to 77%. Principal component analysis quite effectively separated farms from each other but did not cluster them according to cultivation technique. Thus, it was concluded that the biochemical quality of organically grown black currant fruits does not differ from those grown conventionally.

Arnold, R. (1984). "A comparison of quality of liquid milk produced by conventional or alternative farming systems." *Archiv für Lebensmittelhygiene* **35**(3): 66-69.

In sensory tests there was no overall difference between evaluations of or preferences for pasteurized homogenized whole milk produced by conventional methods, and similar milk produced by the Demeter method (organic farming). Compared with conventional milk (CM), Demeter milk (OFM) contained more fat (3.58 vs. 3.50%), C15 and C17 fatty acids and non-protein N, but less protein (av. 3.13 vs. 3.38%), ash, Ca, P, Na, K, valine, methionine, phenylalanine and alanine. Contents of vitamins A and E, β-carotene, thiamin and riboflavin were similar overall, but in Sept. -March, OFM contained more vitamin E and less vitamin A than CM. There was no significant difference in contents of 19 organochlorine pesticides, the only ones found being α-HCH, lindane, HCB, heptachlor epoxide and *p,p*'-DDE in trace amounts. OFM contained on average more Pb and Cd than CM, but contents were within normal ranges. OFM tended to have higher bacterial counts than CM in April-Sept. but in Sept.-March counts of total bacteria, lactic acid bacteria and somatic cells were lower in OFM. Antibiotics were not detected in any sample, coliforms were detected in occasional samples of both types, and *E. coli* in 1 sample of OFM. The OFM formed softer rennet curd than CM but other renneting characteristics did not differ consistently.

Asami, D. K., Y. J. Hong, et al. (2003). "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." *Journal of Agricultural and Food Chemistry* **51**(5): 1237-1241.

Secondary phenolic metabolites play an important role in plant defense mechanisms, and increasing evidence indicates that many are important in human health. To date, few studies have investigated the impact of various agricultural practices on levels of secondary plant metabolites. To address this issue, the total phenolic (TP) content of marionberries, strawberries, and corn grown by sustainable, organic, or conventional cultural practices were measured. Additionally, the effects of three common postharvest processing treatments (freezing, freeze-drying, and air-drying) on the TP content of these agricultural products were also investigated. Statistically higher levels of TPs were consistently found in organically and sustainably grown foods as compared to those produced by conventional agricultural practices. In all samples, freeze-drying preserved higher levels of TPs in comparison with air-drying.

Barrett, D. M., C. Weakley, et al. (2007). "Qualitative and nutritional differences in processing tomatoes grown under commercial organic and conventional production systems." *Journal of Food Science* **72**(9): C441-C451.

Organically grown products experienced a doubling in percent penetration of organic sales into retail markets during the period from 1997 to 2003; however, there is still a debate over the perceived quality advantage of organically, grown fruits and vegetables. In a study focusing on commercial production of processing tomatoes, samples were ananlyzed from 4 growers with matched organic and conventional fields. For the 4 growers studied, individual analysis of variance results indicated that tomato juice prepared from organically product tomatoes on some farms was significantly higher in soluble solids (degrees Brix), higher in consistency, and titratable acidity, but lower in red color, ascorbic acid, and total phenolics content in the microwaved juice. Results were significantly cultivar, environmental; conditions, or other production-related factors. Higher level of soluble solids, titratables acidity, and consistency are desirable for the production of tomato paste, in that tomatoes with these attributes may be more flavorful and require less thermal treatment. This has the potentially a higher quality product due to less thermal degradation of color, flavor, and nutrients. Future work may involve a larger number of commercial growers and correlation to controlled university research plots.

Basker, D. (1992). "Comparison of taste quality between organically and conventionally grown fruits and vegetables." *American journal of alternative agriculture* **7**(3): 129-136.

Panels of 40 to 60 "non-expert " consumers attempted to distinguish between the taste of organically and conventionally grown fruits and vegetables. Wherever possible, samples of the two types of produce were obtained by picking them in the growing orchards/fields to avoid any question of authenticity, and cold-stored without treatment under the same conditions, for periods reflecting their shipping time to markets. Some physical, chemical and instrumental analytical tests were also performed. No consistent preference pattern emerged. For grapefruit, grapes, carrots, spinach, sweet corn and tomatoes, the differences in hedonic ratings and scores between the two types of produce were not significant. For mangoes and orange juice, the conventional type was preferred, while the reverse was true for bananas; in each of these three instances the result could be ascribed to fruit being tasted closer to its optimum maturity. Screening tests were performed to detect any traces, at the parts-per-billion level, of chlorinated hydrocarbons and organophosphorus compounds used as pesticides, or their degradation products. No traces were detected in any of the samples examined (bananas, grapes, carrots, spinach, sweet corn or tomatoes), whether organically or conventionally grown. In those samples examined (bananas, grapes, carrots, spinach, sweet corn and tomatoes) by quantitative tests for the three major fertilizer elements used conventionally (NPK), nitrogen and phosphorus concentrations were not consistently greater, while potassium concentrations were either equal or greater, than in the organically grown samples. Among the anion analyses performed on orange juice, grapefruit juice, carrots, spinach and tomatoes, nitrates and particularly nitrites either were not detected, or occurred at negligible concentrations in all samples. Phosphates were found at higher concentrations, but not significantly so, in four of the five organic products tested; no phosphates were detected in either type of tomatoes.

Baxter, G. J., A. B. Graham, et al. (2001). "Salicylic acid in soups prepared from organically and non-organically grown vegetables." *European Journal of Nutrition* **40**(6): 289-292.

Background: Salicylic acid is a chemical signal in plants acid is a chemical signal in plants infected by pathogens and it is responsible for the anti-inflammatory action of aspirin. Patients who take aspirin have a reduced risk of developing atherosclerosis and colorectal cancer, both of these pathologies having an inflammatory component. Dietary salicylic acid may help to prevent these conditions. We wondered if foods made from organically-reared plantes might have a higher content of salicylic acid than those made from non-organic plants, since the latter are more likely to be protected from infection by the application of pesticides. Objective: To determine if organic vegetable soups have a higher salicylic acid content than non-organic vegetable soups. Methods The contents of salicylic acid in organic and non-organic vegetable soups purchased from supermarkets were determined. Salicylic acid was identified by varying the chromatographic conditions and comparing the retention times of the unknown substance in the extracts with salicylic acid; by treating extracts of the soups with salicylate hydroxylase; and by using GCMS. Salicylic acid was determined by using HPLC with electrochemical detection. Results: Salicylic acid was present in all of the organic and most of the non-organic vegetable soups. The median contents of salicylic acid in the organic and non-organic vegetable soups were 117 (range, 8-1040) $ng.g^{-1}$ and 20 (range, 0-248) $ng.g^{-1}$ respectively. The organic soups had a significantly higher content of salicylic acid ($p=0.0032$ Mann Whitney U test), with a median difference of 59 $ng.g^{-1}$ (95% confidence interval, 18-117 $ng.g^{-1}$)). Conclusions: Organic vegetable soups contained more salicylic acid than non-organic ones, suggesting that the vegetables and plants used to prepare them contained greater amounts of the phenolic acid than the corresponding non-organic ingredients. Consumption of organic foods may result in a greater intake of salicylic acid.

Benge, J. R., N. H. Banks, et al. (2000). "Pairwise comparison of the storage potential of kiwifruit from organic and conventional production systems." *New Zealand Journal of Crop and Horticultural Science* **28**(2): 147-152.

In 1996, the responses of organic and conventional (Kiwigreen) Hayward kiwifruits to typical postharvest handling and storage regimes were compared, as were their compositional attributes. Although harvested on the same day, Kiwigreen fruits were generally more mature, as indicated by soluble solids concentrations, but their average firmness did not differ significantly. Despite the differences in maturity, whole fruit softening during storage at 0 deg C did not differ significantly with production system. However, organic fruits nearly always developed less soft patches on the fruit surface than Kiwigreen fruits with the average difference being significant. Fruits from organic production sites often contained more Ca with the average difference being on the borderline of significance while across all production sites, the incidence of soft patches was negatively associated with the average levels of Ca in fruit. Typical postharvest handling practices, compared to harvesting directly into trays, did not significantly affect whole fruit softening.

Bergamo, P., E. Fedele, et al. (2003). "Fat-soluble vitamin contents and fatty acid composition in organic and conventional Italian dairy products." *Food Chemistry* **82**(4): 625-631.

Fatty acid composition and fat-soluble vitamin concentrations were measured to compare the milk fat composition in organic certified milk and dairy products with those produced by conventional systems. Significantly higher cis-9 trans-11 C-18:2 (CLA), linolenic acid (LNA), trans-11 C-18:1 (TVA) and alpha-tocopherol (TH) concentrations were measured in organic buffalo milk and mozzarella cheese. Similar results were obtained from the analysis of heat-treated cows milk and dairy products where all organic samples contained significantly higher CLA, TVA, LNA, TH and beta-carotene concentrations than did conventional dairy foods. A negligible influence of milk processing on CLA and TVA yield was seen. Among the different parameters, the CLA/LA ratio value better characterised organic versus conventional milk fat and its use as a marker for the identification of organic dairy products is suggested. The influence of animal diet, and potential implications of milk fat composition, on nutritional quality of organic dairy products is considered.

Bicanová, E., I. Capouchová, et al. (2006). "The effect of growth structure on organic winter wheat quality." *Žemdirbystė, Mokslo Darbai* **93**(4): 297-305.

The effects of inter-row distance (125, 250 and 375 mm) and sowing rate (200, 300 and 400 seeds/m^2) on the grain yield and protein content of two winter wheat cultivars (Ludwig and Sulamit) grown in organic and conventional farming were studied during 2004/05 and 2005/06, in the Czech Republic. Grains from organic farming had lower protein content than those from conventional farming when grown under 125 mm inter-row distance. However, when the distance between rows was increased from 125 to 375 mm in organic farming, the grain protein content increased by 0. 5-1.3% depending on the cultivar. Widening the row spaces did not decrease grain yield.

Borguini, R. G. and M. V. d. Silva (2005). "Physical-chemical and seasonal characteristics of organic tomato in comparison to the conventional tomato." *Alimentos e Nutricao* **16**(4): 355-361.

This survey seeks to describe the physical, chemical and sensorial characteristics of organic tomato in comparison to the conventional tomato. Samples of tomatoes Carmem and Débora cultivate produced through the organic and conventional underwent physical analyses of texture and colour, and chemical analyses of pH, total soluble solids and titratable acidity. Samples also were sensorally evaluated for aroma, flavour, colour and general aspect. The results showed that Carmem and Débora cultivate did not present significant differences between the organic and conventionally grown tomatoes, in relation to the tonality of red. It can be observed that the texture presented very similar values between the organic lot (8,85 N x 10^5) and conventional lot (8,47 N x 10^5) of Carmem cultivate. Débora cultivate exhibited values of 10.28 and 9.38 N x 10^5, these values were observed for the organic and conventional cultivation, respectively. The values of pH, total soluble solids and titrable acidity exhibit differences for organic and conventional tomatoes. Through the sensorial analysis of the fruits, it was verified that just for the flavour and general aspect had significant difference at the level of 5% among the treatments.

Borguini, R. G. and M. V. d. Silva (2007). "Nutrient contents of tomatoes from organic and conventional cultivation. *Higiene Alimentar* **21**(149): 41-46.

Tomatoes cv. Carmem and Debora were cultivated under organic or conventional conditions and compared with regard to contents of ascorbic acid, lycopene, β-carotene and minerals (P, K, Ca, S, Cu and Fe). Conventionally produced Debora tomatoes had higher ascorbic acid contents than other samples (28.9 vs. 21.9-24.9 mg/100g), whereas lycopene and carotene contents did not differ significantly between organically and conventionally grown samples for either cv. Organic Carmem and Debora tomatoes had lower contents of Ca and higher contents of S than their conventionally grown counterparts.

Briviba, K., B. A. Stracke, et al. (2007). "Effect of consumption of organically and conventionally produced apples on antioxidant activity and DNA damage in humans." *Journal of Agricultural and Food Chemistry* **55**(19): 7716-7721.

The present study was performed to compare the effects on antioxidant activity and on DNA damage of organic and conventionally produced apples grown under controlled conditions in human peripheral blood lymphocytes. Six healthy volunteers consumed either organically or conventionally grown apples (Golden Delicious, 1000 g) from two neighboring commercial farms in a double-blinded, randomized, cross-over study. The average content of total identified and quantified polyphenols in the organically and conventionally produced apples was 308 and 321 micro g/g fresh weight, respectively. No statistically significant differences in the sum of phenolic compounds or in either of the polyphenol classes were found between the agricultural methods. Consumption of neither organically nor conventionally grown apples caused any changes in antioxidant capacity of low-density lipoproteins (lag time test), endogenous DNA strand breaks, Fpg protein-sensitive sites, or capacity to protect DNA against damage caused by hydrogen peroxide. However, a statistically significant decrease in the levels of endonuclease III sensitive sites and an increased capacity to protect DNA against damage induced by iron chloride were determined 24 h after consumption in both groups of either organic or conventionally grown apples, indicating the similar antigenotoxic potential of both organically and conventionally grown apples.

Carbonaro, M. and Mattera, M. (2001). "Polyphenoloxidase activity and polyphenol levels in organically and conventionally grown peach (*Prunus persica L., cv. Regina bianca*) and pear (*Pyrus communis L., cv. Williams*)." *Food Chemistry* **72**(4): 419-424.

Polyphenoloxidase (PPO) activity and total polyphenol content were tested in organically and conventionally grown whole fruits, peach (*Prunus persica L., cv. Regina bianca*) and pear (*Pyrus communis L., cv. Williams*), in order to evaluate the existence of a relationship between these parameters and of differences between fruits obtained with the two cultivation practices. Organic fruits were obtained on three different grounds: subterranean clover (sample A), spontaneous weed cover (sample B) and tilled (sample C). From the latter soil, the conventionally grown fruits were produced. All organic peach samples showed a highly significant ($P<0.001$) increase in polyphenols (mg equivalents of tannic acid/100 g fresh sample) compared with conventional peaches, while, of the three organic pear samples, samples B and C displayed an increased polyphenol content with respect to the conventionally grown sample ($P<0.05$). Activity of PPO (U.E./100 g fresh sample), extracted in appropriate conditions and tested towards 1 mM chlorogenic and caffeic acid, was significantly higher in most of the organic peach and pear samples analyzed with respect to the conventional samples.

Carbonaro, M., Mattera, M. et al. (2002). "Modulation of antioxidant compounds in organic vs conventional fruit (peach, *Prunus persica L.*, and pear, *Pyrus communis L.*)." *Journal of Agricultural and Food Chemistry* **50**(19): 5458-5462.

Despite the increasing interest in organic products, knowledge about how different levels of fertilization affect nutritionally relevant components is still limited. The concentration of polyphenols and the activity of polyphenoloxidase (PPO), together with the content in ascorbic acid, citric acid, and alpha- and gamma-tocopherol, were assayed in conventional and organic peach (*Prunus persica L., cv. Regina bianca*) and pear (*Pyrus communis L., cv. Williams*). 2-Thiobarbituric acid reactive substances and the tocopherolquinone/alpha-tocopherol ratio were used as markers of oxidative damage in fruits. A parallel increase in polyphenol content and PPO activity of organic peach and pear as compared with the corresponding conventional samples was found. Ascorbic and citric acids were higher in organic than conventional peaches, whereas a.-tocopherol was increased in organic pear. The concentration of oxidation products in organic samples of both fruits was comparable to that of the corresponding conventional ones. These data provide evidence that an improvement in the antioxidant defense system of the plant occurred as a consequence of the organic cultivation practice. This is likely to exert protection against damage of fruit when grown in the absence of pesticides.

Carcea, M., Salvatorelli, S. et al. (2006). "Influence of growing conditions on the technological performance of bread wheat (*Triticum aestivum L.*)." *International Journal of Food Science and Technology* **41**: 102-107.

Six bread wheat cultivars were grown in the same environment according to a conventional and an organic agricultural protocol. Hardness, moisture, test weight, protein and ash content and falling number were determined on kernels. Flour yield, particle size distribution and damaged starch were determined on flours together with farinograph and alveograph parameters. Loaves of bread were also baked following a straight dough standardised recipe. Results indicated that protein content was the quality parameter which was negatively influenced by organic farming. Hardness was also negatively influenced in four out of six cultivars, whereas the other technological parameters did not show the same trend for all the cultivars. The milling performance was similar between organic and conventional samples, whereas the differences in protein contents were clearly responsible for differences in rheological properties. As expected, volumes of the organic loaves of breads were significantly lower than those of the corresponding conventional ones.

Caris-Veyrat, C., Amiot, M. J. et al. (2004). "Influence of organic versus conventional agricultural practice on the antioxidant microconstituent content of tomatoes and derived purees; Consequences on antioxidant plasma status in humans." *Journal of Agricultural and Food Chemistry* **52**(21): 6503-6509.

The present study aims first to compare the antioxidant microconstituent contents between organically and conventionally grown tomatoes and, second, to evaluate whether the consumption of purees made of these tomatoes can differently affect the plasma levels of antioxidant microconstituents in humans. When results were expressed as fresh matter, organic tomatoes had higher vitamin C, carotenoids, and polyphenol contents (except for chlorogenic acid) than conventional tomatoes. When results were expressed as dry matter, no significant difference was found for lycopene and naringenin. In tomato purees, no difference in carotenoid content was found between the two modes of culture, whereas the concentrations of vitamin C and polyphenols remained higher in purees made out of organic tomatoes, For the nutritional intervention, no significant difference (after 3 weeks of consumption of 96 g/day of tomato puree) was found between the two purees with regard to their ability to affect the plasma levels of the two major antioxidants, vitamin C and lycopene.

Castellini, C., Mugnai, C. et al. (2002). "Effect of organic production system on broiler carcass and meat quality." *Meat Science* **60**(3): 219-225.

The effect of organic production on broiler carcass and meat quality was assessed. Two hundred and fifty Ross male chickens were assigned to two different systems of production: conventional, housing in an indoor pen (0.12 m(2)/bird); organic, housing in an indoor pen (0.12 m(2)/bird) with access to a grass paddock (4 m(2)/bird). At 56 and 81 days of age, 20 chickens per group were slaughtered to evaluate carcass traits and the characteristics of breast and drumstick muscles (m. pectoralis major and m. Peroneus longus). The organic chickens had carcasses with a higher breast and drumstick percentages and lower levels of abdominal fat. The muscles had lower pHu and water holding capacity. Instead cooking loss, lightness values, shear values, Fe, polyunsaturated fatty acids of n-3 series and TBA-RS were higher. The sensory quality of the breast muscle was better. Organic production system seems to be a good alternative method, due to better welfare conditions and good quality of the carcass and meat. A negative aspect was the higher level of TBA-RS in the muscles, probably due to greater physical activity.

Caussiol, L. P. and D. C. Joyce (2004). "Characteristics of banana fruit from nearby organic versus conventional plantations: A case study." *Journal of Horticultural Science & Biotechnology* **79**(5): 678-682.

This case study reports the post-harvest qualities of conventionally versus organically grown banana fruit from nearby plantations in the Dominican Republic. The comparison involved six repeated harvests over the transition from cooler to hotter seasons. Green mature Cavendish 'Grande Naine' banana fruit were shipped to the UK. They were triggered to ripen with ethylene gas and kept under simulated retail conditions. Fruit mass, colour, firmness and flavour parameters were measured every second day over 12 d of shelf life. Sensory comparisons were conducted on four of the six harvest times. Significant differences ($P<0.05$) in measured quality attributes between conventionally and organically grown fruit were few and marginal. Moreover, any differences were inconsistent across harvest-times and during shelf life. Thus, organically and conventionally grown product had almost identical qualities. Sensory comparison confirmed that there was no flavour difference. This case study provides data that challenge a general perception that organic bananas have better flavour than conventional bananas.

Cayuela, J. A., J. M. Vidueira, et al. (1997). "Influence of the ecological cultivation of strawberries (*Fragaria x ananassa cv. Chandler*) on the quality of the fruit and on their capacity for conservation." *Journal of Agricultural and Food Chemistry* **45**(5): 1736-1740.

The quality of strawberries cultivated ecologically was studied and compared with that of conventionally cultivated strawberries. Cv. Chandler was cultivated in adjacent plots in Almonte, Huelva, Spain, in plastic tunnels, under identical environmental conditions. Ecological plots received farmyard manure as a basal dressing, and humic acids and liquefied poultry manure were applied via the irrigation system; only approved pesticides were used. The conventional plots received synthetic fertilizers at equivalent rates of NPK, and chemical pesticide use was permitted. Yields for the ecological and conventional plots were 21000 and 37000 kg/ha, respectively. The quality parameters analysed were both physical and chemical. The organoleptic characteristics of both types of fruit were evaluated by a taste panel. By means of a simulation trial, possible differences between changes in the quality of the fruits from each group during transportation and shelf life were examined. The results showed that the ecologically-grown fruits had a superior quality to the conventionally grown fruits, the former showing a more intense colour, higher sugar and DM contents, and better organoleptic characteristics. Ecologically-grown fruits had a higher resistance to deterioration during simulated marketing conditions and thus a better storage quality.

Chang, P., Salomon,. M. (1977). "Metals in grains sold under various label - organc, natural, conventional." *Journal of Food Quality* **1**(4): 373-377.

Samples of barley, brown rice, corn meal and lentils purchased under labels as organic and natural were compared for metal content to samples marketed normally (conventinal). With very few exceptions no significant differences were found between the market labels. Differences between replicate samples of similarly labeled grains were very large and inconsistent. There appeared to be more Zn and Pb in "organic" corn meal than in the "natural" but more Cu in the "natural." Average levels (range) of metals (µgms/gm) are similar to those reported in the literature: (Fe, 13–117) (Zn, 12–42) (Cu, 0.8–9), (Pb, 0.5–7) (Cd, .09–0.4). Lentils accumulate higher levels of metals than the cereal grains.

Chassy, A. W., L. Bui, et al. (2006). "Three-year comparison of the content of antioxidant microconstituents and several quality characteristics in organic and conventionally managed tomatoes and bell peppers." *Journal of Agricultural and Food Chemistry* **54**(21): 8244-8252.

Understanding how the environment and production and cultivation practices influence the composition and quality of food crops is fundamental to the production of high-quality nutritious foods. In this 3-year study, total phenolics, percent soluble solids, ascorbic acid, and the flavonoid aglycones quercetin, kaempferol, and luteolin were measured in two varieties of tomato (Lycopersicon esculentum L. cv. Ropreco and Burbank) and two varieties of bell peppers (Capsicum annuum L. cv. California Wonder and Excalibur) grown by certified organic and conventional practices in a model system. Significantly higher levels of percent soluble solids (17%), quercetin (30%), kaempferol (17%), and ascorbic acid (26%) were found in Burbank tomatoes (fresh weight basis; FWB), whereas only levels of percent soluble solids (10%) and kaempferol (20%) were significantly higher in organic Ropreco tomatoes (FWB). Year-to-year variability was significant, and high values from 2003 influenced the 3-year average value of quercetin reported for organic Burbank tomatoes. Burbank tomatoes generally had higher levels of quercetin, kaempferol, total phenolics, and ascorbic acid as compared to Ropreco tomatoes. Bell peppers were influenced less by environment and did not display cropping system differences.

Clarke, R. P. M., S.B. (1979). "Nutrient composition of tomatoes homegrown under different cultural procedures." *Ecology of Food and Nutrition* **8**: 37-49.

To study the extent to which pH, dry matter, and nine selected nutrients are affected by cultural procedures, two tomato cultivars were grown. Three growers used conventional and three used organic cultural practices. Differences were statistically significant ($P \leq 0.05$) among fruits of the six growers in two seasons for sodium, calcium, zinc, protein and dry matter. There were also differences for one season but not the other in ascorbic acid, carotene, phosphorous, and iron with no differences for either season in magnesium or pH. While results do not differentiate between the two cultural practices on the basis of nutrient composition, organically grown fruits were significantly larger than conventionally grown fruits.

Colla, G., J. P. Mitchell, et al. (2000). "Soil physical properties and tomato yield and quality in alternative cropping systems." *Agronomy Journal* **92**(5): 924-932.

The Sustainable Agriculture Farming Systems (SAFS) Project has studied the transition to low-input and organic alternatives in California's Sacramento Valley. This project compares a 4-year rotation of tomato (*Lycopersicon esculentum*), safflower (*Carthamus tinctorius*), maize (*Zea mays*), and wheat (*Triticum aestivum*) followed by double-cropped bean (*Phaseolus vulgaris*) in the conventional system and oat (*Avena sativa*)-purple vetch (*Vicia benghalensis*) in the low-input and organic systems. A conventional 2-year rotation (tomato-wheat) is also studied. In 1997 and 1998, we evaluated the transition to alternative systems on soil bulk density, water holding capacity, infiltration and storage, water use efficiency, and Brigade tomato yield and quality. No differences in laboratory determinations of soil bulk density and water holding capacity were found; however, *in situ* water holding capacity was highest in the organic system, lowest in the conventional 4-year rotation and intermediate in the low-input and conventional 2-year rotations. In 1998, infiltration during 3-h irrigations was 0.028 $m^3 m^{-1}$ for the conventional, and 0.062 $m^3 m^{-1}$ and 0.065 $m^3 m^{-1}$ for the low-input and organic systems, respectively. Similar results were observed in 1997. The alternative systems required more water per irrigation for uniform application, resulting in higher soil water content in the organic systems throughout 1998. Evapotranspiration was higher in the conventional systems in both years relative to other systems. Tomato yields did not differ among systems in either year. Fruit quality was highest in the conventional 4-year system.

Colla, G., J. P. Mitchell, et al. (2002). "Changes of tomato yield and fruit elemental composition in conventional, low input, and organic systems." *Journal of Sustainable Agriculture* **20**(2): 53-67.

The Sustainable Agriculture Farming System (SAFS) Project was begun in 1988 to compare conventional 4-year and 2-year rotations receiving synthetic fertilizers and pesticides to low input and organic farming systems. In 1998 and 1999, we evaluated the influence of 10 years of organic, low input, and conventional management practices on soil chemical properties, processing tomato yields, and fruit mineral composition. The organic system had highest soil total C, N, soluble P, exchangeable Ca, and K levels as a result of 10 years of manure application and cover crop use. In both years, fruit yields were similar in the three farming systems. Organic fruits contained highest amounts of P, and Ca. Conventionally-grown tomatoes were richer in N, and Na, while the low input system had an intermediate values for N, P, and Na, and the lowest Ca concentration of the three systems.

Dani, C., L. S. Oliboni, et al. (2007). "Phenolic content and antioxidant activities of white and purple juices manufactured with organically- or conventionally-produced grapes." *Food and Chemical Toxicology* **45**(12): 2574-2580.

Although the beneficial effects of moderate wine intake are well-known, data on antioxidant capacity of grape juices are scarce and controversial. The purpose of this study was to quantify total polyphenols, anthocyanins, resveratrol, catechin, epicatechin, procyanidins, and ascorbic acid contents in grape juices, and to assess their possible antioxidant activity. Eight Vitis labrusca juices - white or purple, from organically- or conventionally-grown grapes, and obtained in pilot or commercial scale - were used. Organic grape juices showed statistically different ($p < 0.05$) higher values of total polyphenols and resveratrol as compared conventional grape juices. Purple juices presented higher total polyphenol content and in vitro antioxidant activity as compared to white juices, and this activity was positively correlated ($r = 0.680$; $p < 0.01$) with total polyphenol content. These results indicate that white and purple grape juices can be used as antioxidants and nutritional sources.

Danilchenko, H. (2002). "Effect of growing method on the quality of pumpkins and pumpkin products." *Folia Horticulturae* **14**(2): 103-112.

Three cultivars of *Cucurbita pepo* (Makaronowa Warszawska, Jack O'Lantern and Miranda) and 2 cultivars of *C. maxima* (Stofuntovaja and Bambino) were grown conventionally or organically in a field experiment conducted in Kaunas, Lithuania during 1999-2001 to determine the effects of growing method on the quality of pumpkins and pumpkin products. Organically grown pumpkins recorded higher dry matter, soluble solid, β-carotene, vitamin E and ascorbic acid content compared to conventionally-grown pumpkins, with the exception of cv. Miranda which produced higher ascorbic acid content when grown organically. In sweetmeats with black currants, a strong positive correlation was established between β-carotene and the colour of the products from organically and conventionally grown pumpkins. In sweetmeats with apples, a positive correlation was established between β-carotene and the colour of products from organically grown pumpkin.

Daood, H. G., R. Tömösközi-Farkas, et al. (2006). "Antioxidant content of bio and conventional spice red pepper (*Capsicum annuum L.*) as determined by HPLC." *Acta Agronomica Hungarica* **54**(2): 133-140.

In the present work, biological and conventional forms of spice red pepper obtained from Hungary were analysed using various high performance liquid chromatographic (HPLC) systems for their carotenoid, tocopherol and vitamin C [ascorbic acid] contents. The carotenoid pigment was fractionated into free xanthophylls, monoesters, carotenes and diesters with newly developed reversed phase HPLC, while α-, β-and γ-isomers of vitamin E were separated by normal phase chromatography. Ion-pair chromatography on a C-18 column provided good separation and quantification of vitamin C. The peppers included new resistant varieties and hybrids that are essential for bio-production. It was found that crossing new disease-resistant varieties such as Kaldom and Kalorez with susceptible ones such as Rubin and SZ-20 produced resistant hybrids that contained higher levels of quality components compared to the parents, particularly when grown and cultivated under organic farming conditions.

De Martin, S. and P. Restani (2003). "Determination of nitrates by a novel ion chromatographic method: occurrence in leafy vegetables (organic and conventional) and exposure assessment for Italian consumers." *Food Additives and Contaminants* **20**(9): 787-792.

A novel ion chromatographic method to detect nitrates in vegetables was developed, and the nitrate contents in green salad (a mixture of endive and prickly lettuce), lettuce, chicory, rocket and spinach were determined from Italian markets in 1996-2002. These leaf vegetables were included because they are currently supposed to provide most of the nitrate intake in the typical Italian diet. The highest content of nitrate was detected in chicory (6250 mg kg^{-1}) and rocket (6120 mg kg^{-1}), which are consumed in large quantities in some regions of Italy. Green salad and lettuce contained less nitrate (highest values = 4200 and 3300 mg kg^{-1}, respectively), but because they are consumed more generally, they provided 60% of the total intake of nitrates. Only a few samples were above the legal limits, with seasonal variation. A significantly higher nitrate content was found in organically grown green salad and rocket than in those conventionally produced. These data indicate that the average intake of nitrates from leafy vegetables is below the acceptable daily intake, i.e. 3.7 mg nitrate ion kg^{-1} body weight day^{-1} , but the total intake should be monitored to protect groups at risk, such as children and vegetarians.

DeEll, J. R. and R. K. Prange (1992). "Postharvest Quality and Sensory Attributes of Organically and Conventionally Grown Apples." *Hortscience* **27**(10): 1096-1099.

Postharvest quality and sensory attributes of organically and conventionally grown 'McIntosh' and 'Cortland' apples (*Malus domestica Borkh*.) stored at 3C in ambient air or in controlled atmospheres were evaluated. Organically grown apples had higher soluble solids concentration than conventionally grown apples, while there were no significant differences in firmness or titratable acids content. Organically grown 'McIntosh' were perceived by sensory panelists as firmer than conventionally grown 'McIntosh' at harvest but not after storage, which may have been due to maturity differences. No significant differences were perceived in juiciness, sweetness, tartness, and off-flavor of apples at harvest or after storage.

DeEll, J. R. and R. K. Prange (1993). "Postharvest physiological disorders, diseases and mineral concentrations of organically and conventionally grown McIntosh and Cortland apples." *Canadian Journal of Plant Science* **73**(1): 223-230.

Environmental effects and human health risks associated with synthetic chemicals have prompted several apple growers to convert to organic production. Organically and conventionally grown cv. McIntosh and cv. Cortland apples were stored in refrigerated (3 deg C) ambient air and controlled atmospheres (CA) and evaluated for 2 consecutive years. More of the conventionally grown apples were marketable after storage than of the organically grown apples. Organically grown apples had higher incidence of storage rots (*Penicillium expansum*, *Botrytis cinerea* and *Gloeosporium perennans* [*Pezicula malicorticis*]), apple scab (*Venturia inaequalis*) and russeting. Production method did not influence incidence of brown core. Organically grown McIntosh stored in ambient air for 8 months had the highest incidence of senescent breakdown. Conventionally grown McIntosh stored in CA for 8 months had the highest incidence of internal browning. Conventionally grown McIntosh stored in air had a higher incidence of scald than organically grown McIntosh. After 4 months of storage in air, organically grown McIntosh had the highest incidence of splitting. Production method did not affect fruit Ca or Mg concentrations. Organically grown apples had higher P and K concentrations and lower N concentrations than conventionally grown apples.

del Amor, F. M., A. Serrano-Martinez, et al. (2008). "Differential effect of organic cultivation on the levels of phenolics, peroxidase and capsidiol in sweet peppers." *Journal of the Science of Food and Agriculture* **88**(5): 770-777.

BACKGROUND: Coincident with the changes in agricultural practices from conventional to organic, changes in the nutrient composition of fresh fruits and vegetables have been identified. The levels of peroxidase, total phenolics content, and capsidiol activity in organic as compared with conventional sweet pepper fruit were examined in this study. In order to avoid interferences of environmental factors on the studied parameters, the sweet peppers were grown (organically and conventionally) in a greenhouse under the same soil and climate conditions. RESULTS: Peroxidase was partially purified using the Triton X-114 method and both organic and conventional peppers had the same isoenzymatic form. However, peroxidase activity in organic sweet peppers was higher than in conventional ones, in both maturity stages studied. The level of total phenolics compunds was also higher in organic than in conventional sweet peppers. With respect to the capsidiol activity, expressed as inhibition of fungus growth, it was not affected by the cultivation method at the green mature stage. However, at the red mature stage, organic sweet peppers showed higher capsidiol activity than those grown under the conventional system. CONCLUSION: Sweet peppers grown under organic culture have a maturity-related response, with high levels of phenolic compounds, and peroxidase and capsidiol activity that contribute to disease resistance in organic farming.

Dimberg, L. H., C. Gissen, et al. (2005). "Phenolic compounds in oat grains (*Avena sativa L.*) grown in conventional and organic systems." *Ambio* **34**(4-5): 331-337.

The concentrations of avenanthramides (AVAs), hydroxycinnamic acids (HCAs), a sucrose-linked truxinic acid (TASE), and certain agronomic parameters were analyzed in organically and conventionally grown oats. Three cultivars of oats (i.e. Freja, Sang, and Matilda) were grown according to standards for both conventional and organic farming in Sweden, from 1998 to 2000. Two levels of nitrogen (N) and three replicates were included. Overall, there were significant differences between years, cultivars, and N rate for AVA concentration in the grains, but there were no differences in concentration as a consequence of the conventional or organic cropping system used. The AVA content was higher in the samples grown in 2000, particularly in the cultivar Matilda, and was negatively affected by higher N rates. The HCAs showed cultivar and year differences, but were not influenced by N rates or the cropping system. The HCA content was highest in Matilda, and was significantly lower in samples grown in 1999. The concentration of TASE differed only between years, and was about 100% higher in samples from 1999, compared with samples from 1998 and 2000. The AVA and HCA concentrations were negatively correlated to the yield and specific weight of the grains and positively correlated to the protein content. Conversely, the concentration of TASE was positively correlated to the yield. The specific parameters responsible for the variation in the phenolic compounds are not known, but it seems that factors affecting the yield and/or the specific weight also affect the concentrations of AVAs, HCAs, and TASE in oat grains.

Ellis, K. A., G. Innocent, et al. (2006). "Comparing the fatty acid composition of organic and conventional milk." *Journal of Dairy Science* **89**(6): 1938-1950.

During a 12-mo longitudinal study, bulk-tank milk was collected each month from organic (n = 17) and conventional (n = 19) dairy farms in the United Kingdom. All milk samples were analyzed for fatty acid (FA) content, with the farming system type, herd production level, and nutritional factors affecting the FA composition investigated by use of mixed model analyses. Models were constructed for saturated fatty acids, the ratio of polyunsaturated fatty acids (PUFA) to monounsaturated fatty acids, total n-3 FA, total n-6 FA, conjugated linoleic acid, and vaccenic acid. The ratio of n-6: n-3 FA in both organic and conventional milk was also compared. Organic milk had a higher proportion of PUFA to monounsaturated fatty acids and of n-3 FA than conventional milk, and contained a consistently lower n-6: n-3 FA ratio (which is considered beneficial) compared with conventional milk. There was no difference between organic and conventional milk with respect to the proportion of conjugated linoleic acid or vaccenic acid. A number of factors other than farming system were identified which affected milk FA content including month of year, herd average milk yield, breed type, use of a total mixed ration, and access to fresh grazing. Thus, organic dairy farms in the United Kingdom produce milk with a higher PUFA content, particularly n-3 FA, throughout the year. However, knowledge of the effects of season, access to fresh grazing, or use of specific silage types could be used by producers to enhance the content of beneficial FA in milk.

Ellis, K. A., A. Monteiro, et al. (2007). "Investigation of the vitamins A and E and beta-carotene content in milk from UK organic and conventional dairy farms." *Journal of Dairy Research* **74**(4): 484-491.

During a 12-month longitudinal study, bulk-tank milk was collected from organic (n=17) and conventional (n=19) dairy farms in the UK. Milk samples were analysed for vitamin A (retinol), vitamin E (alpha-tocopherol) and beta-carotene content. The farming system type, herd production level and nutritional factors affecting the milk fat vitamin content were investigated by use of mixed model analyses. Conventionally produced milk fat had a higher mean content of vitamin A than organically produced milk fat, although there were no significant differences in the vitamin E or beta-carotene contents between the two types of milk fat. Apart from farming system, other key factors that affected milk fat vitamin content were season, herd yield and concentrate feeding level. Milk vitamin content increased in the summer months and in association with increased concentrate feeding, whilst higher-yielding herds had a lower milk vitamin E and beta-carotene content. Thus, conventional dairy farms in the UK produced milk with a higher vitamin A content, possibly owing to increased vitamin A supplementation in concentrate feeds. However, knowledge of the effects of season, access to fresh grazing or specific silage types and herd production level may also be used by all producers and processors to enhance the vitamin content in milk.

Eltun, R. (1996). "The Apelsvoll cropping system experiment. III. Yield and grain quality of cereals." *Norwegian Journal of Agricultural Sciences* **10**(1): 7-22.

In the Apelsvoll Cropping System Experiment the productivity and environmental side-effects of six cropping systems, involving conventional, integrated and ecological arable and forage crop systems, are being investigated. The grain yield and quality evaluations for spring sown barley, oats and wheat and also winter wheat are presented for the first four-year cropping period. Yields were reduced by 10-20% in the integrated systems compared with the conventional systems, while the average yield difference for barley, oats and spring wheat with ecological and conventional farming were 33 and 20%, respectively, for the arable and the forage systems. Differences in nutrient availability appeared to be the main reason for yield differences between the cropping systems; the ecological system received only slurry, while both other systems received mineral N. Wheat leaf diseases also seriously affected the yield level of ecological systems. Reduced grain size and protein content in ecological cropping were probably also related to nutrient availability and disease incidence. With regard to Cd content, mycotoxins or pesticide residues in the grain, no differences could be found between cropping systems.

Eurola, M., V. Hietaniemi, et al. (2004). "Selenium content of Finnish oats in 1997-1999: effect of cultivars and cultivation techniques." *Agricultural and Food Science* **13**(1-2): 46-53.

Se-supplemented fertilization is the main factor affecting the selenium (Se) contents of cereals in Finland. Soil and climatic conditions determine the activity of selenate added to soils and bioavailability to plants. In the present study the Se contents and its variation in Finnish oats, the differences between oat cultivars and cultivation techniques were examined. The selenium (Se) contents of oats (*Avena sativa L.*) in Finland were examined during 1997-1999 in 3 types of trial: official variety, organic cultivation variety and organic vs. conventional cultivation trials. Farm samples were also examined. The mean Se contents of oats in official variety trials were 0.110, 0.120 and 0.160 mg kg^{-1} dry weight (dw) range 0.016-0.460 mg kg^{-1}dw in 1997-1999, respectively. The mean Se contents in farm samples were 0.050 and 0.130 mg kg^{-1}dw in 1998 and 1999, ranging between < 0.010 and 0.330 mg kg^{-1} dw. Considerable regional and seasonal variations existed. The Se contents of oats were significantly higher in 1999 probably due to the combined effect of not increased fertilizer level (from 6 to 10 mg Se kg^{-1} fertilizer) and very low precipitation in 1999. The Se contents of oats were significantly lower in organic cultivation, due to the absence of Se-supplemented fertilization. Significant (P < 0.001) cultivar differences were detected in official variety trials. The cultivars Veli and Leila showed higher levels of Se.

Ferreres, F, et al. (2005). "Phenolic compounds in external leaves of tronchuda cabbage (*Brassica oleracea L. var. costata DC*)." *Journal of Agricultural and Food Chemistry* **53**((8)): 2901-7.

Glycosylated kaempferol derivatives from the external leaves of tronchuda cabbage (*Brassica oleracea L. var. costata DC*) characterized by reversed-phase HPLC-DAD-MS/MS-ESI were kaempferol 3-O-sophorotrioside-7-O-glucoside, kaempferol 3-O- (methoxycaffeoyl/caffeoyl)sophoroside-7-O-glucoside, kaempferol 3-O-sophoroside-7-O-glucoside, kaempferol 3-O-sophorotrioside-7-O-sophoroside, kaempferol 3-O-sophoroside-7-O-sophoroside, kaempferol 3-O-tetraglucoside-7-O-sophoroside, kaempferol 3-O-(sinapoyl/caffeoyl)sophoroside-7-O-glucoside, kaempferol 3-O-(feruloyl/caffeoyl)sophoroside-7-O-glucoside, kaempferol 3-O-sophorotrioside, kaempferol 3-O-(sinapoyl)sophoroside, kaempferol 3-O-(feruloyl)sophorotrioside, kaempferol 3-O-(feruloyl)sophoroside, kaempferol 3-O-sophoroside, and kaempferol 3-O-glucoside. These acylated derivatives are reported for the first time in nature, with the exception of kaempferol 3-O-(sinapoyl)sophoroside. Quantification of the identified compounds was achieved by HPLC-DAD and carried out in samples cultivated under conventional or organic practices and collected at different times. In general, samples from organic production exhibited higher total phenolics content than those from conventional practices collected in the same period.

Fischer, I. H., M. C. d. Arruda, et al. (2007). "Postharvest diseases and physical chemical characteristics of yellow passion fruit from organic and conventional crops in the midwest region of São Paulo State." *Revista Brasileira de Fruticultura* **29**(2): 254-259.

After harvested, yellow passion fruit (*Passiflora edulis*) have an increase in rot susceptibility and significant loss of fresh mass. The purposes of this work were to identify and quantify postharvest diseases and to evaluate the physical chemical characteristics of yellow passion fruits grown under conventional and organic cropping systems. Fruits from both cropping systems were individualized and kept in a humid chamber for 24 h, previously at 13 days period at 25 plus or minus 2 deg C and 70-80% RH. The incidence of diseases and the shrinkage index were visually assessed after fruit gathering and, then, every three days. Fruits were also characterized as to skin thickness, pulp content, titratable acidity and soluble solids content. There was high incidence of postharvest diseases in both conventional and organic cropping systems. Anthracnose was the main disease, with 100% of incidence on fruits from both cropping systems, followed by *Fusarium* rot, with 25.5% in the conventional and 19.0% in the organic systems. Incidence of *Phomopsis* rot was higher in the conventional crop (11.0%) than in the organic crop (2.0%). Anthracnose severity was estimated using a diagrammatic scale, and corresponded to 34.1% in organic fruits and 39.8% in conventional ones. Organic fruits were bigger, and presented greater skin thickness, less pulp content and greater soluble solids amount. Shrinkage indexes of fruit from both cropping systems did not differ. The results suggest the adoption of phytosanitary control in the field and during postharvest stage aiming fruits with better quality.

Forster, M. P., E. R. Rodriguez, et al. (2002). "Differential characteristics in the chemical composition of bananas from Tenerife (Canary Islands) and Ecuador." *Journal of Agricultural and Food Chemistry* **50**(26): 7586-7592.

The contents of moisture, protein, ash, ascorbic acid, glucose, fructose, total sugars, and total and insoluble fiber were determined in cultivars of bananas (Gran Enana and Pequena Enana) harvested in Tenerife and in bananas (Gran Enana) from Ecuador. The chemical compositions in the bananas from

Tenerife and from Ecuador were clearly different. The cultivar did not influence the chemical composition, except for insoluble fiber content. Variations of the chemical composition were observed in the bananas from Tenerife according to cultivation method (greenhouse and outdoors), farming style (conventional and organic), and region of production (north and south). A highly significant ($r = 0.995$) correlation between glucose and fructose was observed. Correlations of ash and protein contents tend to separate the banana samples according to origin. A higher content of protein, ash, and ascorbic acid was observed as the length of the banana decreased. Applying factor analysis, the bananas from Ecuador were well separated from the bananas produced in Tenerife. An almost total differentiation (91.7%) between bananas from Tenerife and bananas from Ecuador was obtained by selecting protein, ash, and ascorbic acid content and applying stepwise discriminant analysis. By selecting the bananas Pequena Enana using discriminant analysis, a clear separation of the samples according to the region of production and farming style was observed.

Garnweidner, L., E. Berghofer, et al. (2007). "Comparison of health-relevant contents in apple juices from organical and/or conventional production." *Mitteilungen Klosterneuburg* **57**(2): 108-115.

This research compared the health potential of 49 organically and 57 conventionally produced apple juices. The contents of phenolic compounds as well as the antioxidative capacity were evaluated. Both products varied in their contents of phenolic compounds determined by the Folin-Ciocalteu reagent. Organically produced apple juices had higher values on the average than conventional ones. The antioxidant capacity was determined by two different methods (FRAP-assay, TEAC-method). Organic apple juices showed higher values than conventional ones. Additionally, the contents of single phenolic compounds were analysed by the HPLC-method. The contents of chlorogenic acid predominated quantitatively in both apple juices followed by phloridzin, epicatechin and catechin, where organic juices resulted in higher amounts than conventional juices. Furthermore, organically produced apple juices had higher concentrations of ascorbic acid than conventional ones. Analysis of the mineral nutrients by atomic absorption spectrometry only established differences in the concentrations of sodium. Organic apple juices showed lower concentrations of sodium than conventional apple juices. The reason for the higher values of health potential ingredients of organically produced apple juices could be due to more gentle cultivation methods of organic agriculture (non-use of chemical-synthetic manure and pesticides). Furthermore, technical procedures during production can have substantial influence on the juice. Finally, this research led to the assessment that cloudy or directly pressed apple juices contain higher concentrations of health-relevant ingredients than clear juices or juices which were made from the concentrate.

Guadagnin, S. G., S. Rath, et al. (2005). "Evaluation of the nitrate content in leaf vegetables produced through different agricultural systems." *Food Additives and Contaminants* **22**(12): 1203-8.

The nitrate content of leafy vegetables (watercress, lettuce and arugula) produced by different agricultural systems (conventional, organic and hydroponic) was determined. The daily nitrate intake from the consumption of these crop species by the average Brazilian consumer was also estimated. Sampling was carried out between June 2001 to February 2003 in Campinas, Sao Paulo State, Brazil. Nitrate was extracted from the samples using the procedure recommended by the AOAC. Flow injection analysis with spectrophotometric detection at 460 nm was used for nitrate determination through the ternary complex $FeSCNNO^+$. For lettuce and arugula, the average nitrate content varied ($p < 0.05$) between the three agricultural systems with the nitrate level in the crops produced by the organic system being lower than in the conventional system that, in turn, was lower than in the hydroponic system. For watercress, no difference ($p < 0.05$) was found between the organic and hydroponic samples, both having higher nitrate contents ($p < 0.05$) than conventionally cultivated samples. The nitrate content for each crop species varied among producers, between different parts of the plant and in relation to the season. The estimated daily nitrate intake, calculated from the consumption of the crops produced by the hydroponic system, represented 29% of the acceptable daily intake established for this ion.

Gundersen, V., I. E. Bechmann, et al. (2000). "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)." *Journal of Agricultural and Food Chemistry* **48**(12): 6094-6102.

210 samples of onions (*Allium cepa* Hysam) from 11 conventionally and 10 organically cultivated sites and 190 samples of peas (*Pisum sativum* Ping Pong) from 10 conventionally and 9 organically cultivated sites in Denmark were collected and analyzed for 63 and 55 major and trace elements, respectively, by high-resolution inductively coupled plasma mass spectrometry. Sampling, sample preparation, and analysis of the samples were performed under carefully controlled contamination-free conditions. Comparative

statistical tests of the element concentration mean values for each site show significantly ($p < 0.05$) different levels of Ca, Mg, B, Bi, Dy, Eu, Gd, Lu, Rb, Sb, Se, Sr, Ti, U, and Y between the organically and conventionally grown onions and significantly ($p < 0.05$) different levels of P, Gd, and Ti between the organically and conventionally grown peas. Principal component analysis (PCA) applied to the 63 elements measured in the individual onion samples from the 21 sites split up the sites into two groups according to the cultivation method when the scores of the first and third principal components were plotted against each other. Correspondingly, for peas, a PCA applied to the 55 elements measured as mean values for each site split up the 19 sites into two groups according to the cultivation method when the scores of the third and fourth principal component were plotted against each other. The methodology may be used as authenticity control for organic cultivation after further method development.

Gutiérrez, F., T. Arnaud, et al. (1999). "Influence of ecological cultivation on virgin olive oil quality." *Journal of the American Oil Chemists' Society* **76**(5): 617-621.

The quality of oil extracted from organically cultivated olives (cv. Picual) was compared with oil extracted from Picual olives cultivated using conventional methods. Olive trees were grown in a two-section plot. Fruits from each plot were harvested at various stages of ripeness, and acidity value, peroxide index, ultraviolet absorption at 232 and 270 nm, stability to oxidation, sensory analysis, fatty composition, and contents of tocopherols, phenolic compounds, and sterols were determined on oil extracted from each treatment. The results showed that the virgin olive oil produced by organic culture was of a superior quality to the conventional virgin olive oil for all the quality parameters analysed.

Haglund, A., L. Johansson, et al. (1998). "Sensory evaluation of wholemeal bread from ecologically and conventionally grown wheat." *Journal of Cereal Science* **27**(2): 199-207.

The purpose of the project was to study how conventional and ecological farming systems and different dough kneading intensity affected the baking properties of wholemeal flour, and how those properties affected the taste and consistency of wholemeal bread. Sensory evaluations were performed with respect to wholemeal tin leaves from winter wheat. The dough from each wheat sample was divided into two parts. One part was subjected to low kneading intensity, the other to high kneading intensity. High kneading intensity refers to standard commercial practices. Wholemeal from the conventional farming system had a higher protein content than wholemeal from ecological farming systems. Wholemeal from the conventional farming system resulted in bread with a large volume and a high degree of elasticity while wholemeal from ecological farming systems resulted in a dry bread. High kneading intensity generally resulted in a dry and less elastic bread which had a significantly stronger tinge of grey on the surface of the slice.

Hajslova, J., V. Schulzova, et al. (2005). "Quality of organically and conventionally grown potatoes: four-year study of micronutrients, metals, secondary metabolites, enzymic browning and organoleptic properties." *Food Addit Contam* **22**(6): 514-34.

The quality of potatoes from organic and conventional farming was investigated in this study. Tubers of eight potato varieties, organically and conventionally produced at one or two geographical sites in controlled field trials, were collected in four consecutive harvests from 1996-1999. The parameters analysed included nitrate, trace elements (As, Cd, Co, Cu, Fe, Hg, Mn, Ni, Pb, Se, Zn), vitamin C, potato glycoalkaloids, as well as chlorogenic acid, polyphenol oxidase and rate of tuber enzymic browning. The results indicated lower nitrate content and higher vitamin C and chlorogenic acid content to be the parameters most consistently differentiating organically from conventionally produced potatoes. Elevated concentrations of glycoalkaloids were also observed throughout the experiments in some potato varieties grown in organic farming systems. Principal component analysis (PCA) of the analytical and other data using three PCs confirmed a good separation between the organically and conventionally produced potatoes when studied in single crop years. However, score-plots (objects) and loading-plots (variables) of pooled results from the consecutive harvests showed that between the years' changes and also variety as well as geographical variations are equally or more important factors determining the quality of potatoes than the farming system. Further studies of various marker compounds of potato quality related to the organic or conventional farming systems should be performed before unbiased information can be given to the consumers.

Hakala, M., A. Lapveteläinen, et al. (2003). "Effects of varieties and cultivation conditions on the composition of strawberries." *Journal of Food Composition and Analysis* **16**(1): 67-80.

Mineral elements, vitamin C and pesticides of frozen strawberries (*Fragaria* x a*nanassa* Duch.) grown in Finland were studied. 'Senga Sengana', 'Jonsok', 'Korona', 'Polka', 'Honeoye' and 'Bounty' were cultivated applying normal farming practices and harvested analogously in 1997 and 1998. Organically cultivated 'Polka', 'Jonsok' and 'Honeoye' were also analysed. The variation of components in the 'Senga Sengana' fruit of two domestic and two imported origins was investigated. Ca, Mg, K, Fe, Zn, Cu, and Mn were determined using an atomic absorption spectrometer applying the flame technique, Cd and Pb applying the graphite furnace technique. Vitamin C was measured by using high-pressure liquid chromatography. The average concentration of vitamin C ranged from 32.4 mg/100 g to 84.7 mg/100 g. Strawberries were found to be a good source of potassium (1.55-2.53 g/kg), magnesium (0.11-0.23 g/kg) and calcium (0.16-0.29 g/kg). The lead content was in general below its detection limit (0.004 mg/kg). The cadmium level in the Finnish berries was lower than 0.016 mg/kg. In all samples levels of pesticides were below their maximum residue limits. In general, genotype and origin proved to have a greater effect than the cultivation techniques on parameter levels.

Häkkinen, S. H. and A. R. Törrönen (2000). "Content of flavonols and selected phenolic acids in strawberries and Vaccinium species: influence of cultivar, cultivation site and technique." *Food Research International* **33**(6): 517-524.

The amounts of flavonols (quercetin, myricetin and kaempferol) and phenolic acids (ellagic, *p*-coumaric, caffeic and ferulic acids) were analysed in six strawberry cultivars and in the berries of genus *Vaccinium* (3 *Vaccinium corymbosum*, and *V. brittonii* [*V. angustifolium*] cv. Tumma, wild bilberry (*V. myrtillus*) and wild bog whortleberry (*V. uliginosum*)). Differences between strawberries from organic vs. conventional cultivation were investigated and the influence of geographical origin on phenolic compounds of strawberries and blueberries was studied. Three different extraction and hydrolysis procedures together with two HPLC methods with diode-array UV/vis detection were used. The varietal differences in the total content of the phenolics analysed were larger among the cultivated blueberries (from 4.4 to 9.2 mg/100 g, fresh weight) than among the strawberry cultivars (from 42.1 to 54.4 mg/100 g). Some regional differences were observed in the phenolic contents in blueberries and strawberries. Compared to conventional cultivation techniques, organic cultivation had no consistent effect on the levels of phenolic compounds in strawberries.

Hallmann, E. and E. Rembialkowska (2006). "Antioxidant compounds content in selected onion bulbs from organic and conventional cultivation." *Journal of Research and Applications in Agricultural Engineering* **51**(2): 42-46.

Yellow and red onions contain numerous flavonoids such as quercetin and its derivatives. These compounds are located mostly in internal fresh leaves. Besides flavonoids, the red onion also contains anthocyanins mostly in the external dry skin and also in internal fresh leaves. Onions are a perfect source of sulfur which is an essential element in many metabolic processes. Studies were conducted to determine the antioxidant content of 5 onion cultivars, i.e. Sochaczewska, Wolska, Wenta, Red Baron and Sterling. The dry matter, total and reducing sugars, flavonoids, ascorbic acid and anthocyanins content were determined. Results showed that organically grown onions obtained more flavonoids, ascorbic acid and anthocyanins compared to conventionally grown ones.

Hallmann, E. and E. Rembialkowska (2007a). "The content of bioactive substances in red pepper fruits from organic and conventional production." *Żywienie Czlowieka i Metabolizm* **34**(1/2): 538-543.

Organic agriculture offers food without chemicals, such as mineral fertilizers and pesticides. Organic fruit and vegetables contain more bioactive compounds with antioxidant properties. In Poland, cultivation of red pepper is becoming more and more popular. Red pepper fruits contain a lot of vitamin C, carotenoids, and flavonoids. It also contains capsaicin, an alkaloid, which gives fruits their characteristic spicy taste. An experiment was carried out with 2 red pepper cultivars, Ozarowska and Roberta from organic and conventional production. Fruit dry matter, vitamin C content and total carotenoid content were determined. Results indicate that organic red pepper contained more carotenoids, vitamin C, dry matter and flavonoids in comparison to conventional red pepper.

Hallmann, E., and Rembialkowska, E. (2007b). "Estimation of fruits quality of selected tomato cultivars (*Lycopersicon esculentum* Mill) from organic and conventional cultivation with special consideration of bioactive compounds content." *Journal of Research and Applications in Agricultural Engineering* **52**(3): 55-60.

There is a growing interest for organic farming in Europe and other parts of the world. Consumers are constantly looking for the safe foods rich in the numerous beneficial substances and foods with controlled quality. There are scientific foundations allowing to assume that vegetables and fruits from organic production can contain more beneficial substances (such as polyphenols and ascorbic acid) than crops from the conventional production. Few research studies seem to confirm this hypothesis, but still the knowledge in this respect is insufficient. Studies were conducted to compare the content of bioactive compounds in tomato fruits cultivated in the organic vs. conventional way. The research study comprised the standard cultivars Rumba, Kmicic and Gigant and the cherry tomato cultivar Koralik. The results showed that organic tomatoes contained more total and reducing sugars and more organic acids. Moreover, in the organic fruits, significantly more bioactive compounds such as ascorbic acid, β-carotene, flavonols and phenolic acids were found. Only the content of lycopene was higher in the conventional fruits.

Hallmann, E., E. Rembiakowska, et al. (2007c). Significance of organic crops in health prevention illustrated by the example of organic paprika (*Capsicum annuum*). *Roczniki Panstwowego Zakadu Higieny.* **58**(1): 77-82.

Paprika is a good source of bioactive compounds such as carotenoids (beta-carotene and lutein), flavonoids and vitamin C. The aim of this work is to determine the bioactive compounds in paprika fruits from organic and conventional cultivation. Organic and conventional paprika fruits were chemically analysed. The results obtained showed that organic paprika contained a greater amount of total and reducing sugars, vitamin C and flavonoids compared to the conventional one. Additionally, organic paprika fruits had slightly higher acidity than conventional fruits.

Hamouz, K., J. Epl, et al. (1999a). "Influence of locality and way of cultivation on the nitrate and glycoalkaloid content in potato tubers." *Rostlinná Výroba* **45**(11): 495-501.

In 1995-97 field trials were conducted in the Czech Republic with potatoes to investigate the effects of soil and environmental conditions of localities with different altitudes, cultivars, years and conventional or organic farming systems on the tuber nitrate content (in 7 cultivars) and α-solanine and α-chaconine (in cv. Karin). A higher nitrate content (145.1 mg NO_3^-kg fresh weight) was found in tubers from drier and warmer lower regions in comparison with higher regions (traditional potato-growing regions) (114.4 mg NO_3^-kg). There were significant differences in nitrate contents among cultivars, with the highest content in Impala and the lowest in Agria. Annual variation in nitrate content ranged from 107.0 to 168.9 mg/kg. Organic farming methods may have decreased tuber nitrate content compared with conventional farming methods. Tuber glycoalkaloid contents were variable but were possibly higher with organic farming methods.

Hamouz, K. L., J., Pivec, V. (1999b). "Influence of environmental conditions and way of cultivation on the polyphenol and ascorbic acid content in potato tubers." *Rostlinna Vyroba* **45**(7): 293-298.

In 1995 till 1997 field trials were conducted to study the influence of environmental conditions of regions with different altitudes, variety, year and ecological way of cultivation on total polyphenol content (in Agria and Karin variety) and ascorbic acid (in seven varieties after five months of storage) in potato tubers. In three year trials significantly higher total polyphenol content was determined (46.25 mg.100 g^{-1}) in potato tubers from traditional potato regions of the Czech Republic with higher altitude (cooler and more humid). Highly significant differences of total polyphenol contents were found between two used varieties. In potatoes cultivate in ecological way in three year period higher total polyphenol content in tubers (47.64 mg.100 g^{-1}) was found than in potatoes cultivated in conventional way (43.20 mg.100 g^{-1}). Our experiments have not proved dependence of ascorbic acid content on different ecological conditions. Significant influence on ascorbic acid content has shown the variety.

Hamouz, K., J. Lachman, et al. (2005). "The effect of ecological growing on the potatoes yield and quality." *Plant Soil and Environment* **51**(9): 397-402.

In the years 1995–1997 the effect of ecological growing on the yield and selected parameters of quality of consumer potatoes (in comparison with conventional way) were investigated. The ecological way of growing differed in the lack of chemical protection against diseases and pests and industrial fertilizers. Field trials were realised with seven varieties (Impala, Karin, Agria, Korela, Rosella, Santé and Ornella) on two sites (Uhříněves and Valečov). The ecological way of growing had markedly negative effect on the yield (decrease by 36%). In qualitative parameters the ecological way increased inconclusively polyphenol content (by 10.2%), decreased inconclusively nitrate content (by 11.0%) and reducing sugars (by 22%). It did not affect dry matter content, resistance of tubers to mechanical damage, table value and glycoalkaloid content. Variety Santé achieved the best results from the point of view of the yield and majority of qualitative parameters among varieties. Qualitative parameters of ecologically cultivated potatoes were significantly affected by the year of cultivation

Hamouz, K., J. Lachman, et al. (1997) The effect of the conditions of cultivation on the content of polyphenol compounds in the potato cultivars Agria and Karin, *Rostlinna Vyroba*. **43**(11):541-546

In field trials in 1995 and 1996, potatoes cv. Agria and Karin were grown at 12 sites in the Czech Republic, including organic and conventional farming systems. Tuber polyphenol contents were 5.75% and 19.67% greater in Agria and Karin, respectively, with organic than with conventional farming at Uhrineves. Similar results were also obtained at Valecov. Tuber polyphenol contents were lower in the beet-growing region than in the potato-growing region.

Hanell, U., G. L-Baeckström, et al. (2004). "Quality studies on wheat grown in different cropping systems: a holistic perspective." *Acta Agriculturae Scandinavica. Section B, Soil and Plant Science* **54**(4): 254-263.

Spring wheat from a conventional (CONV) and an organic (ORG1) cropping system, both with animals, and from an organic system without animals (ORG2) was evaluated with respect to baking quality from 1995-2002, in Sweden. Amino acid (AA) composition was studied in both spring and winter wheat in 1993 and 2000-02. The data were combined in multivariate analysis for exploration of the main factors responsible for the variation in quality. The most important factor for baking quality was weather conditions. High rainfall in May favoured baking quality in both cropping systems with animals, as did high temperature in May and high rainfall in July in the ORG1 system, and low rainfall in August in the CONV system. The only significant difference between the cropping systems was falling number, which was higher in ORG1 (252 s) than in CONV (205 s), probably due to a heavier CONV crop stand causing more difficult drying conditions. AA composition differed more between years than between cropping systems for both winter and spring wheat. The content of essential amino acids was high under the weather conditions associated with poor baking quality. The contents of threonine and leucine in spring wheat were significantly higher in ORG1, 1.76 and 8.11 g/100 g crude protein than in CONV, 1.63 and 7.72, respectively. In the interaction between AA and baking quality in spring wheat, it was possible to determine a correlation between phenylalanine, histidine, lysine and good baking properties. The primary effect was associated with weather conditions, but there was also an effect of differences between the cropping systems.

Hansen, L. L., C. Claudi-Magnussen, et al. (2006). "Effect of organic pig production systems on performance and meat quality." *Meat Science* **74**(4): 605-615.

The present study was carried out to establish knowledge of consequence for setting up guidelines of importance for production of competitive organic pork of high quality. Performance and meat quality characteristics were compared between three organic pig production systems based on indoor housing with access to an outdoor area and a Danish conventional indoor system including 100% concentrate during the finishing feeding stage. The three organic systems used the following three feeding regimes: 100% organic concentrate according to Danish recommendations, 70% organic concentrate (restricted) plus ad libitum organic barley/pea silage and 70% organic concentrate (restricted) plus ad libitum organic clover grass silage, respectively. With exception of a slightly lower daily gain in organic pigs fed 100% concentrate, no significant difference was found in performance and meat quality characteristics compared with results obtained in the conventional system. In contrast and independent of roughage used, organic pigs raised on 70% concentrate had a significant reduction in daily gain (P<0.001) compared with pigs raised on 100% concentrate, despite the fact that no difference in feed conversion rate was seen between the tested production systems. However, the percentage of leanness increased significantly in meat from organic pigs raised on 70% concentrate plus roughage compared with meat from pigs given 100% concentrate. This was reflected in higher yield (weight) of lean cuts and lower yield of cuts with high fat content from pigs fed 70% concentrate plus roughage. In general, organic feeding resulted in a significantly higher content of polyunsaturated fatty acids in the back fat (1.8%), which increased further when restricted feeding plus roughage (4%) was used. Restricted concentrate feeding gave rise to a decrease in tenderness compared with pork from pigs fed 100% concentrate.

Hasey, J. K., R. S. Johnson, et al. (1997). "An organic versus a conventional farming system in kiwifruit." *Acta Horticulturae*(No. 444): 223-228.

To determine the feasibility of growing kiwifruits organically in California, a kiwifruit orchard converted to an organic farm was compared with a conventionally farmed orchard from 1990 to 1992. January or March applications of composted chicken manure (organic system) or NH_4NO_3 plus CNH_4NO_3 through microsprinklers during the growing season (conventional system) were applied to give nearly equal rates of 168 kg N/ha. Soil analysis showed a trend towards a higher pH and organic matter content over time for the organic system. In 1992, there was a trend for the organic system to have higher NH_4-N and lower NO_3-N concentrations in the soil. Leaf N concentrations in the organic system were consistently lower than those in the conventional system, but were not deficient. Leaf concentrations of sodium and chloride increased over the 3-year period in the organic system, but not to phytotoxic levels. Leaf zinc levels were adequate and increased over time in both systems. Organically grown fruits were as firm as or firmer than conventionally grown fruits at harvest and 4 months after harvest. No differences were seen in soluble solids content. Damage from latania scale [*Hemiberlesia lataniae*] and omnivorous leaf roller [*Archips podanus*] was small in both systems, except for scale damage in the organic system in 1992. An economic analysis of the cultural practices showed that the organic system cost almost $720 per ha more than the conventional system. The grower reported fewer repack losses for organically grown fruits in 1992. It was concluded that growing kiwifruits organically is feasible if an economic premium is received.

Hermansen, J. E., J. H. Badsberg, et al. (2005). "Major and trace elements in organically or conventionally produced milk." *Journal of Dairy Research* **72**(3): 362-368.

A total of 480 samples of milk from 10 organically and 10 conventionally producing dairy farms in Denmark and covering 8 sampling periods over 1 year (triplicate samplings) were analysed for 45 trace elements and 6 major elements by high-resolution inductively coupled plasma mass spectrometry and inductively coupled plasma atomic emission spectrometry. Sampling, sample preparation, and analysis of the samples were performed under carefully controlled contamination-free conditions. The dairy cattle breeds were Danish-Holstein or Jersey. Sources of variance were quantified, and differences between production systems and breeds were tested. The major source of variation for most elements was week of sampling. Concentrations of Al, Cu, Fe, Mo, Rb, Se, and Zn were within published ranges. Concentrations of As, Cd, Cr, Mn and Pb were lower, and concentrations of Co and Sr were higher than published ranges. Compared with Holsteins, Jerseys produced milk with higher concentrations of Ba, Ca, Cu, Fe, Mg, Mn, Mo, P, Rh, and Zn and with a lower concentration of Bi. The organically produced milk, compared with conventionally produced milk, contained a significantly higher concentration of Mo (48 v. 37 ng/g) and a lower concentration of Ba (43 v. 62 ng/g), Eu (4 v. 7 ng/g), Mn (16 v. 20 ng/g) and Zn (4400 v. 5150 ng/g respectively). The investigation yielded typical concentrations for the following trace elements in milk, for which no or very few data are available: Ba, Bi, Ce, Cs, Eu, Ga, Gd, In, La, Nb, Nd, Pd, Pr, Rh, Sb, Sm, Tb, Te, Th, Ti, Tl, U, V, Y, and Zr.

Hernández Suárez, M., E. M. Rodríguez Rodríguez, et al. (2007). "Mineral and trace element concentrations in cultivars of tomatoes." *Food Chemistry* **104**(2): 489-499.

The concentrations of minerals (P, Na, K, Ca and Mg) and trace elements (Fe, Cu, Zn and Mn) were determined in 167 tomato samples belonging to five cultivars (Dorothy, Boludo, Dunkan, Dominique and Thomas) produced on the island of Tenerife. The contribution to the intake of minerals and trace elements was in general low, with special emphasis on the contributions of K and Mg. The cultivar, cultivation method, period of sampling and region of production in the island influenced the concentrations of minerals and trace elements of the tomatoes. Trace elements seemed more influenced by the cultivar than the minerals, and the cultivation method affected mineral contents more than trace element contents. The period of sampling had an important influence on the mineral and trace elements. Many correlations were observed between the minerals and trace elements studied. Applying discriminant analysis, the tomato samples tended to be classified according to the cultivation method, period of sampling and region of cultivation.

Hernández Suárez, M., E. R. Rodriguez, et al. (2008a). "Analysis of organic acid content in cultivars of tomato harvested in Tenerife." *European Food Research and Technology* **226**(3): 423-435.

The determination of organic acids in tomato samples was optimized using the HPLC method with on-line photodiode array detection, previous to extraction with 80% ethanol at room temperature and clean-up in Accell Plus QMA cartridge. The organic acids (oxalic, pyruvic, malic, citric, fumaric and ascorbic), Brix degree, acidity and pH were determined in five tomato cultivars (Dorothy, Boludo, Dominique, Thomas and Dunkan) harvested in Tenerife. There are several significant differences among cultivars in the concentration of many acids. The cultivation method, sampling period and the region of production were also considered. Citric, malic and oxalic acids were the major organic acids in all the cultivars. Some significant differences in the studied parameters were observed between the cultivars. The cultivation method and sampling period influenced in a variable way the studied parameters, depending on the tomato cultivar. The production region influenced the ascorbic acid concentration of the tomatoes. Applying stepwise discriminant analysis, it was found that the sampling period is more important in the differentiation of the tomato samples than the cultivar, cultivation method and production region.

Hernández Suárez, M., E. M. Rodríguez Rodríguez, et al. (2008b). "Chemical composition of tomato (Lycopersicon esculentum) from Tenerife, the Canary Islands." *Food Chemistry* **106**(3): 1046-1056.

Chemical composition (moisture, ash, total fibre, protein, glucose and fructose), the taste index and maturity were determined in five tomato cultivars (Dorothy, Boludo, Thomas, Dominique, Dunkan) which were cultivated using intensive, organic and hydroponic methods in Tenerife. The chemical composition was similar to most of the data found in the literature. There were many significant differences in the mean values between the analysed parameters according to the cultivar, cultivation method, region of cultivation and sampling period. Glucose and fructose concentrations were strongly and positively correlated, suggesting the common origin of both sugars. The moisture correlated inversely with the rest of the analysed parameters. Applying a stepwise discriminant analysis (DA), low percentages of correct classifications were obtained according to the cultivar and cultivation methods. The correct classification of the tomato samples improved when the DA was applied to differentiate the tomatoes according to the sampling period.

Hidalgo, A., M. Rossi, et al. (2008). "A market study on the quality characteristics of eggs from different housing systems." *Food Chemistry* **106**(3): 1031-1038.

To study the differences among commercial eggs from four housing systems i.e. cage, barn, free range and organic, 41 physical and chemical parameters were evaluated on 28 fresh egg samples from the Italian market. The univariate statistic analysis evidenced that organic eggs had the highest whipping capacity and foam consistency but the lowest freshness (the highest air cell height) and albumen quality (the lowest Haugh Unit); cage eggs presented instead the lowest whipping capacity and the highest shell resistance to breaking. The multivariate technique discriminant partial least-squares regression was unable to correctly classify the eggs from the four housing systems but successfully differentiated cage eggs from alternative (organic + barn + free range) eggs. The variables with the most discriminant power were she'll breaking resistance, overrun, protein content, and shell thickness.

Hogstad, S., E. Risvik, et al. (1997). "Sensory quality and chemical composition in carrots: a multivariate study." *Acta Agriculturae Scandinavica. Section B, Soil and Plant Science* **47**(4): 253-264.

Carrots from designed trials and organic and conventional farms in Norway were analysed for sensory quality and chemical composition. The data were combined in principal component analyses and partial least squares regression for exploration of the main factors responsible for the variation in quality. One of the most important factors was fertilizer application. Carrots grown with no fertilizer and carrots fertilized with 40-80 kg N ha^{-1} as mineral fertilizer or 20-72 t ha^{-1} of organic fertilizer contained more total sugars and had a stronger flavour, less crispness, crude protein, true protein and carotene, and lower pH than carrots fertilized with 100-192 kg N ha^{-1} as mineral fertilizer. Location was also very important in explaining the total variation and was a composite factor of precipitation, temperature in June, growth system and length of growth period. Soil type, amount of organic fertilizer, use of pesticides and temperatures in July and August seemed to be of less importance.

Hoikkala, A., E. Mustonen, et al. (2007). "High levels of equol in organic skimmed Finnish cow milk." *Molecular Nutrition & Food Research* **51**(7): 782-786.

The isoflavonoids, equol, formononetin, daidzein, genistein, biochanin A, and 0-demethylangolensin (O-DMA), were analyzed from commercial cartons of skimmed Finnish milk by HPLC-diode array detector (DAD)-FL. We found 411 +/- 65 ng/mL of equol and traces of formononetin and daidzein in organic skimmed milk whereas conventionally produced milk contained 62 16 ng/mL of equol and no formononetin or daidzein.

Igbokwe, P. E., L. C. Huam, et al. (2005). "Sweetpotato yield and quality as influenced by cropping systems." *Journal of Vegetable Science* **11**(4): 35-46.

Field studies were conducted in Mississippi, USA, in 2001 and 2002, to evaluate the effect of conventional (chemical-intensive) monocropping, transitional (reduced-synthetic input) and an organic (non-synthetic input) multiple cropping systems on sweet potato yield and quality as well as soil properties, on a Dexter silt loam soil. In both years, sweet potato yield was greatest for the transitional and organic cropping systems and lowest for the conventional cropping system. In 2001, cropping system did not affect plant survival. In 2002, plant survival was greatest for the conventional cropping system and lowest for the organic cropping system. Soil extractable nutrient levels prior to planting (preplant soil fertility) were very high for Mg, high for P and Ca, medium for S, and low for K. For the final postharvest soil levels after the second year, the Mg content was very high for the 3 cropping systems and high for P, K and Ca. S was high for the organic cropping system and medium for the conventional and transitional cropping systems.

In 2001, sweet potato P content was greatest in the conventional cropping system and lowest in the transitional cropping system. Both Ca and Mg were greatest in the conventional cropping system but were not different from the transitional cropping system. K was greatest in the organic cropping system and lowest for in transitional cropping system. Both N and S were not affected by cropping systems. In 2002, N content in roots was greatest in the conventional and organic cropping systems and lowest in the transitional cropping system. The other nutrients were not affected by cropping system. Sweet potato roots under the conventional cropping system had the greatest protein, fat and ash contents, whereas crude fibre was the greatest for roots under the transitional cropping system. Root dry matter was greatest in the organic cropping system and lowest in the conventional cropping system. Data suggest that the sweet potato cultivar Beauregard can be successfully grown on a Delta silt loam soil in northern Mississippi. Where the production of high quality sweet potato roots are desired, both the transitional and organic cropping systems are recommended over the conventional cropping system. While the conventional cropping system will enhance root protein, fat and ash contents more than the transitional and organic cropping systems, both cropping systems will, respectively, enhance crude fibre and dry matter more than the conventional cropping system.

Ismail, A. (2003). "Determination of Vitamin C, β-carotene and Riboflavin Contents in Five Green Vegetables Organically and Conventionally Grown." *Malaysian Journal of Nutrition* **9**(1): 31-39.

s consumer interest in organically grown vegetables is increasing in Malaysia, there is a need to answer whether the vegetables are more nutritious than those conventionally grown. This study investigates commercially available vegetables grown organically and conventionally, purchased from retailers to analyse β-carotene, vitamin C and riboflavin contents. Five types of green vegetables were selected, namely Chinese mustard (sawi) (*Brassica juncea*), Chinese kale (kai- lan) (*Brassica alboglabra*), lettuce (daun salad) (*Lactuca sativa*), spinach (bayam putih) (*Amaranthus viridis*) and swamp cabbage (kangkung) (*Ipomoea aquatica*). For vitamin analysis, a reverse-phase high performance liquid chromatography was used to identify and quantify β -carotene, vitamin C and riboflavin. The findings showed that not all of the organically grown vegetables were higher in vitamins than that conventionally grown. This study found that only swamp cabbage grown organically was highest in β -carotene, vitamin C and riboflavin contents among the entire samples studied. The various nutrients in organically grown vegetables need to be analysed for the generation of a database on nutritional value which is important for future research.

Jahan, K. and A. Paterson (2007). "Lipid composition of retailed organic, free-range and conventional chicken breasts." *International Journal of Food Science and Technology* **42**(3): 251-262.

Lipid fractions of 20 retailed chicken breasts were correlated with production system: organic, corn-fed, free-range and conventional. Neutral lipid (NL), phospholipid (PL) and free fatty acids (FFA) were examined separately. Influence of production systems was found more pronounced in PL composition than NLs. Corn-fed and free-range NLs had higher contents of nutritionally beneficial eicosapentanoic acid (C20:5 n-3) and docosahexanoic acid (C22:6 n-3) than organic and conventional. Lower polyunsaturated fatty acids in organic and free-range PLs could be beneficial for tissue stability. Principal component product space for PLs showed clear clustering related to product category. In contrast, this was not observed with FFA except in the partial least square regression product space suggesting influences on NLs and PLs and FFA. PLs had lower contents of arachidonic acid than in earlier studies. Advantages were observed in lipid fractionation using advanced sorbent extraction matrices.

Jahan, K., A. Paterson, et al. (2004). "Fatty acid composition, antioxidants and lipid oxidation in chicken breasts from different production regimes." *International Journal of Food Science & Technology* **39**(4): 443-453.

Chicken breast from nine products and from the following production regimes: conventional (chilled and frozen), organic and free range, were analysed for fatty acid composition of total lipids, preventative and chain breaking antioxidant contents and lipid oxidation during 5 days of sub-ambient storage following purchase. Total lipids were extracted with an optimal amount of a cold chloroform methanol solvent. Lipid compositions varied, but there were differences between conventional and organic products in their contents of total polyunsaturated fatty acids and n-3 and n-6 fatty acids and n-6:n-3 ratio. Of the antioxidants, α-tocopherol content was inversely correlated with lipid oxidation. The antioxidant enzyme activities of catalase, glutathione peroxidase and glutathione reductase varied between products. Modelling with partial least squares regression showed no overall relationship between total antioxidants and lipid data, but certain individual antioxidants showed a relationship with specific lipid fractions.

Jahreis, G., J. Fritsche, et al. (1997). "Conjugated linoleic acid in milk fat: high variation depending on production system." *Nutrition Research* **17**(9): 1479-1484.

Over a 1-year period, bulk milk samples were collected monthly from 3 different types of farm: conventional - indoor feeding with silages for the whole year; conventional - grazing during the summer season; and organic farming - grazing during the summer season. Milk concentrations of conjugated linoleic acids (CLA), *trans* vaccenic and other isomers of milk fatty acids were determined. There was substantial variation (0.26 to 1.14% of total methyl esters) in the CLA content of the milk; this variation was also season-dependent. The lowest percentage of CLA (0.34%) was found in the group fed only on fermented roughage and concentrates and the highest (0.80%) in the organically-produced milk fat. The concentration of CLA and vaccenic acid was positively correlated. It was concluded that the percentage of CLA in milk products can be increased through a suitable dietary regimen.

Jorhem, L. and P. Slanina (2000). "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* **80**(1): 43-48.

The effect of organic cultivation systems on the level of Cd in wheat was studied in two consecutive harvests. Additionally, the concentrations of Cd, Pb, Cr and Zn were analysed in single harvests of rye, carrots and potatoes from different farming systems. Wheat and rye were obtained from controlled field trials using several conventional and ecological systems at two separate locations in Sweden. Potatoes and carrots were collected at private farms with conventional or ecological production. These farms were juxtapositioned and had similar soil properties. The levels of Cd in the wheat did not correlate with the cultivation system or the Cd content in the soil. Conventionally grown wheat from one field trial showed a significantly higher Cd level compared with ecologically grown wheat, while in the other field trial significantly lower Cd levels were detected in the conventionally grown wheat. No statistically significant differences in the concentrations of Cd, Pb, Cr or Zn in rye, carrots and potatoes were detected between the cultivation systems. The results indicate that organic farming, at least in the short term, does not necessarily result in reduced levels of Cd and other potentially harmful metals in foods of vegetable origin. Factors other than cultivation system may be of greater importance for the final concentration of Cd and other metals in plant foods.

Keukeleire, J. d., I. Janssens, et al. (2007). "Relevance of organic farming and effect of climatological conditions on the formation of α-acids, ß-acids, desmethylxanthohumol, and xanthohumol in hop (*Humulus lupulus L.*)." *Journal of Agricultural and Food Chemistry* **55**(1): 61-66.

The concentrations of α-acids, β-acids, desmethylxanthohumol, and xanthohumol were monitored in the hop varieties Admiral (A), Wye Challenger (WC), and First Gold (FG) during the harvest seasons of 2003 through 2005. Hops grown under an organic regimen were compared to plants grown conventionally in hop fields in close vicinity. The concentrations of the key compounds depended very much on climatological conditions showing, in general, highest levels in poorest weather conditions (2004). Of the three varieties studied, FG was the only one showing a clear trend for higher concentrations of secondary metabolites under organic growing conditions than under conventional farming conditions. Cultivation of A and WC seems to be very sensitive to climatic conditions and environmental stresses caused by pests and diseases, thereby leading to various results. WC proved to be a rich source of bioactive chalcones, particularly desmethylxanthohumol.

Knöppler, H. O. and G. Averdunk (1986). "A comparison of milk quality from conventional farms or from 'alternative' farms." *Archiv für Lebensmittelhygiene* **37**(4): 94-96.

Between May 1982 and April 1983 pooled milk samples were taken from 21 farms classified as 'alternative' farms (farms committed to following specific standards set down by the dairy on manuring, use of herbicides, rotation of crops and feed) and compared with pooled milk samples from 21 conventional farms. Sensory evaluation, cheesemaking properties, contents of Na, K, Ca, nitrate, amino acids and fatty acids as well as organochlorine pesticides and polychlorinated biphenyls were similar on both types of farm.

Koh, E., K. M. S. Wimalasiri, et al. (2008). "A comparison of flavonoids, carotenoids and vitamin C in commercial organic and conventional marinara pasta sauce." *Journal of the Science of Food and Agriculture* **88**(2): 344-354.

BACKGROUND: Characterising the levels of key phytochemicals in foods commonly consumed in the Western diet is critical for database development, estimating intake and assessing the potential health benefits associated with the consumption of these products. This paper describes a market-basket evaluation of the key flavonoids, carotenoids and vitamin C in commercial organic (five brands) and conventional (five brands) marinara pasta sauces. RESULTS: Levels of ascorbic acid ranged from undetected up to 6.87 mg per 100 g fresh weight. The levels of total vitamin C in six of the ten samples were significantly lower than the amount listed on the Nutrition Facts Panel ($P < 0.001$ or $P < 0.01$). The contents of total vitamin C, flavonoids and lycopene were not statistically different between organic and conventional samples. Conventional pasta sauces demonstrated a significantly higher level of all-trans-beta-carotene ($P < 0.05$). CONCLUSION: This suggests that any beneficial differences in levels of flavonoids, carotenoids and vitamin C gained through cultivation practices are not measurable at the consumer level in processed tomato products. Additionally, the results point to a large disparity between the actual vitamin C content of these products and the content listed on the Nutrition Facts Panel.

Krejčířová, L., Capouchová, I., Petr., J, Bicanová., E., Faměr (2007). "The effect of organic and conventional growing systems on quality and storage protein composition of winter wheat." *Plant Soil Environ* **53**(11): 499-505.

Protein composition of the grain storage proteins (evaluation using electrophoresis in polyacrylamide gel – the SDS-PAGE method) and selected parameters of bread-making quality in a set of 6 winter wheat varieties from organic and conventional growing in Central Bohemia (elevation 295 m a.s.l.) were evaluated during a two-year experiment (2004 and 2005). In comparison with the varieties from organic growing, wheat varieties from the conventional growing were characterized by twice the percentage of High Molecular Weight (HMW) glutenins, responsible for dough elasticity (conventional wheat in average 25.22%, organic wheat 12.71%). At the same time, varieties from conventional growing generally reached higher, more positive values of crude protein content and wet gluten content in grain dry matter, sedimentation index by Zeleny and yield of bread. On the other hand, wheat varieties from organic growing were mainly characterized by significantly higher percentage of nutritionally valuable albumins and globulins (organic wheat in average 17.69%, conventional wheat 7.33%). In both systems of growing the highest percentage of HMW glutenins was determined in varieties from the quality group E (elite, the most suitable for bread-making), while the varieties from the quality group C (wheat unsuitable for bread-making) reached the highest percentage of residual albumins and globulins.

Krejčířová, L., I. Capouchová, et al. (2008). "Storage protein composition of winter wheat from organic farming " *Scientia Agriculturae Bohemica* **39**(1): 6-11.

We tested the grain storage protein composition and wheat quality parameters in a set of varieties from different quality groups from organic farming during a two-year experiment. We also tested a set of varieties from conventional farming for orientation comparison of results. Our results show a noticeable influence of organic and conventional ways of growing on the wheat grain storage protein composition and the technological quality characteristics, predicative partly of the storage protein quantity, partly of the protein complex quality (sedimentation index by Zeleny, rheology characteristics determination of pharinograph and the yield of bread). Varieties with higher content of HMW glutenins (varieties from conventional growing systems and varieties from the elite (E) and high-quality (A) quality groups), which are the most suitable for baking utilisation, reached higher values of sedimentation index, pharinographic characteristics predetermining good baking quality and higher values of yield of the bread. Varieties from organic farming and from the C quality group (wheat unsuitable for baking utilization) were mainly characterized by the higher content of residual albumins and globulins, due to higher content of amino essential acids and higher nutritional quality of albumins and globulins we suppose, that this wheat is more suitable for feeding and also for human nutrition.

Krejčířová, L., I. Capouchová, et al. (2006). "Protein composition and quality of winter wheat from organic and conventional farming." *Žemdirbystė, Mokslo Darbai* **93**(4): 285-296.

A 2-year field experiment was conducted during 2004 and 2005 to evaluate the relationship between grain protein composition and quality parameters in a set of wheat cultivars from different quality groups (elite, high-quality and others) grown under conventional and organic farming systems in Czech Republic. Elite and high-quality cultivars had higher content of high molecular weight glutenins and exhibited better rheological and baking quality characteristics. Other cultivars (those unsuitable for baking) had higher content of low molecular weight glutenins and gliadins as well as higher content of valuable nutritional albumins and globulins. Such trend was observed from both conventional and organic farming systems.

Langenkämper, G., C. Zörb, et al. (2006). "Nutritional quality of organic and conventional wheat." *Journal of Applied Botany and Food Quality* **80**(2): 150-154.

The popularity of organic food and the farming area managed according to organic agriculture practices have been increasing during the last years. It is not clear, whether foods from organic and conventional agriculture are equal with respect to nutritional quality. We chose wheat (*Triticum aestivum* L., cv. Titlis) as one of the most important crop plants to determine a range of substances relevant for human nutrition in crops from organic and conventional agriculture systems. Wheat grains of 2003 originating from a long term field experiment, the Swiss *DOK* trial, consisting of bio-dynamic, bio-organic and conventional farming systems were used. Thousand seed weight, protein content, phosphate levels, antioxidative capacity, levels of phenols, fibre, fructan, oxalate and phytic acid were determined in whole wheat meal from the various organic and conventional growing systems of the *DOK* trial. Levels of these substances fell into a range that is known to occur in other wheat crops, indicating that wheat from the *DOK* trial was not special. Clear-cut differences were observed for none-fertilised wheat, which was significantly lowest in thousand seed weight, protein and significantly highest in total oxalate. For the majority of the nutritionally important substances analysed, there were no significant differences between bio-dynamic, bio-organic, and conventional growing systems. Only protein content and levels of fibres were statistically different. Taken together, the magnitude of observed variations was very small. The results of our investigations do not provide evidence that wheat of one or the other agriculture system would be better or worse.

Lanzanova, C., C. Balconi, et al. (2006). Phytosanitary and quality evaluation of rice kernels organically and conventionally produced. *Informatore Fitopatologico*. **56**(3): 66-72.

Organic farming (or nature farming) is gaining much attention from the public because of the environmental concern and the interest in food safety aspects. Due to the lack of information about yielding performance of this farming method, research is actively underway to gain data related to the performance of Italian rice varieties to nature farming, respect to conventional culture. The objective of the present study was the evaluation of the product of two Italian cultivars "Baldo" and "Loto" grown during the very hot season 2003, with special regard to fungal contamination and alteration in the caryopsis protein profile, when cultivated under conventional and organic farming procedures. The two cultivars showed differences in the percentage of grain contamination depending both from the genotype and the agricultural practice. No differences were found in the rate of fungal attack to the caryopsis. Furthermore, no alterations were detected in the peptide profile of any of the storage protein classes in both cultivars.

Lavrencic, A., A. Levart, et al. (2007). "Fatty acid composition of milk produced in organic and conventional dairy herds in Italy and Slovenia." *Italian Journal of Animal Science* **6**: 437-439.

Thirty eight bulk milk samples were collected from 19 organic and conventional farms in Italian Region of Friuli Venezia Giulia and Slovene Regions of Obalno-Kraska and Goriska with the aim to determine variation in fatty acid (FA) composition between two States and between two production systems. Results show that milk from Slovene organic farms contain the highest proportion of saturated FA (SFA; 70.32 %) and the lowest proportion of monounsaturated FA (MUFA; 25.49 %). Milk from both production systems in Slovenia contained greater proportions of n-3 polyunsaturated FA (PUFA; 0.99 and 1.20 % in conventional and organic farms, respectively) and lower proportions of n-6 PUFA (2.60 and 2.33 % in conventional and organic farms, respectively) than Italian milk samples (0.54 and 0.68 % n-3 PUFA and 3.03 and 3.39 % n-6 PUFA in conventional and organic farms, respectively). The ratio between n-6 and n-3 PUFA was thus lower in Slovene than in Italian milk samples, yet they did not differ statistically between production systems within the States. Slovene milk samples contained higher proportions of conjugated linoleic acid (CIA; 0.72 and 0.64 % in conventional and organic farms, respectively) than Italian milk samples (0.45 and 0.49 % in conventional and organic farms, respectively).

L-Baeckstrom, G., U. Hanell, et al. (2004). Baking quality of winter wheat grown in different cultivating systems, 1992-2001: a holistic approach. *Journal of Sustainable Agriculture*. **(24)**1: 53-79.

The aim of this study was to determine whether organic and conventional cultivation systems differ with respect to baking quality of winter wheat and to evaluate the influence of seasonal variations on this parameter. The research site was at Kvinnersta, Central Sweden, on a clay loam containing 3-6% humus with a mean annual temperature of 5.7 degrees C and a mean annual rainfall of 540 mm. A PCA analysis showed that differences existed between the cultivation systems. PCl explained the greatest variation, 46%, which was significant. The main factors affecting the variation were the farinogram dough stability and bread volume. Rainfall during April affected the conventional system and during April-June the organic system. Univariate statistics showed that the conventional system was significantly better than the organic system with respect to: protein content, wet gluten, farinogram dough stability, dough breakdown, extensogram surface, dough yield, bread volume and yield. The overall outcome of the study was that nitrogen was the most limiting factor in the organic cultivation system.

L-Baeckström, G., U. Hanell, et al. (2006). "Nitrogen use efficiency in an 11-year study of conventional and organic wheat cultivation." *Communications in Soil Science and Plant Analysis* **37**(3/4): 417-449.

Resource conservation with respect to nitrogen (N) was compared in organic and conventional cultivation of winter and spring wheat. Sustainability was measured in the nitrogen use efficiency of plant-available N. The amounts of N entering each system and the amounts removed in the harvested crop and remaining as unused mineral nitrogen in the soil at harvest were determined. Net surpluses and losses during the growing season were also monitored, and the environmental variables influencing N harvest in the different cultivation systems were identified. The study was conducted in 3 different cultivation systems, i.e. conventional animal production (CONV), organic animal production (ORG1) and organic cereal production (ORG2). On average for all years and sampling occasions in winter wheat, there were approximately 60 kg more mineral nitrogen left in the soil during the growing season in CONV than in ORG1, and coefficients of variation were higher in CONV. The maximum values were considerably higher in CONV than in ORG1, which increased the risk of leaching in the former, particularly in winter wheat cultivation. Nitrogen use efficiency in winter and spring wheat cultivation was 74% in whole crop conventional winter wheat and 81% in organic. Nitrogen use efficiency in harvested winter wheat grain was 44% for CONV and 49% for ORG1. ORG1 spring wheat was as efficient as ORG1 winter wheat, whereas ORG2 spring wheat used 73% of N in the whole crop and 39% in grain. Multivariate regression analysis showed that climate affected CONV and ORG1 winter wheat differently. High temperature in May increased grain yields in ORG1, but the converse was true for CONV. Large unused mineral N reserves at harvest coincided with large N harvest in CONV winter wheat. Residual fertility effects from the preceding crop produced high yields in ORG1 winter and spring wheat but had no effect in CONV. Generally, an increase in N reserves between plant development stages 13 and 31 was positive for both CONV and ORG1 winter wheat. Both winter and spring wheat require most N during this period, so the potential for improvement seems to lie in increasing mineralization (e.g. by intensified weed harrowing early in stage 13 in winter wheat and between stages 13 and 31 in spring wheat). Cultivation of winter wheat in ORG1 was a more efficient use of nitrogen resources than CONV. CONV efficiency could be improved by precision fertilizer application on each individual field with the help of N analysis before spring tillage and sensor-controlled fertilizer application.

Leclerc, J., M. L. Miller, et al. (1991). "Vitamin and mineral contents of carrot and celeriac grown under mineral or organic fertilization." *Biological Agriculture & Horticulture* **7**(4): 339-348.

For each vegetable, a grower using organic methods was paired with one using conventional methods. Criteria for pairing were: geographical area, soil type, same cultivar, same growing period (carrots 120 days, celeriac 7 months) and, where possible, same sowing date. Twenty-four sets of growers were thus paired (6 per year per crop) in 1987 and 1988 in the Burgundy area and in Dôle in the Jura region. Samples were analysed for mineral content and for vitamin C, β-carotene, B vitamins and nitrate. Organically grown carrots had more β -carotene (+ 12%), while organically grown celeriac had more vitamin C (+ 11%), less nitrate (-56%) and less Zn (-19%), than conventionally grown crops. The last figure was explained by the use of zinc-based pesticide on conventionally grown celeriac.

Lester, G. E., J. A. Manthey, et al. (2007). "Organic vs conventionally grown Rio Red whole grapefruit and juice: comparison of production inputs, market quality, consumer acceptance, and human health-bioactive compounds." *Journal of Agricultural and Food Chemistry* **55**(11): 4474-4480.

Most claims that organic produce is better tasting and more nutritious than nonorganic (conventional) produce are largely unsubstantiated. This is due mainly to a lack of rigor in research studies matching common production variables of both production systems, such as microclimate, soil type, fertilizer elemental concentration, previous crop, irrigation source and application, plant age, and cultivar. The aforementioned production variables common to both production systems were matched for comparison of Texas commercially grown conventional and certified organic Rio Red red-fruited grapefruit. Whole grapefruits from each production system were harvested between 800 and 1000 h at commercial early (November), mid- (January), and late season (March) harvest periods for three consecutive years. Within each harvest season, conventional and organic whole fruits were compared for marketable qualities (fruit weight, specific gravity, peel thickness, and peel colour), and juices were compared for marketable qualities (specific gravity, % juice, and colour), human health-bioactive compounds (minerals, ascorbic acid, lycopene, sugars, pectin, phenols, and nitrates), and consumer taste intensity and overall acceptance. Conventional fruit was better colored and higher in lycopene, and the juice was less tart, lower in the bitter principle naringin, and better accepted by the consumer panel than the organic fruit. Organic fruit had a commercially preferred thinner peel, and the juice was higher in ascorbic acid and sugars and lower in nitrate and the drug interactive furanocoumarins.

Leszczyska T. (1996). "Nitrates and nitrites in vegetables from conventional and ecological cultures." *Bromatologia i Chemia Toksykologiczna* **29**(3): 289-293.

Samples of beetroots, white cabbages, carrots, parsley roots and potatoes were taken from market-places and from health food shops in Poland. The concentrations of dry matter (DM), nitrates and nitrites were estimated. Mean values for nitrate in beetroots, cabbages, parsley roots, carrots and potatoes from market-places and health food shops were 834 and 350, 433 and 303, 383 and 234, 293 and 154 and 203 and 145 mg/kg fresh vegetable, respectively. Corresponding mean values for nitrite were 1.54 and 0.42, 1.14 and 0.72, 0.54 and 0.34, 0.53 and 0.34 and 0.63 and 0.37 mg/kg. All mean nitrate values for these vegetables were below the respective maximum concentrations allowed by Polish regulations. All values for nitrite in vegetables from health food shops were below the limit set by Polish regulations (1.0 mg/kg). In general nitrite values in vegetables from market-places were also below 1.9 mg/kg. In all kinds of vegetables from health food shops the DM content was higher, by up to 34%, than in those from market places.

Lockeretz, W., G. Shearer, et al. (1980) Maize yields and soil nutrient levels with and without pesticides and standard commercial fertilizers. *Agronomy Journal* **72**: 65-72.

This paper reports maize yields on 2 groups each of 26 commercial mixed grain and livestock farms covering a wide range of soil types in the western Corn Belt. One group was managed with conventional fertilization and pest control practices while no herbicides, insecticides or standard commercial fertilizers were used on the other. The mean yield from the conventional fields was 8.5% higher than from the matched fields on which conventional fertilizers or pesticides were not used. The difference was not statistically significant (P <90%). Conventional maize yields tended to be higher than maize yields on fields which received no pesticides or fertilizers under favourable growing conditions and lower when conditions were adverse. Grain from the fields receiving pesticides and fertilizers had a significantly higher crude protein content. Soils from fields receiving no pesticides and fertilizers had a significantly higher (P >95%) organic C content, as well as higher total N (P >90%), but lower P1 phosphorus (P >90%). From summary.

Lombardi-Boccia, G., M. Lucarini, et al. (2004). "Nutrients and antioxidant molecules in yellow plums (Prunus domestica L.) from conventional and organic productions: A comparative study." *Journal of Agricultural and Food Chemistry* **52**(1): 90-94.

Yellow plums (*Prunus domestica* L) conventionally and organically grown in the same farm were selected to study the influence of different agronomic practices on antioxidant vitamins (ascorbic acid, vitamin E, beta-carotene) and phenolics (total polyphenols, phenolic acids, flavonols) concentration. Conventional plums were grown on tilled soil. Three organic cultivations were performed: tilled soil, soil covered with trifolium, and soil covered with natural meadow. Differences in macronutrients were marginal, whereas antioxidant vitamins and phenolic compounds concentration markedly differed among cultivations. Ascorbic acid, (alpha-, gamma-tocopherols, and beta-carotene were higher in organic plums grown on soil covered with natural meadow. The highest phenolic acids content was detected in plums grown on soil covered with trifolium. Total polyphenols content was higher in conventional plums. Quercetin was higher in conventional plums, but myrecitin and kaempferol were higher in organic plums. Under the same cultivar and climate conditions, the type of soil management turned out of primary importance in influencing the concentration of health-promoting compounds.

Ludewig, M., N. Palinsky, et al. (2004). "Quality of organic and directly marketed conventionally produced meat products." *Fleischwirtschaft* **84**(12): 105-108.

The quality of organic and directly marketed conventionally produced meat products was tested microbiologically, organolepticly and chemically. A total of 85 organic (18 fermented sausages, 25 scalding sausages, 9 boiling sausages, 30 preserves, 3 cured meat products) and 66 directly marketed conventional meat products (6 fermented sausages, 7 scalding sausages, 11 boiling sausages, 42 preserves) were investigated. The microbiological investigations resulted in remarkable findings of the organic products as well as of the directly marketed conventional products. Particularly high total aerobic plate counts and high lactic acid bacteria counts were observed. Salmonella was not detected. The organoleptic results show most deficiencies in smell and taste in both groups. Protein-values of the majority of the samples were in agreement with the minimum values according to the "LEITSATZE ZUM DEUTSCHEN LEBENSMITTEL-BUCH" (2003). The most deficiencies of quality can be removed by technological improvement. There were no signs with importance for food safety.

Lund, P. (1991). "Characterization of Alternatively Produced Milk." *Milchwissenschaft-Milk Science International* **46**(3): 166-169.

A comparative investigation was carried out from May 1988 to May 1989 on traditionally and alternatively produced ("organic") milk. The purpose was to determine whether organic milk was different from traditional milk with regard to composition, bacteriological quality and technological and allergenic properties. The results showed that there were some minor differences in composition and technological properties between the two types of milk. The organic milk had a higher content of protein and vitamin C and a lower content of mono-unsaturated fatty acids than the traditional milk. The fresh organic milk obtained a lower organoleptic score than the fresh traditional milk but no difference was observed after 7 days of storage. The organic milk from the heavy breeds (Red Danish Dairy Cattle and Black and White Danish Dairy Cattle) had better renneting properties than the traditional milk from the heavy breeds. However, there was no difference in renneting properties for the Jersey milk. No aflatoxin was found in the organically produced milk but in a few samples of traditionally produced milk small amounts of aflatoxin was found. The results showed no differences with regard to bacteriological quality, allergenic properties or content of fat, lactose, minerals, antibiotics, pesticides and heavy metals between the two types of milk. Most of the differences in composition and technological properties could be explained by differences in the feeding of the cows.

Macit, t, et al. (2007). "Yield, quality and nutritional status of organically and conventionally-grown strawberry cultivars." *Asian Journal of Plant Sciences* **6**(7): 1131-1136.

In this study, five short-day strawberry (*Fragaria* x *ananassa* Duch) cultivars including Sweet Charlie, Redlans Hope, Kabarla, Festival and Camarosa were grown to evaluate their yield, quality and nutritional status under organic and conventional growing conditions in 2004-2005 seasons. In the conventional system, plants had early flowering and fruit development and produced higher yield when compared to the organic system. According to total yield of two years, there were significant differences between two growing systems, ranging from 21 (Camarosa) to 29% (Sweet Charlie). There were also significant differences in average fruit weight among cultivars in organic and conventional system. However, difference between growing systems in terms of fruit weight of each cultivar was not significant. Redlans Hope had the highest average fruit weight under conventional and organic system, followed by Camarosa and Kabarla. Total Soluble Solid (TSS) content and Titretable Acidity (TA) of fruit differed among the cultivars. Sweet Charlie and Festival cultivars had the highest TSS content under conventional system. Titretable acidity of fruit was strongly affected by fertilizer management and it was lower under organic growing conditions when compared to the conventional system. Cultivars differed significantly in Chlorophyll (CHL) and leaf N contents, Kabarla and Redlans Hope had the highest values. It was found that there was significant correlation between CHL and leaf N ($r=0.551$, $p<0.001$). Kabarla and Camarosa were the cultivars yielded higher not only in conventional system but also in organic system.

Mäder, P., D. Hahn, et al. (2007). "Wheat quality in organic and conventional farming: results of a 21 year field experiment." *Journal of the Science of Food and Agriculture* **87**(10): 1826-1835.

Consumers have become more aware of healthy and safe food produced with low environmental impact. Organic agriculture is of particular interest in this respect, as manifested by 5. 768 million hectares managed pursuant to Council Regulation (EEC) 2092/91 in Europe. However, there can be a considerable risk that the avoidance of chemical inputs in organic farming will result in poor food quality. Here the results of a study on the quality of wheat (*Triticum aestivum* L.) grown in a 21 year agrosystem comparison between organic and conventional farming in central Europe are reported. Wheat was grown in a ley (grass/clover) rotation. The 71% lower addition of plant-available nitrogen and the reduced input of other means of production to the organic field plots led to 14% lower wheat yields. However, nutritional value (protein content, amino acid composition and mineral and trace element contents) and baking quality were not affected by the farming systems. Despite exclusion of fungicides from the organic production systems, the quantities of mycotoxins detected in wheat grains were low in all systems and did not differ. In food preference tests, as an integrative method, rats significantly preferred organically over conventionally produced wheat. The findings indicate that high wheat quality in organic farming is achievable by lower inputs, thereby safeguarding natural resources.

Mäder, P., L. Pfiffner, et al. (1993). "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 Horticulturae* **(339)**: 11-31.

In a long-term field trial in Therwil, Switzerland, bio-dynamic (D), bio-organic (O) and conventional (C) farming systems were compared (DOC trial). The D and O systems received farmyard manure and biological crop protection, while the C system received mineral fertilizers and conventional crop protection. Yields of beetroot cv. Mobile were generally high due to the favourable climate and soil. Yields in both biological systems were approx equal to 75% that of the conventional system, while N and K inputs were approx equal to 60% lower. The proportion of roots of marketable quality was similar in all systems, but the C system produced a larger proportion of heavy roots (500-1000 g). In food preference tests, beetroots from the O system were preferred to those from the other systems.

Malmauret, L., D. Parent-Massin, et al. (2002). "Contaminants in organic and conventional foodstuffs in France." *Food Addit Contam* **19**(6): 524-32.

The aim was to compare the levels of contamination in organic and conventional raw materials. To this end, the level of contamination by heavy metals (lead, cadmium, arsenic, mercury), nitrates and nitrites, and some mycotoxins were monitored. Fifteen products were tested in their organic and conventional forms, including meat, milk, eggs, vegetables and cereals. The median levels of contamination were calculated and compared with the recommended or regulated maximum levels. The maximum levels were exceeded for lead in organic carrots and buckwheat, and in conventional wheat; for cadmium, in both organic and conventional buckwheat; for nitrates, in organic spinach; and for patulin in organic apples. Moreover, contamination of both conventional and organic wheat by deoxynivalenol was observed with a higher level in organic products. However, the health risk for consumers might be real only for the contamination by mycotoxins as the contaminated foods (apples, wheat) are the main contributors to total exposure.

Matallana González, C., C. Hurtado, et al. (1998). "Study of water-soluble vitamins (thiamin, riboflavin, pyridoxine and ascorbic acid) in ecologically-grown lettuce (*Lactuca sativa* L.)." *Alimentaria* **35**(293): 39-43.

Thiamin, riboflavin and ascorbic acid were estimated fluorimetrically and pyridoxine was estimated spectrophotometrically in samples of lettuce grown conventionally (LC) or using ecological (organic) methods (LE) on sale unwrapped in specialized stores and in samples of conventionally-grown lettuce sold in plastic wrapping (LW). Mean values for LC were 0.021 plus or minus 0. 013, 0.059 plus or minus 0.007, 5.330 plus or minus 2.651 and 0.038 plus or minus 0.004 and for LE 0.036 plus or minus 0.006, 0.069 plus or minus 0.007, 3.536 plus or minus 0.966 and 0.061 plus or minus 0.026 mg/100 g, respectively. Values for LW were 0.038 plus or minus 0.007, 0.050 plus or minus 0.020, 4.639 plus or minus 2.619 and 0.063 plus or minus 0.010 mg/100 g.

Meyer, M. and S. T. Adam (2008). "Comparison of glucosinolate levels in commercial broccoli and red cabbage from conventional and ecological farming." *European Food Research and Technology* **226**(6): 1429-1437.

Broccoli heads and red cabbage of both conventional and ecological origin were purchased from the market at monthly intervals over a 1-year period. After freeze-drying of the samples the glucosinolates were extracted, enzymatically desulphated and analyzed by HPLC-UV. Glucoraphanin, glucobrassicin and neo-glucobrassicin turned out to be the predominant glucosinolates in broccoli. Red cabbage contained similar amounts of glucoraphanin and glucobrassicin but, in addition, appreciable amounts of glucoiberin, progoitrin, sinigrin, gluconapin and glucoerucin, while neo-glucobrassicin occurred at trace levels only. No significance was found comparing the contents of glucoraphanin in the two cultivation groups for either broccoli or red cabbage. Organic broccoli and red cabbage both contained significantly higher amounts of glucobrassicin than their conventionally grown counterparts. Conventional crops of red cabbage yielded significantly higher quantities of gluconapin than ecological crops. Broccoli imported from Spain and Italy during the winter months yielded levels of glucosinolates similar to those of the home-grown products available in summer and autumn.

Miceli, A., C. Negro, et al. (2003). "Polyphenols, resveratrol, antioxidant activity and ochratoxin A contamination in red table wines, controlled denomination of origin (DOC) wines and wines obtained from organic farming." *Journal of Wine Research* **14**(2/3): 115-120.

In this work, 15 red wines (5 table wines, 4 Apulian Denominazione di origine controllata (DOC) wines and 6 wines obtained from organic farming) were assayed in relation to their content of polyphenolic compounds (total phenols, total flavonoids, total anthocyans, non-anthocyan flavonoids and orthodiphenols), resveratrol, antioxidant activity and ochratoxin A (OTA) contamination. The results showed that the quantity of the various classes of polyphenolic substances and the antioxidant activity was on average higher in wines obtained from organic farming and DOC wines; the contamination by OTA, present in all wines, proved to be lower in those obtained from organic farming, which averaged to 0.14 micro g/litre.

Mikkonen, T. P., K. R. Määttä, et al. (2001). "Flavonol content varies among black currant cultivars." *Journal of Agricultural and Food Chemistry* **49**(7): 3274-3277.

Flavonoids and related plant compounds in fruits and vegetables are of particular importance as they have been found to possess antioxidant and free radical scavenging activity. The HPLC-based quantitative procedure, with improved extraction and hydrolysis, was used to analyse the content of the flavonols quercetin, myricetin, and kaempferol in 10 black currant cultivars from organic farms (Triton, Ben Tron, Ojebyn, Titania, Hedda, Ola, Mortti, Melalahati, Hangaste and a local cultivar) and in 5 cultivars from conventional farms (Ben Tron, Sunnia, Ojebyn, Intercontinental, Ben Alder). Myricetin was the most abundant flavonol, and its amount varied significantly among cultivars, from 8.9 to 24.5 mg 100 g^{-1} (fresh weight). The quercetin levels in black currant also varied widely among the cultivars, from 5.2 to 12.2 mg 100 g^{-1}. The kaempferol levels in black currant cultivars were low, ranging from 0.9 to 2.3 mg 100 g^{-1}. The sum of these major flavonols varied widely among black currant cultivars. No consistent differences in the contents of flavonols were found between the same black currant cultivars grown in organic and conventional ways. The high variability in the levels of flavonols in different cultivars offers possible avenues for identifying and selecting cultivars rich in certain flavonols for the special production of berries for industrial use.

Minelli, G., F. Sirri, et al. (2007). "Egg quality traits of laying hens reared in organic and conventional systems." *Italian Journal of Animal Science* **6**: 728-730.

This study aims to compare the physico-chemical properties of eggs (weight, eggshell breaking strength, Haugh index, yolk colour lipid, cholesterol, protein, ash and dry matter) laid either by hens reared according to the organic method or by caged hens kept in conventional system. More than 1,400 eggs have been analysed at the beginning, in the middle and at the end of the laying cycle in organic and conventional farms. The egg obtained from the organic system were lighter (64.4 vs 66.2 g) being yolk, albumen and eggshell weights statistically lower in comparison with those produced in conventional system. The yolk/albumen ratio resulted lower in the organic eggs (0.38 vs 0.39). The percentage of eggshell was not affected by the hen rearing system while the eggshell strength resulted higher in the eggs produced in the conventional system (3.265 vs 3.135 kg). The organic yolks were paler than the conventional ones. Organic eggs showed significantly higher contents of protein (17.1% vs 16.7%) and cholesterol (1.26% vs 1.21%).

Mirzaei, R., H. Liaghati, et al. (2007). "Evaluating yield quality and quantity of garlic as affected by different farming systems and garlic clones." *Pakistan Journal of Biological Sciences* **10**(13): 2219-2224.

In order to study the effects of different farming systems and garlic (*Allium sativum* L.) clones on yield quality and quantity of garlic, an experiment was conducted with split plot arrangement with three completely randomized blockes in the 2005 growing season at the experimental research station of Shahid Beheshti University at Zirab, north of Iran. Two factors were involved in the experiment: farming systems in three levels (intensive, conventional and organic farming), as main plots and garlic clones in three levels (Atoo, Hamedani and Khorassani) as sub-plots. The studied factors in this experiment consisted of leaf number, LAI, stem height and diameter, bulb yield, weight of bulbs, number of cloves, weight of cloves and level of allicin. Results showed that the farming systems had significant effect (p less than or equal to 0.05) on LAI, number of plant and bulb yield, but the effect on the other factors was not significant. The highest and lowest bulb yields were obtained in intensive (9.5 ton ha^{-1}) and organic (7.4 ton ha^{-1}) systems, respectively. All of the top factors were significantly (p less than or equal to 0.01) affected by garlic clones. Maximum and minimum yields were obtained from Hamedani, Atoo (9.2 ton ha^{-1}) and Virani (7.1 ton ha^{-1}) clones, respectively. Level of allicin was not significantly affected by farming systems but, differences among garlic clones were significant. Maximum and minimum allicin yields were obtained from Hamedan (5.96 mg g^{-1}) and Virani (4. 52 mg g^{-1}) clones, respectively. As a result, however, organic farming systems can not influence the yield in short term, but can increase it by applying crop rotation, use of organic fertilizer and cover crops in the long term.

Mitchell, A. E., Y. J. Hong, et al. (2007). "Ten-year comparison of the influence of organic and conventional crop management practices on the content of flavonoids in tomatoes." *Journal of Agricultural and Food Chemistry* **55**(15): 6154-6159.

Understanding how environment, crop management, and other factors, particularly soil fertility, influence the composition and quality of food crops is necessary for the production of high-quality nutritious foods. The flavonoid aglycones quercetin and kaempferol were measured in dried tomato samples (*Lycopersicon esculentum* L. cv. Halley 3155) that had been archived over the period from 1994 to 2004 from the Long-Term Research on Agricultural Systems project (LTRAS) at the University of California-Davis, which began in 1993. Conventional and organic processing tomato production systems are part of the set of systems compared at LTRAS. Comparisons of analyses of archived samples from conventional and organic production systems demonstrated statistically higher levels ($P<0.05$) of quercetin and kaempferol aglycones in organic tomatoes. Ten-year mean levels of quercetin and kaempferol in organic tomatoes [115.5 and 63.3 mg g^{-1} of dry matter (DM)] were 79 and 97% higher than those in conventional tomatoes (64.6 and 32.06 mg g^{-1} of DM), respectively. The levels of flavonoids increased over time in samples from organic treatments, whereas the levels of flavonoids did not vary significantly in conventional treatments. This increase corresponds not only with increasing amounts of soil organic matter accumulating in organic plots but also with reduced manure application rates once soils in the organic systems had reached equilibrium levels of organic matter. Well-quantified changes in tomato nutrients over years in organic farming systems have not been reported previously.

Moreira, M. d. R., S. I. Roura, et al. (2003). "Quality of Swiss chard produced by conventional and organic methods." *Lebensmittel-Wissenschaft und -Technologie* **36**(1): 135-141.

The storage lives of Swiss chard produced by conventional and organic methods was investigated. No significant differences were found in the initial populations of yeast, molds (1-3 x 10^4 CFU/g) and psychrotrophic (1 x 10^4-1.5 x 10^5 CFU/g), mesophilic (4 x 10^3-5 x 10^4 CFU/g) and lactic acid bacteria (2 x 10^2 and 1. 5 x 10^3 CFU/g). The evolutions of the population of those microorganisms during storage were also similar for both chards. First-order kinetics after an induction period were found for the degradation of ascorbic acid. Although the rate constant (0.057 $days^{-1}$) was similar for both chard, the induction period for organic chard (approx equal to 10 days) was longer than for conventional chard (approx equal to 3 days). No significant differences were found between the water and chlorophyll contents and in pH and titratable acidity of both chards. Sensorial analysis showed that organically produced chard retained turgidity, color and brightness longer than the conventionally produced chard.

Nakagawa, S., Y. Tamura, et al. (2000). "Comparison of rice grain qualities as influenced by organic and conventional farming systems." *Japanese Journal of Crop Science* **69**(1): 31-37.

From 1994 through 1996, qualities of rice grains cultivated under organic and conventional farming systems have been compared at 13 different locations in Japan with respect to their appearances, indices of the eating quality, mineral content, and shelf life. At each location, the organically managed paddy and conventionally managed paddy were adjacent to each other and managed by almost the same farmers. The results of the paired t-tests showed that statistically significant differences in qualities of organic and conventional rice grains were found in 1994 (n = 13), 1996 (n = 13), and a total of three years (n= 39). The organically grown rice had higher Mg/(K . N), zinc content, and embryo activity during storage and lower imperfect rice kernel ratio, nitrogen content, potassium content, and calcium content than the conventionally grown rice. Among these indices, the lower nitrogen content, higher Mg/(K . N), lower potassium content, and higher zinc content of the organically grown rice could be explained because of the lower nitrogen application in organic farming systems than in conventional farming systems. Furthermore, it was found that the organic paddies contained higher available silica than the conventional paddies did statistically, at significant levels at all the locations. This may contribute to the inhibition of nitrogen accumulation in organic rice grains.

Nguyen, M. L., R. J. Haynes, et al. (1995). "Nutrient budgets and status in three pairs of conventional and alternative mixed cropping farms in Canterbury, New Zealand." *Agriculture, Ecosystems & Environment* **52**(2-3): 149-162.

The major inputs of N, P and S as fertilizer and biological N_2 fixation, and the removals of these nutrients in harvested products (grain, meat and wool) for each year of the rotation of three pairs of farms in New Zealand were calculated. The farms were under a mixed cropping system, common to the study area, in which grazed grass/white clover (*Trifolium repens*) pasture and/or grass and white clover seed crops are grown in rotation with arable crops. One of each pair of farms was managed conventionally and the other was under an alternative organic system. The nutrient status of soils, harvested grain and pasture herbage were measured along with the OM content and enzyme activities of the soils. Nutrient budgets for N, P and S on the conventional farms were generally balanced or positive so that the supply of these nutrients was unlikely to be limiting production. Nitrogen budgets were positive at all three alternative farms with biological N_2 fixation accounting for most or all of the N input. One alternative farm had positive P and S budgets because of additions of compost, phosphate rock and elemental S. By contrast, at the other two alternative farms, net removal of P, and in one case S, occurred. In the other case, the S budget was balanced by one application (per rotation) of S fertilizer to the pasture. At these two sites, concn of grain N, P and S were lower than those at conventional sites and pasture herbage P and S concn were below recommended critical concn. Levels of total S and P and available P in soils were also lower on the alternative than conventional farms. Production on these alternative farms is relying on soil reserves of P and S, and additions of P and S will be required in the future to sustain current production levels. Organic C content and arylphosphatase, arylsulphatase and urease activities tended to be higher under alternative than conventional pastoral management. This was attributed to the longer pastoral phase under alternative (3-4 year) than conventional (1-2 year) management resulting in a small build up of organic matter. However, organic C content and enzyme activities were similar under conventional and alternative systems during the arable phase suggesting that conventional management had no adverse effect on soil biological activity.

Ninfali, P., M. Bacchiocca, et al. (2008). "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* **85**(2): 151-158.

The quality of extra-virgin olive oils (EVOO) from organic and conventional farming was investigated in this 3-year (2001-2003) study. The oils were extracted from Leccino and Frantoio olive (Olea europaea) cultivars, grown in the same geographical area under either organic or conventional methods. Extra-virgin olive oils (EVOO) were produced with the same technology and samples were analyzed for nutritional and quality parameters. Volatile compounds were measured with solid-phase microextraction combined with gas chromatography and mass spectrometry (SPME-GC-MS). Sensory evaluation was also completed by a trained panel. Significant differences were found in these parameters between organic and conventional oils in some years, but no consistent trends across the 3 years were found. The acidity of organic Leccino oils was higher than conventional oils in 2001 and 2002 but not in 2003; Frantoio oils were never different. Organic Leccino oils had higher peroxide index than conventional oils in 2001 and 2002 but it was the reverse in 2003. Organic Frantoio oils had lower peroxide index in 2001, but values were not statistically different in the other years. The concentrations of phenols, o-diphenols, tocopherols, the antioxidant capacity and the volatile compounds showed differences in some years and no difference, or opposite differences, in others. Sensory analysis showed only slight differences in few aromatic notes. Our results showed that organic versus conventional cultivation did not affect consistently the quality of the high quality EVOO considered in this study, at least in the measured parameters. Genotype and year-to-year changes in climate, instead, had more marked effects.

Nyanjage, M. O., H. Wainwright, et al. (2001). "A comparative study on the ripening and mineral content of organically and conventionally grown Cavendish bananas." *Biological Agriculture & Horticulture* **18**(3): 221-234.

A study was undertaken to compare the postharvest properties of organically and conventionally grown bananas. The effects of ethrel treatment on the skin colour of organic and non-organic bananas (Musa AAA group Cavendish subgroup, Robusta) were determined during ripening at 22-25 degreesC. In addition, pulp temperature, impedance (at 100 Hz, 500 Hz. 1 kHz. 10 kHz), gravimetric and volumetric pulp: peel ratios, fruit density, total soluble solids (TSS) and major (N, P, K, Ca and Mg) minerals of ripe fruit were also compared for organically and conventionally grown bananas. Organic bananas ripened faster than non-organic bananas as measured by peel colour change (reflectance. chroma and hue angle). Hedonic scale values showed that ethrel treatment promoted uniform skin change from green to yellow. Visual colour values had strong positive correlation against reflectance, chroma or hue angle, but was more closely related to hue angle. Organic and non-organic bananas had no significant difference in TSS contents. Impedance decreased with rise in frequency and pulp temperature and showed strong negative correlation against reflectance, chroma and hue angle of organic and non-organic banana at 100 Hz. Ripe non-organic bananas had both higher gravimetric pulp: peel ratio and impedance compared with organic fruits. In all fruits, the peel had higher N. P, K. Mg and Ca than the pulp. The peel of non-organic fruits had higher N and lower P contents than organic fruits. Differences in mineral content between the pulp of organic and non-organic fruits were much less than those between the peel. This study shows that production methods of bananas has a significant influence on the postharvest behaviour of bananas and this in turn must influence their subsequent management in order to optimize quality for the consumer.

Olsson, I. M., S. Jonsson, et al. (2001). "Cadmium and zinc in kidney, liver, muscle and mammary tissue from dairy cows in conventional and organic farming." *Journal of Environmental Monitoring* **3**(5): 531-538.

Input of Cd to arable soils occurs mainly through atmospheric deposition and mineral fertilisers. Phosphate fertilisers are often contaminated with Cd. In organic farming the use of mineral fertilisers is restricted. The impact of conventional and organic farming on Cd and Zn levels in tissues from dairy cows was studied. Kidney, liver, muscle and mammary tissue samples were collected at slaughter from 67 cows, aged 30-95 months, in a project with conventional and organic production at the same farm. Samples were analysed by electrothermal atomic absorption spectrometry with a quality control programme. Significantly lower levels of Cd were found in cows from the organic system (n = 29) than from the conventional cows (n = 38) in kidney [330 +/- 100 (mean +/- s) mug kg^{-1} vs. 410 +/- 140]. liver (33 +/- 15 vs. 44 +/- 19) and mammary tissue (0.38 +/- 0.14 is 0.59 +/- 0.37), while there were no differences in muscle (0.48 +/- 0.13 vs. 0.49 +/- 0.14). Organic cow kidneys had lower Zn levels than conventional cows (19 +/- 1.4 mg kg^{-1} vs. 20 +/- 2), whereas muscles had higher Zn levels than conventional cows (67 +/- 16 vs. 51 +/- 12). Cd and Zn in mammary tissue were positively related to age and milk production. There was a positive relationship between levels in kidney of Cd and metallothionein (M-nand a Cd/MT concentration ratio indicating protection from Cd-induced renal dysfunction, When older animals, that entered the project as milk-producing cows, were included the differences in kidney and liver Cd levels between the systems were no longer significant, while-Cd in kidney became related to age- and production-related parameters. The change of significant relationships when older animals were included shows the importance of controlled conditions for environmental monitoring.

Olsson, M. E., C. S. Andersson, et al. (2006). "Antioxidant levels and inhibition of cancer cell proliferation in vitro by extracts from organically and conventionally cultivated strawberries." *Journal of Agricultural and Food Chemistry* **54**(4): 1248-1255.

The effects of extracts from five cultivars of strawberries on the proliferation of colon cancer cells HT29 and breast cancer cells MCF-7 were investigated, and possible correlations with the levels of several antioxidants were analyzed. In addition, the effects of organic cultivation compared to conventional cultivation on the content of antioxidants in the strawberries and strawberry extracts on the cancer cell proliferation were investigated. The ratio of ascorbate to dehydroascorbate was significantly higher in the organically cultivated strawberries. The strawberry extracts decreased the proliferation of both HT29 cells and MCF-7 cells in a dose-dependent way. The inhibitory effect for the highest concentration of the extracts was in the range of 41-63% (average 53%) inhibition compared to controls for the HT29 cells and 26-56% (average 43%) for MCF-7 cells. The extracts from organically grown strawberries had a higher antiproliferative activity for both cell types at the highest concentration than the conventionally grown, and this might indicate a higher content of secondary metabolites with anticarcinogenic properties in the organically grown strawberries. For HT29 cells, there was a negative correlation at the highest extract concentration between the content of ascorbate or vitamin C and cancer cell proliferation, whereas for MCF-7 cells, a high ratio of ascorbate to dehydroascorbate correlated with a higher inhibition of cell proliferation at the second highest concentration. The significance of the effect of ascorbate on cancer cell proliferation might lie in a synergistic action with other compounds.

Olsson, V., K. Andersson, et al. (2003). "Differences in meat quality between organically and conventionally produced pigs." *Meat Science* **64**(3): 287-297.

This study compared organic pig meat production with conventional production with regard to carcass- and meat quality traits. 80 crossbred female and castrated male pigs were used [(Swedish Landrace x Swedish Yorkshire) x Hampshire] of which 40 were raised under organic conditions and the other 40 were raised in a conventional production system. The organic pigs were raised outdoors in one large group following the regulations for organic standards. The conventionally raised animals were kept indoors in groups of eight and were given a conventional feed mixture. It was found that meat of organically raised non-carriers of the RN- allele was of poorer quality (higher drip loss and increased shear force values) compared with meat from the other animals. The RN genotype had a relatively small effect on carcass and technological traits in this study. The sex of the animals affected carcass traits.

Otreba, J. B., E. Berghofer, et al. (2006). "Polyphenols and anti-oxidative capacity in Austrian wines from conventional and organic grape production." *Mitteilungen Klosterneuburg* **56**(1/2): 22-32.

The influence of organic and conventional, grape production on the contents of polyphenols, in particular resveratrol and leucoanthocyanidin, as well as the antioxidative capacity of white and red wines was examined. AA total of 189 wine samples (six white and four red cultivars; three vintages) was compared. Generally, a large dispersion of the values and only a small dependence on the grape production method could be determined. As a tendency, white wines from organic grape production showed higher contents of phenols and leucoanthocyanidins as well as higher values of the anti-oxidative capacity than wines from conventional grape production. With red wines in those from organic grape production significantly higher contents of resveratrols and anthocyanidins were determined than in the conventional. Values of the anti-oxidative capacity showed no uniform course, with the vintage 2002 wines from conventionally produced grapes showed a higher average value and in 2001 organically produced wines. During the vintage-independent evaluation according to cultivar groups the wines of the cultivars Grüner Veltliner, Chardonnay and Weissburgunder showed higher contents of resveratrols and total phenolics and a higher anti-oxidative potential from organic grape production than those from conventionally produced grapes. It is remarkable that wines from all red and white wine cultivars out of organic grape production showed higher contents of cis-resveratrol than wines from conventionally produced grapes. Cis-resveratrol therefore could be a natural means of defence in organic viticulture against fungal infections.

Peck, G. M., P. K. Andrews, et al. (2006). "Apple orchard productivity and fruit quality under organic, conventional, and integrated management." *HortScience* **41**(1): 99-107.

Located on a 20-ha commercial apple (*Malus domestica* Borkh.) orchard in the Yakima Valley, Washington, a 1.7-ha study area was planted with apple trees in 1994 in a randomized complete block design with four replications of three treatments: organic (ORG), conventional (CON), and integrated (INT). Soil classification, rootstock, cultivar, plant age, and all other conditions except management were the same on all plots. In years 9 (2002) and 10 (2003) of this study, we compared the orchard productivity and fruit quality of 'Galaxy Gala' apples. Measurements of crop yield, yield efficiency, crop load, average fruit weight, tree growth, color grades, and weight distributions of marketable fruit, percentages of unmarketable fruit, classifications of unmarketable fruit, as well as leaf, fruit, and soil mineral concentrations, were used to evaluate orchard productivity. Apple fruit quality was assessed at harvest and after refrigerated (0 to 1 deg C) storage for three months in regular atmosphere (ambient oxygen levels) and for three and six months in controlled atmosphere (1.5% to 2% oxygen). Fruit internal ethylene concentrations and evolution, fruit respiration, flesh firmness, soluble solids concentration (SSC), titratable acidity (TA), purgeable volatile production, sensory panels, and total antioxidant activity (TAA) were used to evaluate fruit quality. ORG crop yields were two-thirds of the CON and about half of the INT yields in 2002, but about one-third greater than either system in 2003. High ORG yields in 2003 resulted in smaller ORG fruit. Inconsistent ORG yields were probably the result of several factors, including unsatisfactory crop load management, higher pest and weed pressures, lower leaf and fruit tissue nitrogen, and deficient leaf tissue zinc concentrations. Despite production difficulties, ORG apples had 6 to 10 N higher flesh firmness than CON, and 4 to 7 N higher than INT apples, for similar-sized fruit. Consumer panels tended to rate ORG and INT apples to have equal or better overall acceptability, firmness, and texture than CON apples. Neither laboratory measurements nor sensory evaluations detected differences in SSC, TA, or the SSC to TA ratio. Consumers were unable to discern the higher concentrations of flavor volatiles found in CON apples. For a 200 g fruit, ORG apples contained 10% to 15% more TAA than CON apples and 8% to 25% more TAA than INT apples. Across most parameters measured in this study, the CON and INT farm management systems were more similar to each other than either was to the ORG system. The production challenges associated with low-input organic apple farming systems are discussed. Despite limited technologies and products for organic apple production, the ORG apples in our study showed improvements in some fruit quality attributes that could aid their marketability.

Pérez-Llamas, F., I. Navarro, et al. (1996). "Comparative study on the nutritive quality of foods grown organically and conventionally." *Alimentaria* **34**(274): 41-44.

Lettuce (var. Iceberg), carrots (cv. Nantesa) and peas (cv. Lincoln) were grown conventionally using inorganic fertilizers or by organic methods. There was no difference between conventionally and organically grown vegetables in protein, ether extract, fibre, mineral and carbohydrate contents. Organically grown carrots and peas had lower nitrate values (P<0.05), 71 plus or minus 6 and 9 plus or minus 3 mg/kg, respectively, than had those grown conventionally, 98 plus or minus 8 and 71 plus or minus 6 mg/kg. Organically grown lettuce had lower nitrite values (P<0.05), 0.45 plus or minus 0.08 mg/kg, than had conventionally grown lettuce, 0.83 plus or minus 0.09 mg/kg. It is concluded that it might be advantageous for groups such as growing children and strict vegetarians to take organically rather than conventionally grown vegetables.

Perez-Lopez, A. J., F. M. del Amor, et al. (2007a). "Influence of agricultural practices on the quality of sweet pepper fruits as affected by the maturity stage." *Journal of the Science of Food and Agriculture* **87**(11): 2075-2080.

Background: Peppers are popular vegetables because of their colour, taste and nutritional value. The levels of vitamin C, carotenoids and phenolic compounds in peppers and other vegetables depend on several factors, including cultivar, agricultural practice and maturity stage. Results: In this study the effects of maturation and type of agricultural practice (organic or conventional) on the ascorbic acid, total carotenoid and total phenolic contents and colour parameters of sweet peppers (*Capsicum annuum* cv. Almuden) grown in a controlled greenhouse were determined. Levels of vitamin C, phenolic compounds and carotenoids increased during ripening, with red sweet peppers having higher contents of these bioactive compounds. Moreover, peppers grown under organic culture had higher vitamin C, phenolic and carotenoid levels than those grown under conventional culture. With respect to colour parameters, organic red peppers had higher values of L*, a*, b*, C* and H-ab than conventional red peppers, giving them a higher intensity of red colour. Conclusion: Thus organic farming had a positive effect on the nutritional content of peppers, increasing the vitamin C activity and the level of phenolic compounds, both implicated in the antioxidant activity of vegetables, and the content of carotenoids, implicated in the colour variance observed in pepper fruits.

Pérez-López, A. J., J. M. López-Nicolas, et al. (2007b). "Effects of agricultural practices on color, carotenoids composition, and minerals contents of sweet peppers, cv. Almuden." *Journal of Agricultural and Food Chemistry* **55**(20): 8158-8164.

Consumers demand organic products because they believe they are more flavorful and respectful to the environment and human health. The effects of conventional, integrated, and organic farming, grown in a controlled greenhouse, on color, minerals, and carotenoids of sweet pepper fruits (*Capsicum annuum*), cv. Almuden, were studied. Experimental results proved that organic farming provided peppers with the highest (a) intensities of red and yellow colors, (b) contents of minerals, and (c) total carotenoids. Integrated fruits presented intermediate values of the quality parameters under study, and conventional fruits were those with the lowest values of minerals, carotenoids, and color intensity. As an example, the concentrations of total carotenoids were 3231, 2493, and 1829 mg kg^{-1} for organic, integrated, and conventional sweet peppers, respectively. Finally, organic red peppers could be considered as those having the highest antioxidant activity of all studied peppers (agricultural farming and development stage).

Pérez-López, A. J., J. M. López-Nicolás, et al. (2007c). "Effects of organic farming on minerals contents and aroma composition of Clemenules mandarin juice." *European Food Research and Technology* **225**(2): 255-260.

Consumers demand organic products because they believe that the organic products are more flavorful and respectful to the environment and human health. The effects of organic farming on the minerals contents and aroma composition of Clemenules mandarin juices were studied. Minerals (Fe, Cu, Mn, Zn, Ca, Mg, K, and Na) were quantified using atomic absorption-emission spectroscopy, while volatile compounds were extracted using the dynamic headspace technique and were identified and quantified by GC-MS. In general, organic farming produced a mandarin juice with a higher quality than that produced by conventional agricultural practices. Higher concentrations of both minerals and positive volatile compounds were found in the organic juice, while the formation of off-flavors was higher in the conventional juice, although threshold values were not reached.

Perretti, G., E. Finotti, et al. (2004). "Composition of organic and conventionally produced sunflower seed oil." *Journal of the American Oil Chemists' Society* **81**(12): 1119-1123.

The aim of the present study was to highlight the main differences between seed oils produced from conventionally cultivated crops and organically cultivated ones and processed using mild extraction procedures. The composition and the nutritional and health aspects of both types of sunflower seed oils were compared and were analytically tested to determine the macroscopic differences in proximate composition, the main differences in the minor components, the main quality parameters, the *in vitro* antioxidant activity, and the presence of *trans*-ethylene stereoisomers in FA. No significant trends were found in the oil samples for TAG and FA composition, but remarkable differences were found in the composition of minor components and in the main chemical and analytical quality properties. The organically grown samples had a higher total antioxidant activity compared with the conventional samples. *Trans* FA were found only in the conventional oils.

Petr, J. (2006). "Quality of triticale from ecological and intensive farming." *Scientia Agriculturae Bohemica* **37**(3): 95-103.

The quality of grains of 7 triticale cultivars (Presto, Disco, Danko, Sekundo, Marko, Kolor and Modus) grown in Hradec, Lípa, Krásne Údolí and Uhrineves ECO, Czech Republic, was evaluated during 2001-04. The station in Hradec was located in a potato growing region with an altitude of 450 m above sea level (masl), annual average temperature (AAT) of 6.5 deg C, and annual sum of precipitation (ASP) of 625 mm. The station in Lípa was located in a cereal growing region with an altitude of 505 masl, AAT of 7.7 deg C, and ASP of 632 mm. The station in Krásné Údolí was located in a forage growing region with an altitude of 647 masl, AAT of 6.3 deg C, and ASP of 602 mm. The station in Uhrineves had an altitude of 295 masl, AAT of 8.4 deg C, and ASP of 575 mm. Grains from plants under ecological and intensive cultivation was not suitable for the preparation of proofing doughs. Under ecological cultivation, the contents of prolamins and glutelins were lower, but the contents of albumins and globulins were higher. The crude protein content increased with the increase in the intensity of cultivation. The contents of high-molecular-weight proteins were lower under ecological cultivation, whereas the concentrations of low-molecular-weight proteins and gliadin did not significantly vary between the cropping intensities. Ecological farming did not improve the baking quality, but affected the structure of proteins in favour of the nutritionally more valuable albumins and globulins. The grain yield under ecological farming was 88% of the yield under intensive farming.

Petr, J., ke, et al. (2000). "Quality of malting barley grown under different cultivation systems." *Monatsschrift für Brauwissenschaft* **53**(5/6): 90-94.

Three-year trials were conducted near Prague, Czech Republic on luvisol clay soil to investigate spring barley cultivars grown organically or conventionally. The weather conditions affected most of the quality traits more than factors such as nitrogen application or farming system. Significant differences among years were recorded in grain protein content, relative extract at 45 deg C, Kolbach index, diastatic power, and apparent final attenuation. Farming system markedly influenced the β-glucan content in wort, which was surprisingly low under organic management. The effect of farming system was also apparent in the hot water extract and partially in Kolbach index and friability.

Petr, J., Sr., J. Petr, Jr., et al. (1998). "Quality of wheat from different growing systems." *Scientia Agriculturae Bohemica* **29**(3/4): 161-182.

Wheat cultivars were grown in the Czech Republic in 1994-97 using an ecological production system (no fertilizers or pesticides), a conventional system (NPK fertilizers, seed treatment, and herbicides) and a conventional system with plant protection (as the former system plus growth regulators, fungicide and insecticide). Yield and quality of each cultivar in each production system are tabulated. In the ecological system, cv. Hana and Samanta gave the highest quality.

Procida, G., G. Pertoldi Marletta, et al. (1998). "Heavy metal content of some vegetables farmed by both conventional and organic methods." *Rivista di Scienza dell'Alimentazione* **27**(3): 181-189.

Microelements content (Pb, Cd, Cr, Ni and Zn) was determined in lettuce cv. White Salad Bowl, chicory cv. Zuccherina di Trieste and rocket [*Eruca vesicaria* subsp. *sativa*] and in associated soil from greenhouses managed by traditional and organic methods. The samples were analysed by AAS with electrothermal atomization after dry ashing of vegetables and acid extraction of soils. Preliminary results showed that microelements were accumulated in the vegetables and soils in both conventional and organic greenhouse systems. The concentrations found in all samples were so low (maximum levels of Pb and Cd on fresh weight basis were 0.07 and 0.015 ppm, respectively) that no possible danger could arise for the consumer from either conventional or organic products.

Rembialkowska, E. (1998). "Comparative study into wholesomeness and nutritional quality of carrot and white cabbage from organic and conventional farms." *Roczniki Akademii Rolniczej w Poznaniu, Ogrodnictwo*(No. 27): 257-266.

Carrots and white cabbages from 10 organic farms certified by the Polish EKOLAND organization in Toru and Plock provinces and 10 conventional intensive farms in Warsaw province were compared.Organic carrots had lower nitrite but higher cadmium contents than conventionally grown carrots. Organic cabbages had higher dry matter, ascorbic acid and potassium contents but lower calcium content than their conventional equivalents.

Rembialkowska, E. (1999). "Comparison of the contents of nitrates, nitrites, lead, cadmium and vitamin C in potatoes from conventional and ecological farms." *Polish Journal of Food and Nutrition Sciences* **8**(4): 17-26.

17 Polish organic farms were studied during 1991-93. The content of DM was significantly higher in organically-produced potatoes (OP) than in conventionally-produced potatoes (CPP); the difference being 1.3 g/100 g fresh mass. The content of nitrates in OP was 266.6 mg/kg fresh mass, which was significantly lower than in CPP (838.7 mg/kg fresh mass). The content of $NaNO_2$ was higher in CPP, but the difference was not significant. The Cd content in OP was 0.162 mg/kg fresh mass, which was significantly lower than in CPP (0.292 mg/kg fresh mass). The content of Pb in both types of potatoes was similar and comparable with other published results. The vitamin C content in both types of potatoes was low and similar. It is concluded that the health/quality factors were better for OP than for CPP.

Ren, H. F., H. Bao, et al. (2001). "Antioxidative and antimicrobial activities and flavonoid contents of organically cultivated vegetables." *Journal of the Japanese Society for Food Science and Technology-Nippon Shokuhin Kagaku Kogaku Kaishi* **48**(4): 246-252.

Antioxidative and antimicrobial activities, and flavonoid content were surveyed in the eight organically cultivated (OC) vegetables. The same varieties of vegetables generally cultivated (GC) using a chemical fertilizer harvested from nearby farm on the same day were used for comparison of the activities and chemical composition. in the study. OC vegetables, such as cabbage, spinach, broccoli, and Welsh onion were indicated to show more than 50% higher antioxidative activity compared to that of GC vegetables. OC Chinese cabbage showed higher antimicrobial activity against Salmonella, and OC cabbage and Japanese radish against Vibrio, than those observed in GC vegetables LC/MS quantitative analysis revealed that at least two flavonoids content were determined to be more than double (significant at 95% level in t-test) in Welsh onion, Qing-gen-cai, and spinach in comparison with those in GC vegetables.

Ristic, M., P. (2003). Quality of poultry meat obtained using different production systems and EU regulations for production and marketing of poultry carcasses. *Tehnologija Mesa* **44**(3/4): 149-158.

Five comparative studies were carried out on broiler chickens (n = 7864) reared under conventional farming methods (control) and alternative production systems (free range and organic). Fattening time ranged from 35 days in the control group to less than or equal to 80 days. Genotypes used were Ross 308 (control), slow growing genotypes ISA J457, J257, JA 57, Shaver RedBro, and the rapid growing genotypes, Sena Double Breast and Ross Mini. Subsequent analysis of 380 broiler carcasses revealed considerable influence of production system on carcass and meat composition, including proportions of meat and fatty tissue in breast and thigh meat. Alternative production methods did not produce any significant improvement in organoleptic traits compared with conventional production, however length of fattening period and broiler genotype influenced organoleptic properties in some cases. EU regulatory requirements for poultry transport and for processing and marketing of poultry carcasses are also discussed.

Ristic, M., P. Freudenreich, et al. (2007). Meat quality of broilers: a comparison between conventional and organic. *Fleischwirtschaft* **87**(5): 114-116.

In 3 test series different origins were kept under controlled organic conditions: ISA J 457, ISA J 257 (test A); ISA JA 57 and RedBro (Shaver) - slowly growing; Senna (double breast) and Ross (mini) - fast growing (test B) as well as ISA J 257 and SASSO (test C). They were compared to a control group (conventional) Ross 308. Feeding duration varied from 35, 54, 70 to 77 days. Feeding performance data (n=7200), carcass value as well as the chemical composition of the meat and the abdominal fat (n=692) were recorded. The investigations led to the following results: there were significant differences between fast growing origins, which are also used in organic poultry production, and slowly growing origins, both in live weight and carcass weight (190-345 g and 196-242 g, respectively). The fast growing origins and the control group showed higher values of meat content of breast and thighs (1.7-2.6 and 3.2%, respectively). There was no significant improvement of the sensory parameters of chest and thigh meat (juiciness, tenderness, flavour) of organic production compared to conventional production. With regard to the chemical composition of breast and thigh meat significant differences occurred. The fatty acid pattern of the abdominal fat was due to the influence of the genotype and the production conditions. The recommended feeding duration of at least 81 days for fast growing broilers in organic production can be shortened according to the genetic potential.

Robbins, R. J., A. S. Keck, et al. (2005). "Cultivation conditions and selenium fertilization alter the phenolic profile, glucosinolate, and sulforaphane content of broccoli." *J Med Food* **8**(2): 204-14.

Broccoli is a food often consumed for its potential health-promoting properties. The health benefits of broccoli are partly associated with secondary plant compounds that have bioactivity; glucosinolates and phenolic acids are two of the most abundant and important in broccoli. In an effort to determine how variety, stress, and production conditions affect the production of these bioactive components broccoli was grown in the greenhouse with and without selenium (Se) fertilization, and in the field under conventional or organic farming procedures and with or without water stress. High-performance liquid chromatography/mass spectrometry was used to separate and identify 12 primary phenolic compounds. Variety had a major effect: There was a preponderance of flavonoids in the Majestic variety, but hydroxycinnamic esters were relatively more abundant in the Legacy variety. Organic farming and water stress decreased the overall production of phenolics. Se fertilization increased glucosinolates in general, and sulforaphane in particular, up to a point; above that Se fertilization decreased glucosinolate production. Organic farming and water stress also decreased glucosinolate production. These data show environmental and genetic variation in phenolics and glucosinolates in broccoli, and warn that not all broccoli may contain all health-promoting bioactive components. They further show that selection for one bioactive component (Se) may decrease the content of other bioactive components such as phenolics and glucosinolates.

Rodríguez, J., D. Ríos, et al. (2006). "Physico-chemical changes during ripening of conventionally, ecologically and hydroponically cultivated Tyrlain (TY 10016) tomatoes." *International Journal of Agricultural Research* **1**(5): 452-461.

The following physico-chemical parameters: hardness, moisture, Brix degree, ash, pH, acidity, ascorbic acid, total phenol compounds were determined in tomato samples belonging to Tyrlain cultivar cultivated conventionally, ecological and hydroponically (in tuff and cocoa fiber) and in several points of ripening. A clear tendency in the reduction of hardness and acidity and an increase of Brix degree/acidity ratio and ash was observed when the tomatoes ripened. The overripe tomatoes presented a lower ascorbic acid content than the green or commercial tomatoes. No detectable changes were found in the total phenolic compounds. Ecological tomatoes showed higher moisture content and lower Brix degree, ascorbic acid and total phenolic compounds than conventional and hydroponic cultivations. Hydroponic tomatoes presented a higher mineral content than those ecologically and conventionally cultivated. Many significant correlations were found between the physico-chemical parameters studied for the conventionally and the two hydroponically cultivated tomatoes. Hardness correlated positively with the acidity in all the methods of cultivation and after graphic representation, the overripe tomatoes tend to differentiate from the green and ripen tomatoes. Applying multivariate analysis the tomato samples tend clearly to differentiate according to the ripening stage and to a lesser extent, according to the type of cultivation.

Rutkowska, B. (2001). "Nitrate and nitrite content in potatoes from ecological and conventional farms." *Roczniki Panstwowego Zakladu Higieny* **52**(3): 231-6.

The aim of this investigation was to determine nitrate and nitrite content in potatoes from ecological and conventional farms. The influence of variety on nitrate and nitrite content was also evaluated. Vegetables and potatoes from ecological cultures are supposed to contain less nitrates and nitrites and on this basis could have been advised for children, sick and people in special physiological stages. Nitrite content was determined colorimetrically, with sulfanilic acid, nitrate content was determined following reduction of nitrites by means of metallic cadmium. The results showed significantly lower nitrate content in potatoes from ecological farms, and almost twice higher in those from conventional farms. The nitrite content showed no differentiation in conventional and ecological farms. Within three varieties of potatoes (sokol, bryza, ania) significantly highest content of nitrate was determined in bryza. Considering low nitrate level potatoes from ecological farms could be advised for children and sick people, but for the complete safety evaluation also content of other contaminants (i.e. heavy metals) have to be assessed.

Ryan, M. H., J. W. Derrick, et al. (2004). "Grain mineral concentrations and yield of wheat grown under organic and conventional management." *Journal of the Science of Food and Agriculture* ***84***(3): 207-216.

On the low-P soils in southeastern Australia, organic crops differ from conventional ones primarily in the use of relatively insoluble, as opposed to soluble, P fertilisers and in the non-use of herbicides. As organic management, particularly elimination of soluble fertilisers, is often claimed to enhance grain mineral concentrations, we examined grain from wheat on paired organic and conventional farms in two sets of experiments: (1) four pairs of commercial crops (1991-1993); and (2) fertiliser experiments on one farm pair where nil fertiliser was compared with 40 kg ha^{-1} of P as either relatively insoluble reactive phosphate rock or more soluble superphosphate (1991 and 1992). All wheat was grown following a 2-6 year legume-based pasture phase. Both conventional management and the superphosphate treatment greatly increased yields but reduced colonisation by mycorrhizal fungi. While only minor variations occurred in grain N, K, Mg, Ca, S and Fe concentrations, conventional grain had lower Zn and Cu but higher Mn and P than organic grain. These differences were ascribed to: soluble P fertilisers increasing P uptake but reducing mycorrhizal colonisation and thereby reducing Zn uptake and enhancing Mn uptake; dilution of Cu in heavier crops; and past lime applications on the organic farm decreasing Mn availability. These variations in grain minerals had nutritional implications primarily favouring the organic grain; however, organic management and, specifically, elimination of soluble fertilisers did not induce dramatic increases in grain mineral concentrations. In addition, organic management was coupled with yield reductions of 17-84 per cent due to P limitation and weeds. The impact of large regional variations in the characteristics of organic and conventional systems on the general applicability of the results from this study and other similar studies is discussed.

Saastamoinen, M., V. Hietaniemi, et al. (2004). "ß-glucan contents of groats of different oat cultivars in official variety, in organic cultivation, and in nitrogen ferilization trials in Finland." *Agricultural and Food Science* **13**(1-2): 68-79.

beta-Glucan is a beneficial chemical compound in the diet of humans by decreasing the levels of serum cholesterol and blood glucose. The beta-glucan contents of oat groats were studied in official variety trials (1997-1999), nitrogen fertilization trials (1997-1999) and organic variety trials (1997-1998) in Finland. Eight cultivars were studied in the organic variety trials. Two of them, cultivars Puhti and Veli, were cultivated also with a conventional method at the same fields. The years 1997 and 1999 were very warm and dry and 1998 very cool and rainy. The effects of year and cultivar on beta-glucan content were significant in all three trial series. The Kolbu oat cultivar had a significantly lower beta-glucan content than other cultivars in all trials. N fertilization did not increase the beta-glucan contents of oats in Finland. The effect of cultivation method (traditional vr organic cultivation) had no significant effect on the beta-glucan content. The year x cultivar interaction significantly affected the beta-glucan contents of oat groats in N fertilization trials. The reaction of different cultivars to weather conditions was different. Kolbu oat cultivar had significantly lower beta-glucan contents in 1998 than in warm years in all three trial series.

Samman, S., J. W. Y. Chow, et al. (2008). "Fatty acid composition of edible oils derived from certified organic and conventional agricultural methods." *Food Chemistry* **109**(3): 670-674.

The objective of this study is to compare the fatty acid composition of commercially available edible oils derived from certified organic and conventional agricultural methods. A total of 59 certified organic and 53 conventional oils were purchased from retail markets in Sydney, Australia. Organic and conventional products were matched for comparison according to the description of production methods, labelled total fat content, brand name (wherever possible), and country of origin. Total fat was extracted and the fatty acid composition of the oils was determined by gas chromatography. No consistent overall trend of difference in the fatty acid composition was observed between organic and conventional oils. Saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids were all significantly different between types of oil ($P<0.001$ in all three), and each had significant interaction between type and production method ($P=0.002$, $P<0.001$ and $P<0.001$, respectively) indicating that organic and conventional oils differed in these components in an inconsistent fashion. Despite this, there were large differences particularly between MUFA and PUFA components in specific pairs of oils, especially in sunflower and mustard seed oils. The absence of an overall difference in the fatty acid composition of organic and conventional oils does not support the tenet that organic foods are of a higher nutritional quality than their conventional counterparts.

Santos, J. S. d., L. Beck, et al. (2005). "Nitrate and nitrite in milk produced by conventional and organic systems." *Ciência e Tecnologia de Alimentos* **25**(2): 304-309.

Nitrate and nitrite levels were evaluated in raw milk samples produced via conventional and organic systems. Samples were collected from farms in Rio Grande do Sul, Brazil. The average levels of nitrate and nitrite in samples were 6.65 plus or minus 0.84 and 1.76 plus or minus 0.17 mg/litre, respectively. Milk produced via the organic system showed 7.08 mg/litre nitrate and 1.61 mg/litre nitrite, whereas milk produced the traditional system showed 6.36 and 1.87 mg/litre nitrate and nitrite, respectively.

Seidler-Lozykowska, et al. (2007). "Evaluation of quality of savory herb (*Satureja hortensis* L.) from organic cultivation." *Journal of Research and Applications in Agricultural Engineering* **52**(4): 48-51.

The usefulness of Polish savory (*Satureja hortensis*) cultivar Saturn for organic cultivation was investigated in four field experiments (Plewiska, Slosk, Jary and Wiry, Poland). The following traits were examined: yield of fresh herbs, dried herbs and herbs without stems, stem content in herb, seed yield, 1000-seed weight, essential oil content, mineral elements content and microbiological contamination. The herb yield from only one organic cultivation (in Slosk) was higher than that from conventional cultivation. Savory herb from organic cultivation contained more essential oil and mineral elements except calcium. Microbiological contamination analysis of savory herb showed that all investigated herbs were below the level of standard contamination for raw material treated with hot water.

Shier, N. W., J. Kelman, et al. (1984). "A comparison of crude protein, moisture, ash and crop yield between organic and conventionally grown wheat." *Nutrition Reports International* **30**(1): 71-76.

There was no significant difference in crude protein, moisture or ash estimated at 700˚C between 9 samples of wheat grown organically (without use of synthetic pesticides and fertilizers) and 9 samples grown conventionally on different farms. Ash was significantly greater in conventional samples after ashing at 550˚C. The conventional method produced a significantly greater amount of grain.

Smith (1993). "Organic foods vs. supermarket foods: Element levels." *Journal of Applied Nutrition* **5** (1): 35-39.
Organic food has been noted in various studies as having similar nutritional value as commercial foods. These studies usually look atthe dry ashed concentration and are designed for the food producer. In this study the average elemental concentration in organic foods onafresh weight basis was found to be about twice that of commercial foods.

Sousa, C., P. Valentao, et al. (2005). "Influence of two fertilization regimens on the amounts of organic acids and phenolic compounds of tronchuda cabbage (*Brassica oleracea* L. Var. costata DC)." *Journal of Agricultural and Food Chemistry* **53**(23): 9128-32.
A phytochemical study was undertaken on tronchuda cabbage (*Brassica oleracea* L. var. costata DC) cultivated under conventional and organic practices and collected at different times. Six organic acids (aconitic, citric, ascorbic, malic, shikimic, and fumaric acids) were identified and quantified by HPLC-UV. Qualitative and quantitative differences were noted between internal and external leaves. Analysis of the phenolics of the internal leaves was achieved by HPLC-DAD, and the phenolic profile obtained was revealed to be distinct from that of the external leaves. By this means were identified and quantified 11 compounds: 3-p-coumaroylquinic acid, kaempferol 3-O-sophoroside-7-O-glucoside, kaempferol 3-O-(caffeoyl)sophoroside-7-O-glucoside, kaempferol 3-O-(sinapoyl)sophoroside-7-O-glucoside, kaempferol 3-O-(feruloyl)sophoroside-7-O-glucoside, kaempferol 3-O-sophoroside, two isomeric forms of 1,2-disinapoylgentiobiose, 1-sinapoyl-2-feruloylgentiobiose, 1,2,2'-trisinapoylgentiobiose, and 1,2'-disinapoyl-2-feruloylgentiobiose. In general, internal leaves exhibited more constant chemical profiles.

Starling, W. and M. C. Richards (1990). "Quality of organically grown wheat and barley." *Aspects of Applied Biology* **(25)**: 193-198.
Trial samples from Scottish organic barley trials were of lower specific weight and thousand grain weight than conventional trial samples. This was mainly due to mildew [*Erysiphe graminis*] infection. Quality of purchased organic wheat tended to have higher specific weight, similar Hagberg Falling Number and lower protein than conventional wheat in the H-GCA Cereal Quality Survey. This paper was presented at a conference organized by the Association of Applied Biologists entitled Cereal Quality II held at Churchill College, Cambridge, UK on 17-19 Dec. 1990.

Starling, W. and M. C. Richards (1993). "Quality of commercial samples of organically-grown wheat." *Aspects of Applied Biology* **(36)**: 205-209.
Organic wheat harvested in 1988-92 was analysed. Spring wheat cv. Axona and winter wheat cv. Maris Widgeon were most successful in reaching breadmaking quality, although Maris Widgeon had low Hagberg falling number in poor harvest years. Protein content was lower in organic than in conventionally grown wheat.

Stertz, S. C., M. I. S. Rosa, et al. (2005). "Nutritional quality and contaminants of conventional and organic potato (*Solanum tuberosum* L., Solanaceae) in the metropolitan region of Curitiba - Paraná - Brazil." *Boletim do Centro de Pesquisa e Processamento de Alimentos* **23**(2): 383-396.
Potato samples from conventional and organic cultivation systems of the metropolitan region of Curitiba (Parana - Brazil) were analysed for their nutritional composition and contaminants. The organic potatoes showed 19.57% more dry matter and 138.94% more sugar, when compared in relation to the conventional cultivation system ($p<0.05$). Potatoes with high levels of sodium produced fries with a better texture, less oiliness and better taste when compared to the potatoes which showed low levels of solids. The high sugar content influenced the formation of a golden colour in the fries. The organic potatoes showed higher contents of Fe, Al, Co, P, Ca and Cu and lower contents (80%) of nitrites and nitrates, when compared to the conventional cultivation system; these potatoes also showed no pesticide residues. Monocrotophos residue was detected in a conventional potato sample (at a concentration of 0.13 mg/kg); the levels were above the maximum limit permitted by Brazilian legislation (0.05 mg/kg). It was concluded that the potato cultivated by the organic system offers more appeal in relation to food safety and health quality.

Stopes, C., L. Woodward, et al. (1988). "The nitrate content of vegetable and salad crops offered to the consumer as from "organic" or "conventional" production systems." *Biological Agriculture and Horticulture* **5**(3): 215-221.

This paper briefly reviews the source and extent of ingested nitrates in the human diet. In response to the possible health risk, several countries in Europe have set maximum and/or recommended concentrations of tissue nitrate in vegetables and salad crops. The consequence of adopting such limits in the UK is considered. In order to assess the range of nitrate concentrations in vegetables and salad crops, a market survey was conducted over two winters (1985 and 1986) with samples being taken from commercial outlets. Foods offered as conventionally and organically produced were sampled. These comprised lettuces, cabbages, beetroots, cress, potatoes, carrots and mung bean sprouts. Samples of both organically and conventionally produced leafy winter vegetables contained high nitrate levels, some exceeding recommended and maximum levels for certain European countries. Various approaches to the minimisation of the dietary intake of nitrate are discussed.

Strobel, E., P. Ahrens, et al. (2001). "Contents of substances in wheat, rye and oats at cultivation under conventional and the conditions of organic farming." *Bodenkultur* **52**(4): 221-231.

The contents of crude nutrients, starch, sugar, cell wall substances, non-starch-polysaccharides, arabinoxylans, minerals and apparent metabolizable energy corrected to zero N-retention were estimated in several cultivars of winter wheat, winter rye and oats grown under conventional or organic farming conditions. The content of crude protein was higher in the conventionally produced winter wheat and oats than values from feedstuff tables, the content in the organic cultivated types of cereals were about 23-38% lower. The content of nitrogen-free extractives, crude ash, calcium and phosphorus was generally higher under organic farming than conventional conditions. Non-phytate phosphorus was lower at conventional cultivation in winter wheat and oats. In rye, however, it was higher than under organic farming conditions. The cultivation method had hardly any effect on the content of apparent metabolizable energy. A high variability occurred in oats between the cultivars, so that the higher content in organic cultivation method was not significant. A higher soluble arabinoxylan content and a higher extract viscosity was determined in conventional cultivated winter wheat. A generally high extract viscosity with a considerable difference between both cultivation methods was established in winter rye. This did not correlate with the arabinoxylan content. This is an indication, that other fractions contributed to gel formation. No correlation was observed in oats between the β-glucan content, which was higher under conventional conditions, and the extract viscosity. This parameter was very low in this type of cereal. The low crude protein content and consequently the lower content of amino acids in cereals grown under organic cultivation conditions should be taken into consideration for the formulation of compound diets.

Toledo, P., A. Andrén, et al. (2002). "Composition of raw milk from sustainable production systems." *International Dairy Journal* **12**(1): 75-80.

Organic milk production has increased rapidly in many European countries during the last decade but the merits of organic dairy products are still disputed. Little unbiased information exists regarding any essential differences in gross composition or other parameters of technological and/or nutritional interest. In order to gather more basic information regarding organic milk, raw milk samples from 31 organic dairy farms in Sweden were collected once a month during 1 year between April 1999 and March 2000. The samples were analysed for gross composition, somatic cells, fatty acids, urea, iodine and selenium. As a reference, milk composition data from similar conventional farms was obtained. The results show small or no differences in the investigated parameters between organic milk and the milk from the conventional farms or average values regarding gross composition of Swedish raw milk. The only significant differences found were in urea content and somatic cells, both of which were lower in organic milk. In addition, levels of selenium were lower in organic milk, which is of nutritional importance since dairy products are significant dietary sources of selenium in Scandinavian diets.

Varis, E., L. Pietilä, et al. (1996). "Comparison of conventional, integrated and organic potato production in field experiments in Finland." *Acta Agriculturae Scandinavica. Section B, Soil and Plant Science* **46**(1): 41-48.

The results of field trials on reduced chemical inputs for potato production carried out at the Potato Research Institute, Lammi, Finland, during 1987-90 are reported. The main plots in a split-plot designed trial series consisted of three cropping systems: conventional, integrated and organic. The subplots included three cultivars differing especially in their late blight (*Phytophthora infestans*) resistance: Bintje, Record and Matilda. Canopy measurements showed differences that could be attributed to different nitrogen supply in decreasing order from conventional to integrated to organic system. The trial sites were very heavily infested with potato scab, resulting in a very low percentage of I-class yield in susceptible cultivars Bintje and Matilda. Late blight was a serious problem in organically grown Bintje, as expected. Total yields in the integrated and organic systems were 10% and 36% lower, respectively, than in the conventional system. There was an interaction between cropping system and cultivar in favour of Bintje and the conventional system and Record in the organic system. The percentage of I-class yield was lowest in the conventional system. Some of the quality characteristics were slightly improved in the integrated and/or organic systems. Storage losses, caused mainly by tuber blight, were high in organically grown potatoes. There were no large differences in production costs between the cropping systems. The main determinants of the unit production cost of potatoes were total yield and yield of I-class potatoes. The average unit costs were 1.76 FIM kg^{-1} in the conventional, 1.68 FIM kg^{-1} in the integrated and 2.36 FIM kg^{-1} in the organic system. Record showed the lowest unit production costs in all systems: 1.33, 1.37 and 1.80 FIM kg^{-1} respectively.

Verde Méndez, C. d. M., M. P. Forster, et al. (2003). "Content of free phenolic compounds in bananas from Tenerife (Canary Islands) and Ecuador." *European Food Research and Technology* **217**(4): 287-290.

Determination of free gallic acid and catechin (cianidanol) in banana samples was optimized using a high-performance liquid chromatographic (HPLC) method with on-line photodiode array detection. This method was applied for cultivars of bananas (Gran Enana and Pequeña Enana) harvested in Tenerife (Canary Islands) and for bananas (Gran Enana) from Ecuador. The contents of catechin and gallic acid in bananas from Ecuador were higher (P<0.05) and lower than in bananas produced in Tenerife. Variations in the contents of these polyphenolic compounds in the bananas from Tenerife according to cultivation method (greenhouse and outdoors), farming style (conventional and organic) and region of production (north and south) were observed.

Vian, M. A., V. Tomao, et al. (2006). "Comparison of the anthocyanin composition during ripening of Syrah grapes grown using organic or conventional agricultural practices." *Journal of Agricultural and Food Chemistry* **54**(15): 5230-5235.

The anthocyanin composition of Syrah grapes harvested at different stages of ripening and produced using organic or conventional agriculture was studied. Samples of grapes were collected from veraison to full maturity in each plot, and the content in nine anthocyanins was determined by high-performance liquid chromatography with diode array detection. The total content in anthocyanins during ripening of the conventionally grown grapes was significantly higher compared to that found in the organic production. The accumulation of anthocyanins reached a maximum 28 days after veraison (in agreement with high temperature) and then decreased until harvest. In all samples, grapes from the conventional agriculture presented higher proportions of delphinidin, petunidin, malvidin, and acylated malvidin glucosides compared to grapes from organic agriculture. In contrast with other comparative studies of organically and conventionally grown plants, the results demonstrated a higher content in anthocyanins in conventionally grown grapes.

Walshe, B. E., E. M. Sheehan, et al. (2006). "Composition, sensory and shelf life stability analyses of Longissimus dorsi muscle from steers reared under organic and conventional production systems." *Meat Science* **73**(2): 319-325.

In recent years the demand for organically grown food has increased. In this study, organic (O, n=6) and conventionally (C, n=6) reared steers aged between 18 and 24 months were slaughtered during the month of September 2002. Four days post-slaughter, the *Longissimus dorsi* (LD) muscle was excised from the left side of each carcass. All muscles were vacuum packed and aged in a chill for a further seven days. Steaks were cut from each sample, and from these, lean meat was removed, blended and compositional analysis was carried out. O samples were significantly higher (P>0.05) in fat content and therefore were significantly (P>0.05) lower in moisture content than C samples. No significant differences were observed between C and O samples for protein, ash, β-carotene, α-tocopherol or retinol. There was also no significant difference in fatty acid content between C and O samples. Colour stability and fat oxidative stability of samples were also measured, while stored under retail conditions. Samples were packed using both modified atmosphere packaging (MAP) and by overwrapping with cling film. MAP C samples had the best colour stability while overwrapped C samples had the best lipid stability. Therefore, colour and lipid stability of beef samples were influenced by sample composition and packaging format used, which resulted in C samples outperforming O samples with respect to shelf life stability.

Wang, G. Y., T. Abe, et al. (1998). "Concentrations of Kjeldahl-digested nitrogen, amylose, and amino acids in milled grains of rice (*Oryza sativa* L.) cultivated under organic and customary farming practices." *Japanese Journal of Crop Science* **67**(3): 307-311.

The concentrations of Kjeldahl-digested N were significantly higher in milled rice grains cultivated under customary farming practices than in those grown organically. However, the amylose content showed no differences between the two cultivation methods. The concentrations of hydrolyzed amino acids tended to be higher in milled rice grains obtained using customary farming practices than in those obtained using organic farming practices. In contrast, the concentrations of free amino acids were one hundred or more times lower than those of hydrolyzed amino acids. However, of the free amino acids, aspartic acid, glutamic acid, glutamine, and asparagine were significantly higher in milled rice grains from organically grown rice than in those from the customary farming practices. However, studies on the relationship of amount of components such as Kjeldahl-digested N and amino acids to eating quality of rice remain to be examined.

Warman, P. R. and K. A. Havard (1996). "Yield, vitamin and mineral content of four vegetables grown with either composted manure or conventional fertilizer." *Journal of Vegetable Crop Production* **2**(1): 13-25.

In a comparative study conducted for 3 years in a Pugwash sandy loam in Nova Scotia, Canada, 5 replicates of 2 treatments (organic and conventional) were established annually for carrots (cv. Cellobunch), cabbages (cv. Lennox), potatoes (cv. Superior) and sweetcorn (cv. Sunny Vee in 1990 and cv. Pride and Joy in 1991 and 1992). The addition of pesticides, lime and NPK fertilizer to the conventional plots followed the Nova Scotia Soil Test Recommendations; while rotenone or *Bacillus thuringiensis* (for insect control), lime and composted manure were applied to the organic plots according to the guidelines established by the Organic Crop Improvement Association, Inc. (OCIA). The compost was made using chicken or cow manure and straw. Compost was analysed for total N and applied at rates appropriate to each crop assuming 50% N availability during the cropping season. Marketable yields were recorded and representative leaf samples and edible portions of the vegetables were digested and analysed for 12 macro- and micronutrients. At harvest, α- and β-carotene and vitamins C and E were evaluated by HPLC. There were few differences in yield or vitamin and mineral contents between the organic and conventional systems. This was attributed to the correct use of amendments and pest control procedures.

Warman, P. R. and K. A. Havard (1997). "Yield, vitamin and mineral contents of organically and conventionally grown carrots and cabbage." *Agriculture Ecosystems & Environment* **61**(2-3): 155-162.

Research was conducted for 3 years in different plot areas of a Pugwash sandy loam near Truro, N.S. Five replicates of two treatments (organic and conventional) were established annually for carrots (*Daucus carota* L. cv. 'Cellobunch') and cabbages (*Brassica oleracea* L. var capitata cv. 'Lennox'). The addition of pesticides, lime and NPK fertilizer to the conventional plots followed soil test and provincial recommendations; lime, composted manure and insect control applications to the organic plots were according to the guidelines of the Organic Crop Improvement Association Inc. The compost was analyzed for total N and applied to provide 170 kg N ha^{-1} for carrots and 300 kg N ha^{-1} for cabbages, which assumed 50% availability of N. In addition to marketable yields, carrot leaves and roots and cabbage sections were digested and analyzed for 12 macro- and micronutrients. Vitamins C and E and alpha- and beta-carotene of mature crops were evaluated by high performance liquid chromatography; in 2 of the 3 years, vitamin C was also analyzed up to 24 weeks after harvest. Soil samples were also taken at harvest, extracted with Mehlich-3 or 2 M KCl solution and analyzed for essential nutrients and available N. Analysis of the 3 years of data showed that the yield and vitamin content of the carrots and cabbages were not affected by treatments. Five elements in carrot roots (N, S, Mn, Cu, B) and two elements in carrot leaves (S, Na) were influenced by treatments ($P < 0.11$); in cabbages, N, Mn and Zn were affected. The treatments did not affect the Mehlich-3 extractable soil nutrients in the carrot plots, whereas only Mehlich-3 Cu and the NH4N and NO3-N contents of the soil were affected in the cabbage plots. In a comparison of soil and plant elements, the Mehlich-3 Ca and Mg in the carrot plots and the Mehlich-3 P, K and Zn in the cabbage plots were significantly correlated with both the edible and/or leaf tissue contents of these elements.

Warman, P. R. and K. A. Havard (1998). "Yield, vitamin and mineral contents of organically and conventionally grown potatoes and sweet corn." *Agriculture Ecosystems & Environment* **68**(3): 207-216.

An experiment was conducted for three years in a Pugwash sandy loam near Truro, NS. Five replicates of two treatments (organic and conventional) were established annually in different plot areas for potatoes (*Solanum tuberosum* L. Superior) and sweet corn (*Zen mays* L. var. saccharata 'Sunnyvee' or 'Pride and

Joy'. The addition of pesticides, lime and NPK fertilizer to the conventional plots followed a soil test and provincial recommendations; lime, composted manure and insect control applications to the organic plots were according to the guidelines of the OCIA [Organic Crop Improvement Association, 1990. OCIA Certification Standards. OCIA, Bellefontaine, OH, 11 pp.] The compost was analysed for total N and applied to provide 260 kg N/ha for potatoes and 200 kg N/ha for sweet corn, which assumed 50% availability of the total N. Marketable yields were determined, and potato leaves and tubers, as well as sweet corn kernels and ear leaves were digested and analysed for 12 macro- and micronutrients. In addition, the vitamin C content of the tubers and the vitamin C and E contents of the kernels were analysed. Soil samples were also taken at harvest and analysed for essential nutrients and available N. Analysis of the three years of data showed that the yield and vitamin C content of the potatoes was not affected by treatments. However, the conventionally grown treatment outproduced the organically grown treatment for Pride and Joy (cv.) corn, but there was no difference between treatments in the yield of Sunnyvee (cv.) corn or the vitamin C or E contents of the kernels in any year. At $p < 0.11$, four elements in potato tubers (P, Mg, Na, Mn) and four elements in potato leaves (N, Mg, Fe, B) were influenced by treatments, but only leaf Cu was affected in the sweet corn. Correspondingly, extractable P, Ca, Mg and Cu were higher in organically fertilized potato plots; only extractable Mg was affected by treatments in the sweet corn, with the Mg content higher in the organic plots. Only leaf P and K were significantly positively correlated with extractable P ($r = 0.70$) and K ($r = 0.73$) in the potato plots, while leaf Cu and kernel S were positively correlated with extractable Cu ($r = 0.56$) and S ($r = 0.62$) in the sweet corn plots.

Wawrzyniak, A., S. Kwiatkowski, et al. (1997). "Evaluation of nitrate, nitrite and total protein content in selected vegetables cultivated conventionally and ecologically." *Roczniki Panstwowego Zakladu Higieny* **48**(2): 179-86.

Nitrates, nitrites and total protein content in selected vegetables from conventional and ecological farms were estimated. The beetroots, carrots, potatoes available on market or special shops in January, May and March were evaluated. The content of nitrates and nitrites was determined by colorimetric method with Griess reagent after previous reduction of nitrates to nitrites by metallic cadmium. Total protein content was determined by Kjel-Foss Automatic 16210 analyser working on the basis of classical Kjeldahl method. The higher content of nitrates was found in vegetables from conventional farms. Amounts of nitrates in both groups of vegetables did not exceed allowed limits. Levels of nitrites in ecological and conventional vegetables were similar-above 0.5 mg $NaNO_2$/kg (except conventional potatoes from January). Slightly more content of protein was recorded in conventional vegetables.

Wolfson, J. L. and G. Shearer (1981). "Amino acid composition of grain protein of maize grown with and without pesticides and standard commercial fertilizers." *Agronomy Journal* **73**: 611-613

Measurements were made of the amino acid composition of protein from maize grain produced on 14 pairs of fields with pesticides and standard commercial fertilizers or with organic fertilizers only. The pairs of fields were matched for location, cv., sowing date and soil type. When expressed as a percentage of grain protein, 5 amino acids were at significantly higher conc. in organic grain and 3 were at significantly higher conc. in conventional grain. However, because of the lower protein conc. in the organically fertilized maize grain, most of the amino acids in conventionally fertilized grain had significantly higher conc., when expressed as a percentage of total grain wt. Differences in yield, protein conc. and amino acid composition between organic and conventionally fertilized maize were qualitatively similar to reported differences between N-fertilized and non-N-fertilized maize. There was a greater accumulation of zein in conventionally fertilized maize.

Wszelaki, A. L., J. F. Delwiche, et al. (2005). "Sensory quality and mineral and glycoalkaloid concentrations in organically and conventionally grown redskin potatoes (*Solanum tuberosum*)." *Journal of the Science of Food and Agriculture* **85**(5): 720-726.

Triangle tests were used to determine if panellists could distinguish (by tasting) cooked wedges of potatoes (cv. Dark Red Norland) grown organically, either with (+) or without (-) compost, and conventionally. Mineral and glycoalkaloid analyses of tuber skin and flesh were also completed. When the skin remained on the potatoes, panellists detected differences between conventional potatoes and organic potatoes, regardless of soil treatment. However, they did not distinguish between organic treatments (plus or minus compost) when samples contained skin, or between any treatments if wedges were peeled prior to preparation and presentation. Glycoalkaloid levels tended to be higher in organic potatoes. In tuber skin and flesh, potassium, magnesium, phosphorus, sulfur and copper concentrations were also significantly higher in the organic treatments, while iron and manganese concentrations were higher in the skin of conventionally grown potatoes.

Wunderlich, S. M., C. Feldman, et al. (2008). "Nutritional quality of organic, conventional, and seasonally grown broccoli using vitamin C as a marker." *International Journal of Food Sciences and Nutrition* **59**(1): 34-45.

Organically labeled vegetables are considered by many consumers to be healthier than non-organic or 'conventional' varieties. However, whether the organic-labeled vegetables contain more nutrients is not clear. The purpose of this study is to examine the nutritional quality of broccoli using vitamin C, a fragile and abundant nutrient, in broccoli as a biomarker. The vitamin C content was assayed (2,6-dichlorophenolindophenol method) in broccoli samples obtained from supermarkets that are considered the point of consumer consumption. These samples were obtained during different seasons when the broccoli could be either harvested locally or shipped far distances. The findings indicate that vitamin C could be used as a marker under a controlled laboratory environment with some limitations and, although the vitamin C content of organically and conventionally labeled broccoli was not significantly different, significant seasonal changes have been observed. The fall values for vitamin C were almost twice as high as those for spring for both varieties ($P=0.021$ for organic and $P=0.012$ for conventional). The seasonal changes in vitamin C content are larger than the differences between organically labeled and conventionally grown broccoli.

Yildirim, H. K., Y. D. Akcay, et al. (2004). "Protection capacity against low-density lipoprotein oxidation and antioxidant potential of some organic and non-organic wines." *International Journal of Food Sciences and Nutrition* **55**(5): 351-362.

Current research suggests that phenolics from wine may play a positive role against oxidation of low-density lipoprotein (LDL), which is a key step in the development of atherosclerosis. Considering the effects of different wine-making techniques on phenols and the wine consumption preference influencing the benefical effects of the product, organically and non-organically produced wines were obtained from the grapes of Vitis vinifera origin var: Carignan, Cabernet Sauvignon, Merlot, Grenache, Columbard and Semillon. Levels of total phenols [mg/l gallic acid equivalents (GAE)], antioxidant activity (%) and inhibition of LDL oxidation [%, inhibition of diene and malondialdehyde (MDA) formation] were determined. Some phenolic acids (gallic acid, p-hydroxybenzoic acid, syringic acid, 2,3-dihydroxybenzoic acid, ferulic acid, p-coumaric acid and vanillic acid) were quantified by high-performance liquid chromatography equipped with an electrochemical detection carried at +0.65 V (versus Ag/AgCl, 0.5 muA full scale). The highest concentrations of gallic, syringic and ferulic acids were found in organic Cabernet Sauvignon; 2,3-dihydroxybenzoic acid in organic Carignan and p-coumaric and vanillic acids in non-organic Merlot wine. High levels of antioxidant activity (AOA), inhibition of LDL oxidation and total phenol levels were found in non-organic Merlot (101.950% AOA; 88.570% LDL-diene; 41.000% LDL-MDA; 4700.000 mg/l GAE total phenol) and non-organic Cabernet Sauvignon (92.420% AOA; 91.430% LDL-diene; 67.000% LDL-MDA; 3500.000 mg/l GAE total phenol) grape varieties. Concentrations of some individual phenolic constituents (ferulic, p-coumaric, vanillic) are correlated with high antioxidant activity and inhibition of LDL oxidation.The best r value for all examined characteristics was determined for gallic acid, followed by 2,3-dihydroxybenzoic, syringic, ferulic and p-coumaric acids. Negative correlation of vanillic with MDA and p-hydroxybenzoic acid with LDL were confirmed by principal component analysis (PCA) analyses. Red wines display a higher antioxidant activity (81.110% AOA) than white ones (19.512% AOA). The avarage level of LDL inhibition capacity in red wine was determined as 87.072% and for the white as 54.867%.

Young, J. E., X. Zhao, et al. (2005). "Phytochemical phenolics in organically grown vegetables." *Molecular Nutrition & Food Research* **49**(12): 1136-1142.

Fruit and vegetable intake is inversely correlated with risks for several chronic diseases in humans. Phytochemicals, and in particular, phenolic compounds, present in plant foods may be partly responsible for these health benefits through a variety of mechanisms. Since environmental factors play a role in a plant's production of secondary metabolites, it was hypothesized that an organic agricultural production system would increase phenolic levels. Cultivars of leaf lettuce, collards, and pac choi were grown either on organically certified plots or on adjacent conventional plots. Nine prominent phenolic agents were quantified by HPLC, including phenolic acids (e.g. caffeic acid and gallic acid) and aglycone or glycoside flavonoids (e.g. apigenin, kaempferol, luteolin, and quercetin). Statistically, we did not find significant higher levels of phenolic agents in lettuce and collard samples grown organically. The total phenolic content of organic pac choi samples as measured by the Folin-Ciocalteu assay, however, was significantly higher than conventional samples ($p < 0.01$), and seemed to be associated with a greater attack the plants in organic plots by flea beetles. These results indicated that although organic production method alone did not enhance biosynthesis of phytochemicals in lettuce and collards, the organic system provided an increased opportunity for insect attack, resulting in a higher level of total phenolic agents in pac choi.

Zorb, C., G. Langenkamper, et al. (2006). "Metabolite profiling of wheat grains (*Triticum aestivum* L.) from organic and conventional agriculture." *Journal of Agricultural and Food Chemistry* **54**(21): 8301-8306.

In some European community countries up to 8% of the agricultural area is managed organically. The aim was to obtain a metabolite profile for wheat (*Triticum aestivum* L.) grains grown under comparable organic and conventional conditions. These conditions cannot be found in plant material originating from different farms or from products purchased in supermarkets. Wheat grains from a long-term biodynamic, bioorganic, and conventional farming system from the harvest 2003 from Switzerland were analyzed. The presented data show that using a high throughput GC-MS technique, it was possible to determine relative levels of a set of 52 different metabolites including amino acids, organic acids, sugars, sugar alcohols, sugar phosphates, and nucleotides from wheat grains. Within the metabolites from all field trials, there was at the most a 50% reduction comparing highest and lowest mean values. The statistical analysis of the data shows that the metabolite status of the wheat grain from organic and mineralic farming did not differ in concentrations of 44 metabolites. This result indicates no impact or a small impact of the different farming systems. In consequence, we did not detect extreme differences in metabolite composition and quality of wheat grains.

Appendix 9: Quality Criteria in Included Studies

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, 1992	×	✓	✓	✓	×	×
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	×	✓	✓	✓	✓	×
Cayuela, 1997	×	✓	✓	✓	✓	×

Study	Organic Definition	Cultivar/ Breed	Nutrients analysed	Laboratory methods	Statistical methods	Satisfactory Quality
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	✓	✓	✓	✓	×	×
Hajslova, 2005	✓	✓	✓	✓	✓	✓

Study	Organic Definition	Cultivar/ Breed	Nutrients analysed	Laboratory methods	Statistical methods	Satisfactory Quality
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	×	×	✓	✓	✓	×
Jahan, 2007	×	×	✓	✓	✓	×

Study	Organic Definition	Cultivar/ Breed	Nutrients analysed	Laboratory methods	Statistical methods	Satisfactory Quality
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, 1998	✓	✓	✓	✓	✓	✓

Study	Organic Definition	Cultivar/ Breed	Nutrients analysed	Laboratory methods	Statistical methods	Satisfactory Quality
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	✓	×	✓	✓	×	×
Rembialowska, 1998	✓	×	✓	✓	✓	×

Study	Organic Definition	Cultivar/ Breed	Nutrients analysed	Laboratory methods	Statistical methods	Satisfactory Quality
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	×	✓	✓	✓	×	×
Walshe, 2006	×	×	✓	✓	✓	×

Study		Organic Definition	Cultivar/ Breed	Nutrients analysed	Laboratory methods	Statistical methods	Satisfactory Quality
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**

Appendix 10: Frequency of Numeric Nutrient Comparisons in Crop Studies

Nutrient category	Studies (n)	Comparisons (n)
Nitrogen	42	145
Vitamin C	37	143
Phenolic compounds	34	164
Magnesium	30	75
Calcium	29	76
Phosphorus	27	75
Potassium	27	74
Zinc	25	84
Total soluble solids	22	81
Titratable acidity	21	66
Copper	21	62
Flavonoids	20	158
Iron	20	62
Sugars	19	95
Nitrates	19	91
Manganese	19	58
Ash	16	46
Dry matter	15	35
Specific proteins	13	127
Sodium	12	30
Plant non-digestible carbohydrates	11	40
β-carotene	11	32
Sulphur	10	28
Carbohydrates	9	36
Boron	9	29
Nitrites	9	26
Vitamin E	8	28
Lycopenes	7	22

Nutrient category	Studies (n)	Comparisons (n)
Antioxidant activity	6	13
Fats (unspecified)	6	11
Organic acids	5	79
Carotenoids	5	15
Amino acids	4	119
Tocopherols	4	8
Cobalt	4	6
Selenium	4	5
Saturated fatty acids	3	43
Monounsaturated fatty acids (cis)	3	28
n-6 polyunsaturated fatty acids	3	16
Fatty acids (unspecified)	3	15
Riboflavin	3	10
Thiamin	3	9
Glycoalkaloids	3	8
Volatile compounds	3	6
Molybdenum	3	5
Phytosterols	2	46
Glucosinolates	2	12
Chromium	2	6
Nickel	2	6
n-3 polyunsaturated fatty acids	2	5
Phytoalexin	2	5
Aluminium	2	3
Proteins (unspecified)	2	3
Pyridoxine	2	3
Ethylene	1	8
Triglycerides	1	8
Carbon	1	6

Nutrient category	Studies (n)	Comparisons (n)
Chloride	1	5
Cholesterol	1	5
Phytostanols	1	5
Polyunsaturated fatty acids	1	5
Alcohols	1	4
Carotenes	1	4
Phosphate	1	4
Ratio of n-3/n-6 fatty acids	1	4
Sulphate	1	4
Chlorine	1	3
Minerals	1	3
Nitrogen-free extracts	1	3
Phosphorus derivatives	1	3
Total flavanols & phenols	1	3
α-acids	1	3
β-acids	1	3
Niacin	1	2
Pantothenic acid	1	2
Silicon	1	2
Volatile esters	1	2
Peroxide number	1	1
Polyalcohols	1	1
Vitamin K1	1	1

Appendix 11: Frequency of Numeric Nutrient Comparisons in Livestock Product Studies

Nutrient category	Studies (n)	Comparisons (n)
Saturated fatty acids	13	61
Monounsaturated fatty acids (cis)	13	42
n-6 polyunsaturated fatty acids	12	42
Fats (unspecified)	12	20
n-3 polyunsaturated fatty acids	9	34
Polyunsaturated fatty acids	8	12
Trans fatty acids	6	48
Nitrogen	6	13
Fatty acids (unspecified)	5	19
Ash	5	9
n-6/n-3 fatty acid ratio[1]	5	5
α-tocopherol	4	5
Amino acids	3	35
Proteins (unspecified)	3	8
Calcium	3	6
Ratio of fatty acids	3	5
Dry matter	3	4
Vitamin A	3	3
Iron	2	11
Zinc	2	7
Magnesium	2	5
Phosphorous	2	4
Sugars	2	4
Lipid oxidation	2	3
Potassium	2	3
Sodium	2	3
Ammonia	2	2

Nutrient category	Studies (n)	Comparisons (n)
Cholesterol	2	2
β-carotene	2	2
Phytoestrogens	1	6
Antioxidant activity	1	3
Copper	1	3
Manganese	1	3
Molybdenum	1	3
Niobium	1	3
Rhodium	1	3
Sulphur	1	3
Specific proteins	1	2
Urea	1	2
Vitamin C	1	2
Carbohydrates	1	1
Iodine	1	1
Nitrates	1	1
Nitrites	1	1

[1]Analysis not conducted on n-6/n-3 fatty acid ratio as all studies also included in analyses of n-6 polyunsaturated fatty acids and n-3 polyunsaturated fatty acids

Appendix 12: Individual Nutrient Comparisons for Crop Studies

Results of the analysis for the 23 most frequently reported nutrients or nutrient categories in crop studies are presented below in alphabetical order. Numercal information presented relates only to numerically reported results (excluding extreme outliers).

ASH

Reported as Ash

Reported methods of analysis Residue of moisture determination by desiccation, X-ray fluorescence spectroscopy, gravimetric method, combusted: 450˚C, 550˚C, 700˚C, 900˚C

Reported units of analysis %, % dry matter, g $100g^{-1}$, g kg^{-1}

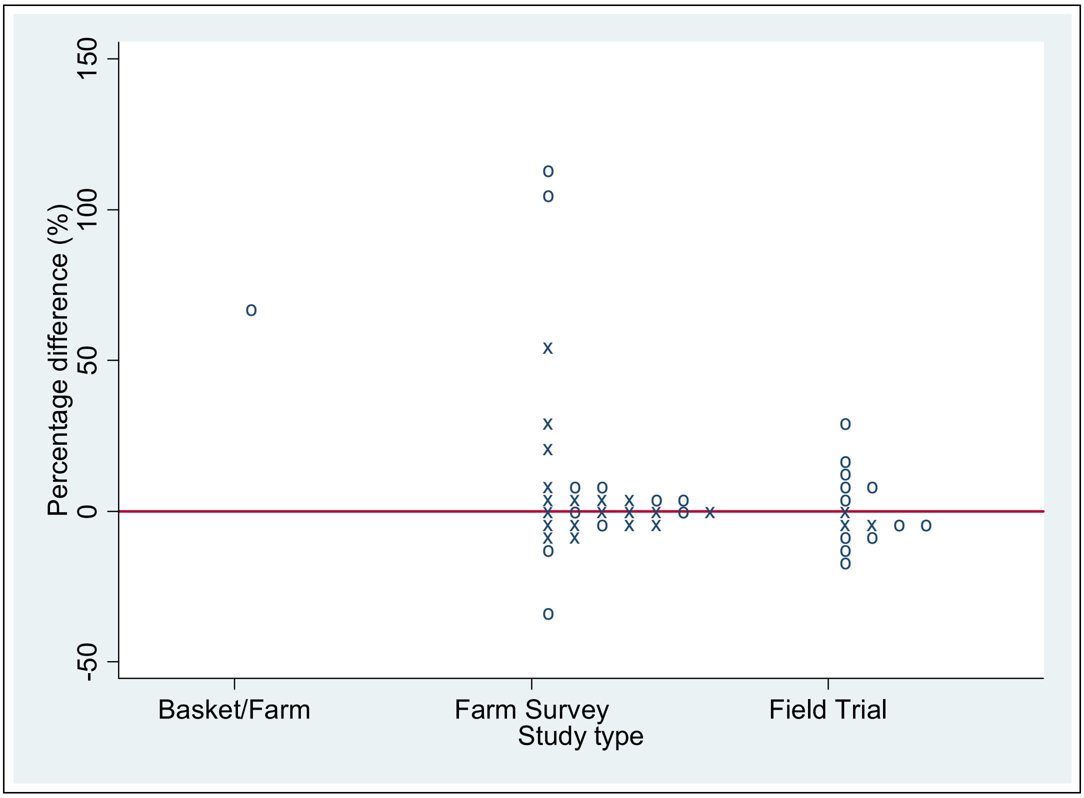
Foods analysed Banana, broccoli, cabbage, carrot, celeriac, onion, paprika, pea, potato, pumpkin, red pepper, strawberry, sweet potato, tomato

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	8	7	0	1	**16**
Satisfactory quality studies	1	4	0	0	**5**
Number of nutrient comparisons reported	15	30	0	1	**46**
Number of nutrient comparisons reported from satisfactory quality studies	3	19	0	0	**22**

Results

Dot plot showing distribution of percentage differences in ash content by study type



x indicates nutrient comparisons from satisfactory quality studies

Statistical analysis of difference in ash content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	46	8.2 (se: 5.2)	0.13
All satisfactory quality nutrient comparisons	22	3.8 (se: 5.5)	0.53

Overall Analysis

Analysis suggests that there is no difference in ash content between organically and conventionally produced crops (p=0.13 for all comparisons; p=0.53 for comparisons from satisfactory quality studies).

β-CAROTENE

Reported as β-carotene, β-carotene equivalents, 13-cis-β-carotene, All-trans-β-carotene

Reported methods of analysis Chromatography, colourimetry, HPLC, HPLC-IS, HPLC-reverse phase, liquid column chromatography, spectrophotometry

Reported units of analysis μg $100g^{-1}$, μg/g, mg $100g^{-1}$, mg kg^{-1}, g kg^{-1}

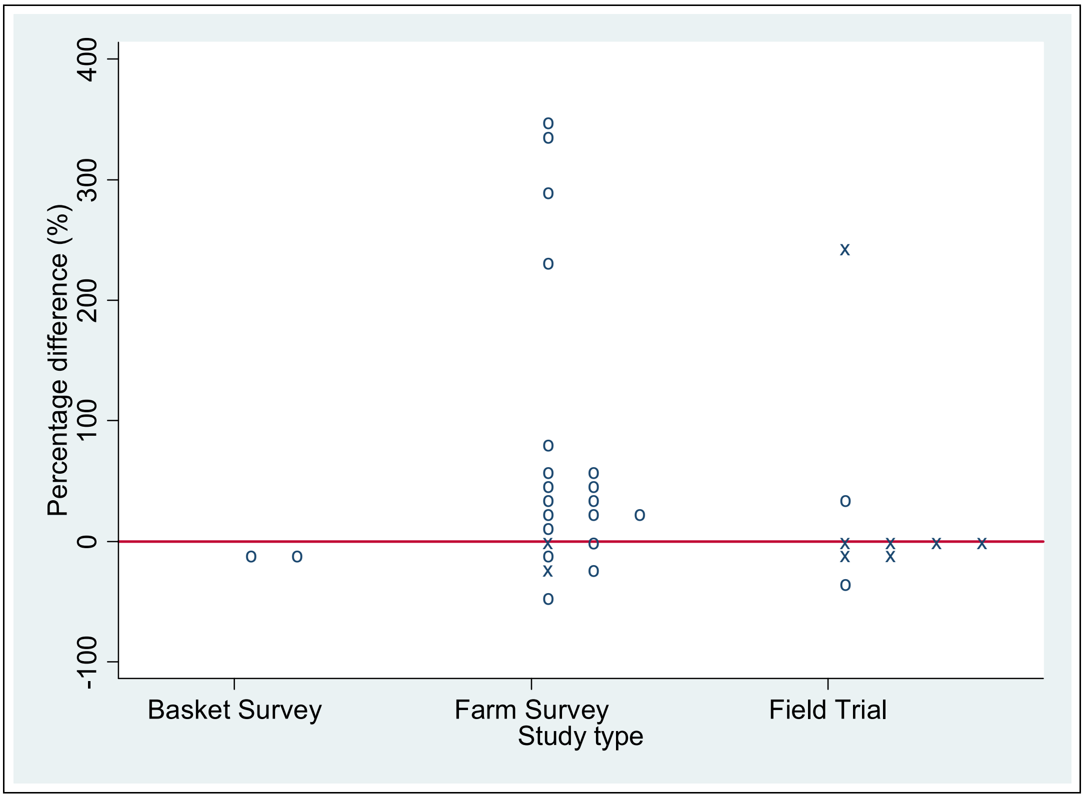
Foods analysed Carrot, Chinese kale, Chinese mustard, lettuce, marinara pasta sauce, paprika, plum, pumpkin, spinach, swamp cabbage, sweet pepper

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	4	6	1	0	**11**
Satisfactory quality studies	2	1	0	0	**3**
Number of nutrient comparisons reported	9	21	2	0	**32**
Number of nutrient comparisons reported from satisfactory quality studies	7	2	0	0	**9**

Results

Dot plot showing distribution of percentage differences in β-carotene content by study type



x indicates nutrient comparisons from satisfactory quality studies

One extreme value (862%) excluded

Statistical analysis of difference in β-carotene content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	32	53.6 (se: 37.0)	0.18
All satisfactory quality nutrient comparisons	9	20.7 (se: 38.8)	0.65

Overall Analysis

Analysis suggests that there is no difference in β-carotene content between organically and conventionally produced crops (p=0.18 for all comparisons; p=0.65 for comparisons from satisfactory quality studies).

CALCIUM

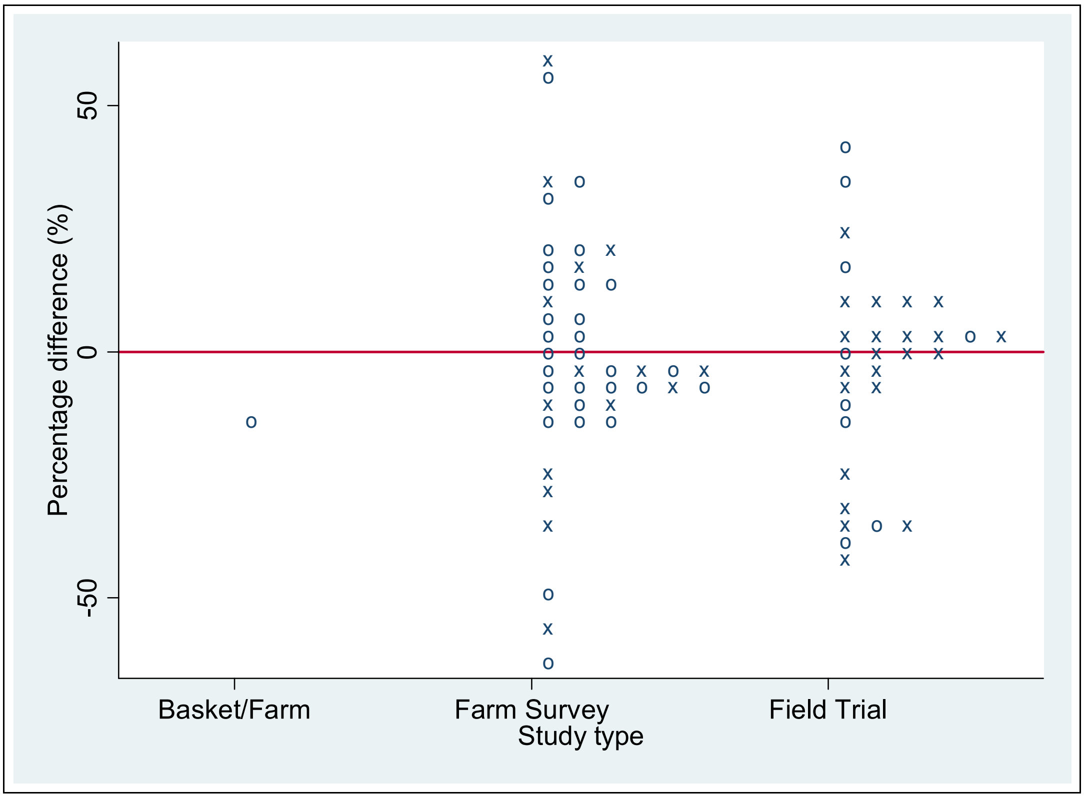
Reported as	Calcium
Reported methods of analysis	Atomic absorption spectrometry, atomic absorption spectrophotometry, flame atomic absorption spectrometry, flame atomic absorption spectrophotometry, flame photometry, inductively coupled plasma - optical emission spectrometry, inductively coupled plasma atomic emission spectrometry, inductively coupled plasma mass spectrometry, colourimetry, nitric/hydrogen microwave digestion, open-vessel hot-plate acid digestion, titrimetric method, X-ray fluorescence spectroscopy
Reported units of analysis	%, ppm, $\mu g\ g^{-1}$, $mmol\ kg^{-1}$, $mg\ 100g^{-1}$, $mg\ kg^{-1}$, $mg\ L^{-1}$, $g\ kg^{-1}$
Foods analysed	Apple, banana, beetroot, cabbage, carrot, celeriac, grapefruit, kiwifruit, mandarin, oat, onion, pea, pear, plum, potato, pumpkin, rice, rye, savoury herb, strawberry, sweet pepper, sweet potato, sweet corn, tomato, wheat

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	14	14	0	1	**29**
Satisfactory quality studies	7	6	0	0	**13**
Number of nutrient comparisons reported	31	44	0	1	**76**
Number of nutrient comparisons reported from satisfactory quality studies	22	15	0	0	**37**

Results

Dot plot showing distribution of percentage differences in calcium content by study type



x indicates nutrient comparisons from satisfactory quality studies

One extreme value (533%) excluded

Statistical analysis of difference in calcium content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	76	-1.5 (se: 2.9)	0.62
All satisfactory quality nutrient comparisons	37	-3.7 (se: 4.8)	0.45

Overall Analysis

Analysis suggests that there is no difference in calcium content between organically and conventionally produced crops (p=0.64 for all comparisons; p=0.45 for comparisons from satisfactory quality studies).

COPPER

Reported as Copper

Reported methods of analysis Atomic absorption spectrometry, atomic absorption spectrophotometry, flame atomic absorption spectrometry, flame atomic absorption spectrophotometry, flame photometry, inductively coupled plasma - optical emission spectrometry, inductively coupled plasma atomic emission spectrometry, inductively coupled plasma mass spectrometry, colourimetry, nitric/hydrogen microwave digestion, open-vessel hot-plate acid digestion, titrimetric method, X-ray fluorescence spectroscopy

Reported units of analysis ppm, $\mu g\ g^{-1}$, $\mu g\ 100g^{-1}$, $\mu g\ kg^{-1}$, $mmol\ kg^{-1}$, $mg\ 100g^{-1}$, $mg\ kg^{-1}$, $mg\ L^{-1}$, $g\ kg^{-1}$

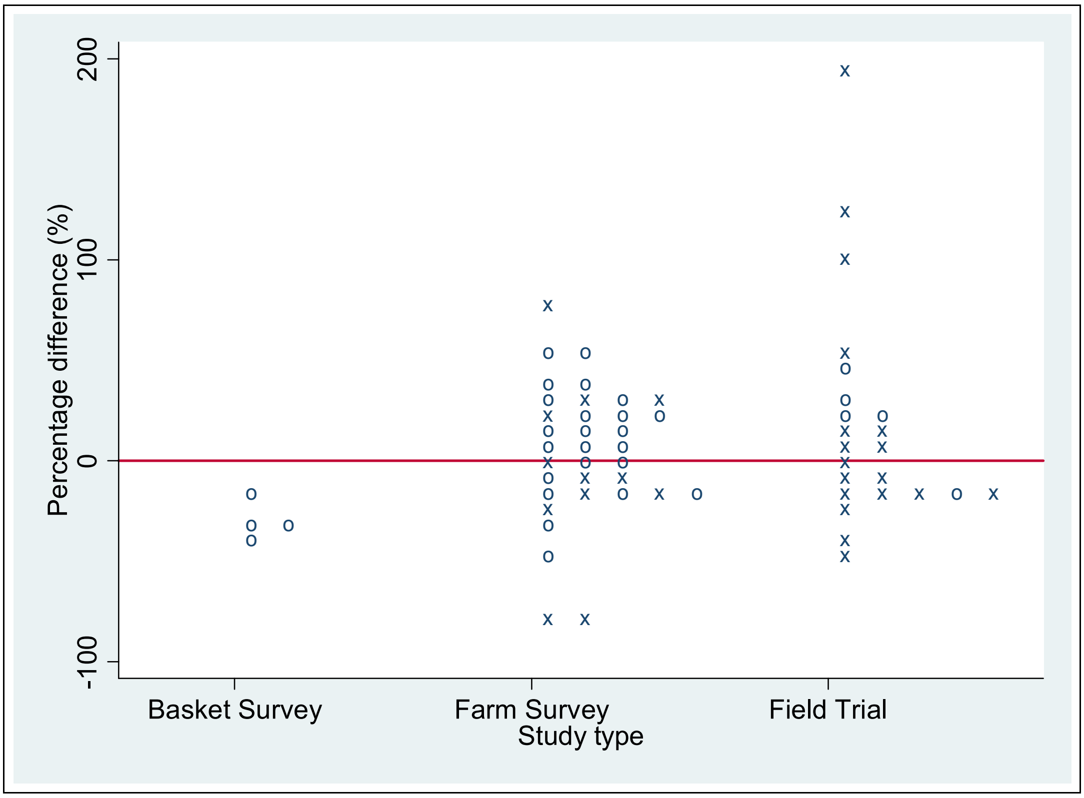
Foods analysed Apple, barley, cabbage, carrot, celeriac, corn meal, grapefruit, lentil, mandarin, onion, pea, pear, plum, potato, pumpkin, rice, savoury herb, strawberry, sweet pepper, sweet corn, tomato, wheat

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	10	10	1	0	**21**
Satisfactory quality studies	6	5	0	0	**11**
Number of nutrient comparisons reported	23	35	4	0	**62**
Number of nutrient comparisons reported from satisfactory quality studies	18	12	0	0	**30**

Results

Dot plot showing distribution of percentage differences in copper content by study type



x indicates nutrient comparisons from satisfactory quality studies

Statistical analysis of difference in copper content between organic and conventionally produced foods

	Number of comparisons	**Mean percentage difference**	**p-value**
All nutrient comparisons	62	8.3 (se: 6.6)	0.22
All satisfactory quality nutrient comparisons	30	8.6 (se: 11.5)	0.47

Overall Analysis

Analysis suggests that there is no difference in copper content between organically and conventionally produced crops (p=0.22 for all comparisons; p=0.47 for comparisons from satisfactory quality studies).

DRY MATTER

Reported as Dry matter

Reported methods of analysis Gravimetric method, Scale method, Difference of fresh and freeze drying, Drying at: 50-60˚C for 12 hours, 50-60˚C for 10 days, 70˚C for 7 hours (vacuum), 80˚C for 24 hours, 102˚C for 16 hours, 110˚C for 45 hours, 105˚C

Reported units of analysis %, % Nitrogen, % Dry matter, g kg^{-1}

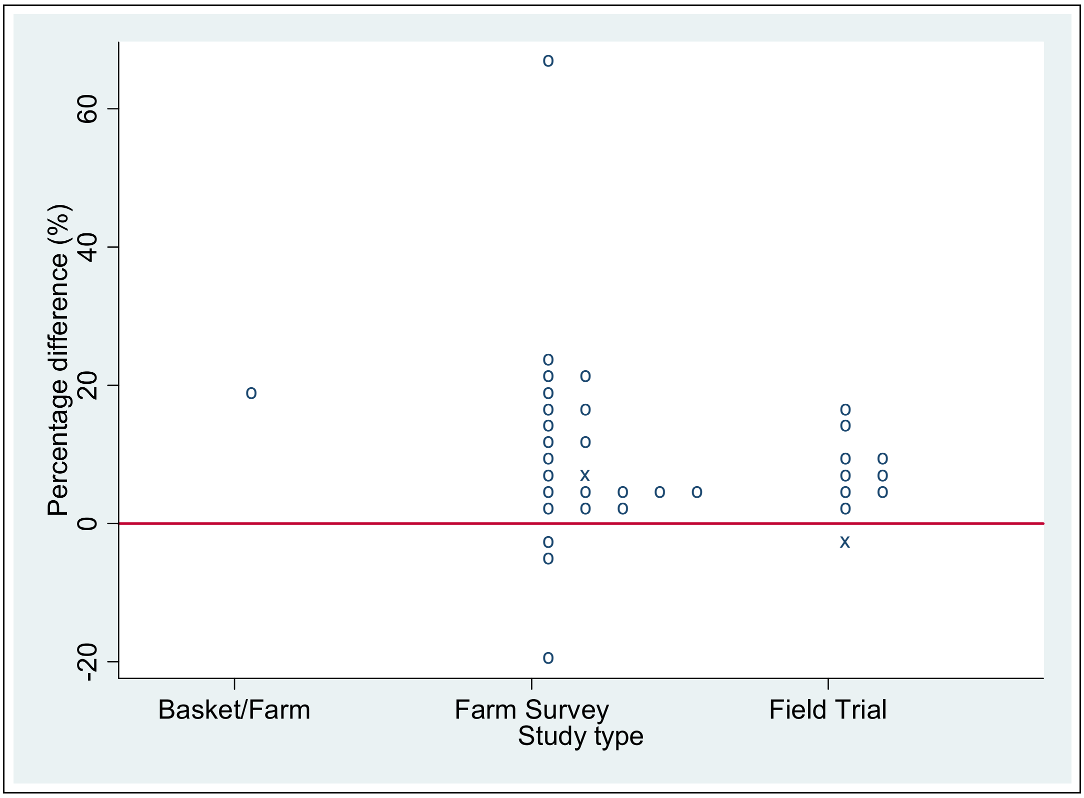
Foods analysed Banana, broccoli, cabbage, carrot, celeriac, onion, paprika, pea, potato, pumpkin, red pepper, strawberry, sweet potato, tomato

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	5	9	0	1	**15**
Satisfactory quality studies	1	1	0	0	**2**
Number of nutrient comparisons reported	10	24	0	1	**35**
Number of nutrient comparisons reported from satisfactory quality studies	1	1	0	0	**2**

Results

Dot plot showing distribution of percentage differences in dry matter content by study type



x indicates nutrient comparisons from satisfactory quality studies

Statistical analysis of difference in dry matter content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	35	9.8 (se: 3.0)	0.005
All satisfactory quality nutrient comparisons	2	1.8 (se: 4.5)	0.76

Overall Analysis

Analysis suggests that there is significantly greater dry matter content in organically than in conventionally produced crops (p=0.005 for all comparisons). Analysis of data from satisfactory quality studies suggest that there is no difference in dry matter content between organically and conventionally produced crops (p=0.76 for comparisons from satisfactory quality studies).

FLAVONOIDS

Reported as

Flavonoids, total flavonoids, flavonols, total flavanols, total anthocyanins, total anthocyans, non-anthocyan flavonoids, naringenin, rutin, kaempferol, luteolin, quercetin, (+) catechin, cyanidin, delphynidin, (-) epicatechin, malvidin, peonidin, procyanidins B1, procyanidins B2, procyanidins B3, procyanidins B4, phloridzin, anthocyanins, quercetin-3-rhamnozide, apigenin, kaempferol-3-O-glucoside, 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 glucoside, kaempferol rutinoside, isorhamnetin rutinoside, desmethylxanthohumol, xanthohumol

Reported methods of analysis

Christa-Mullera method, colourimetry, Folin-Ciocalteu method, HPLC, reverse phase-HPLC, liquid chromatography/mass spectrometry, pH shift, spectrophotemetry, spectrophotometry by pH differential method

Reported units of analysis

% w/w, ppm, GAE g^{-1}, mg catechin equivalent L^{-1}, μg g^{-1}, μg kg^{-1}, μmol g^{-1}, mg g^{-1}, mg $100g^{-1}$, mg kg^{-1}

Foods analysed

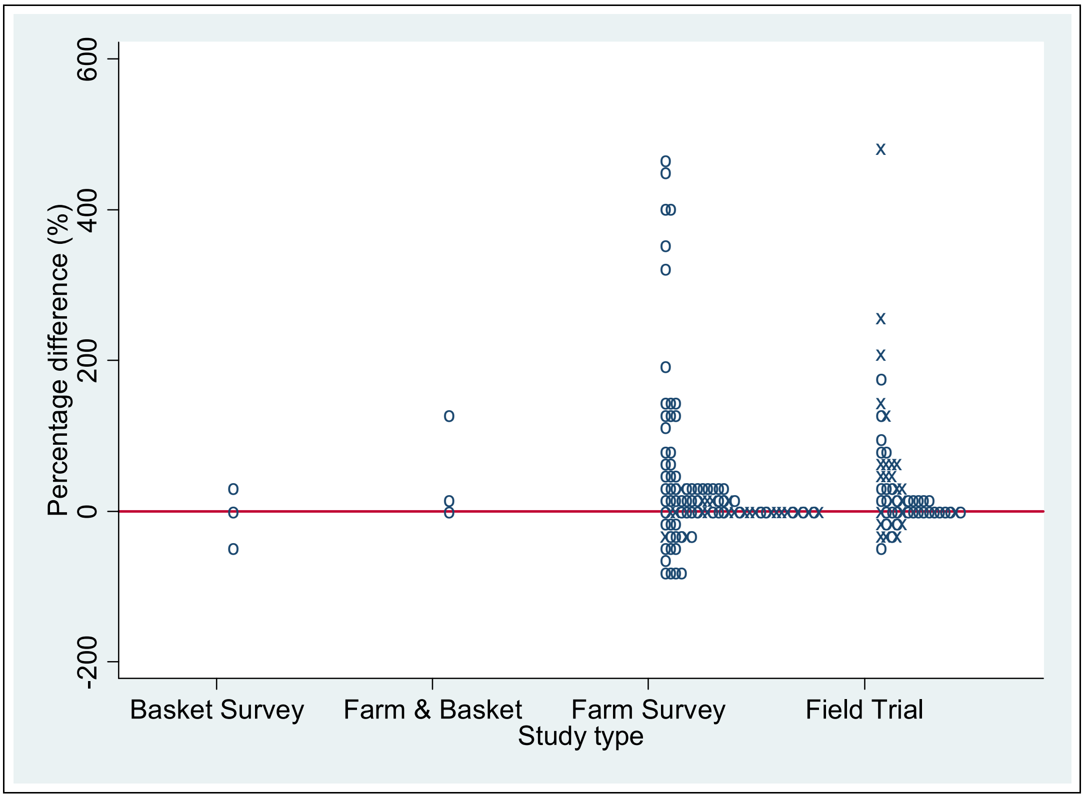
Apple, banana, blackcurrant, collard, grape, hop, lettuce, marinara pasta sauce, onion, pac choi, paprika, pepper, plum, qing-gen-cai, red orange, red pepper, spinach, strawberry, tomato, vine, Welsh onion, wine

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	7	11	1	1	**20**
Satisfactory quality studies	1	3	0	0	**4**
Number of nutrient comparisons reported	58	94	3	3	**158**
Number of nutrient comparisons reported from satisfactory quality studies	25	23	0	0	**48**

Results

Dot plot showing distribution of percentage differences in flavonoids content by study type



x indicates nutrient comparisons from satisfactory quality studies

Five extreme values (541%, 943%, 1451%, 1545%, 3580%) excluded

Statistical analysis of difference in flavonoids content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	158	38.4 (se: 10.6)	0.002
All satisfactory quality nutrient comparisons	48	32.9 (se: 21.0)	0.22

Overall Analysis

Analysis suggests that there is a significantly greater flavonoid content in organically than in conventionally produced crops (p=0.002 for all comparisons). Analysis of data from satisfactory quality studies suggests that there is no difference in flavonoid content between organically and conventionally produced crops (p=0.22 for comparisons from satisfactory quality studies).

IRON

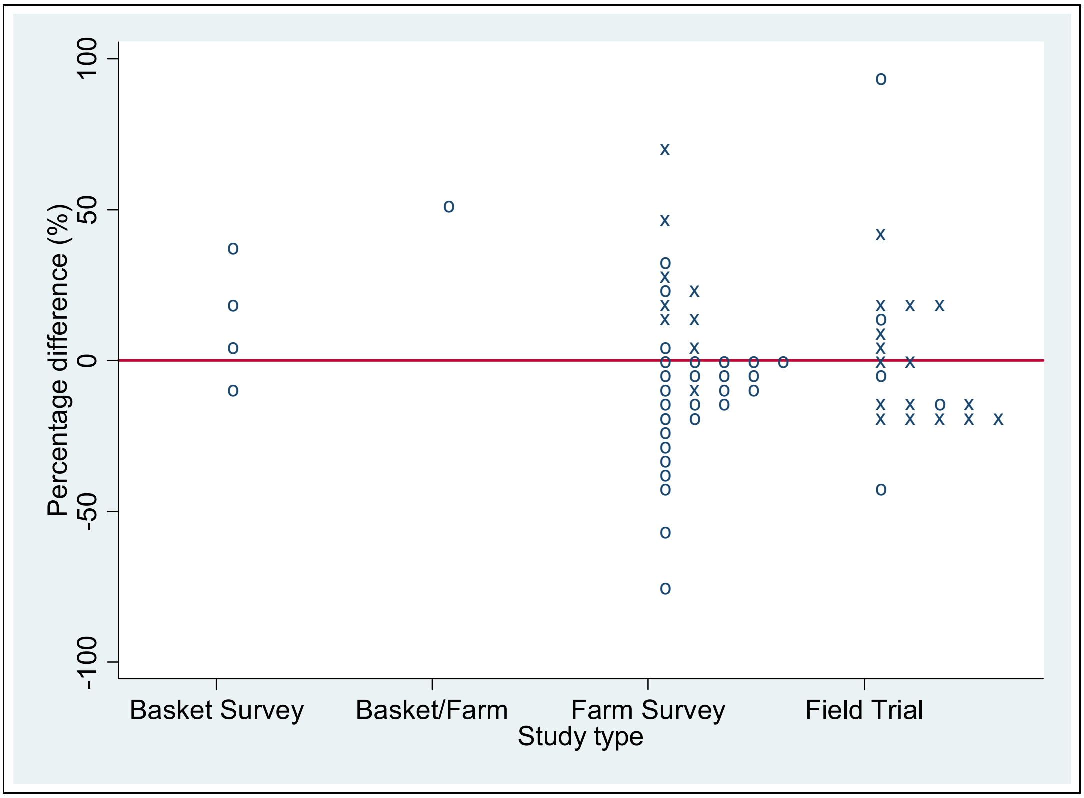
Reported as	Iron
Reported methods of analysis	Atomic absorption spectrometry, atomic absorption spectrophotometry, flame atomic absorption spectrometry, flame atomic absorption spectrophotometry, inductively coupled plasma - optical emission spectrometry, inductively coupled plasma atomic emission spectrometry, inductively coupled plasma mass spectrometry, colourimetry, open-vessel hot-plate acid digestion
Reported units of analysis	ppm, µg g^{-1}, µg $100g^{-1}$, mg $100g^{-1}$, mg kg^{-1}, mg L^{-1}, g kg^{-1}
Foods analysed	Apple, barley, cabbage, carrot, celeriac, corn meal, grapefruit, lentil, mandarin, onion, pea, pear, plum, potato, pumpkin, rice, savoury herb, strawberry, sweet pepper, sweet corn, tomato, wheat

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	8	10	1	1	**20**
Satisfactory quality studies	4	4	0	0	**8**
Number of nutrient comparisons reported	21	36	4	1	**62**
Number of nutrient comparisons reported from satisfactory quality studies	16	9	0	0	**25**

Results

Dot plot showing distribution of percentage differences in iron content by study type



x indicates nutrient comparisons from satisfactory quality studies

Statistical analysis of difference in iron content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	62	-0.5 (se: 4.7)	0.92
All satisfactory quality nutrient comparisons	25	7.1 (se: 6.1)	0.29

Overall Analysis

Analysis suggests that there is no difference in iron content between organically and conventionally produced crops (p=0.92 for all comparisons; p=0.29 for comparisons from satisfactory quality studies).

MAGNESIUM

Reported as Magnesium

Reported methods of analysis Atomic absorption spectrometry, atomic absorption spectrophotometry, flame atomic absorption spectrometry, flame atomic absorption spectrophotometry, inductively coupled plasma - optical emission spectrometry, inductively coupled plasma atomic emission spectrometry, inductively coupled plasma mass spectrometry, colourimetry, nitric/hydrogen microwave digestion, open-vessel hot-plate acid digestion, titrimetric method, X-ray fluorescence spectroscopy

Reported units of analysis %, ppm, mmol kg^{-1}, µg g^{-1}, mg 100g^{-1}, mg kg^{-1}, mg L^{-1}, g kg^{-1}

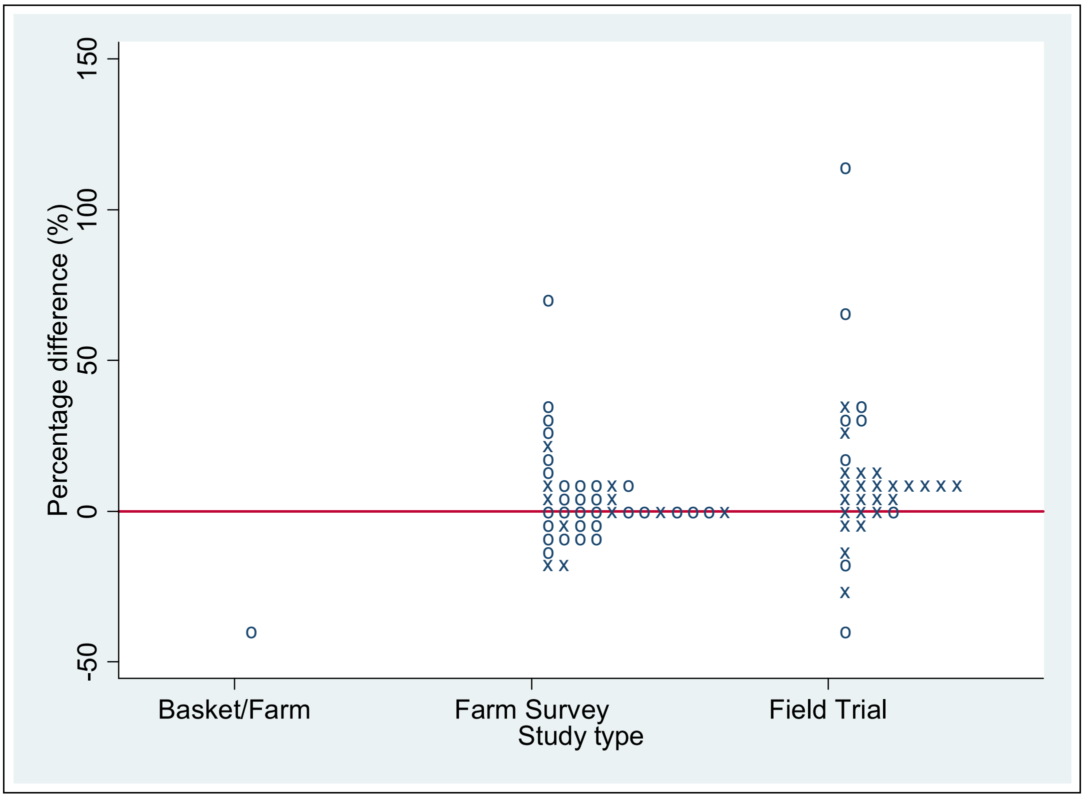
Foods analysed Apple, banana, beetroot, cabbage, carrot, celeriac, grapefruit, kiwifruit, mandarin, onion, pea, pear, plum, potato, pumpkin, rice, savoury herb, strawberry, sweet pepper, sweet potato, sweet corn, tomato, wheat

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	15	14	0	1	**30**
Satisfactory quality studies	8	5	0	0	**13**
Number of nutrient comparisons reported	33	41	0	1	**75**
Number of nutrient comparisons reported from satisfactory quality studies	24	11	0	0	**35**

Results

Dot plot showing distribution of percentage differences in magnesium content by study type



x indicates nutrient comparisons from satisfactory quality studies

Statistical analysis of difference in magnesium content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	75	7.1 (se: 2.4)	0.005
All satisfactory quality nutrient comparisons	35	4.2 (se: 2.3)	0.10

Overall Analysis

Analysis suggests that there is a significantly higher magnesium content in organically than in conventionally produced crops (p=0.005 for all comparisons). Analysis of data from satisfactory quality studies suggests that there is no difference in magnesium content between organically and conventionally produced crops (p=0.10 for comparisons from satisfactory quality studies).

MANGANESE

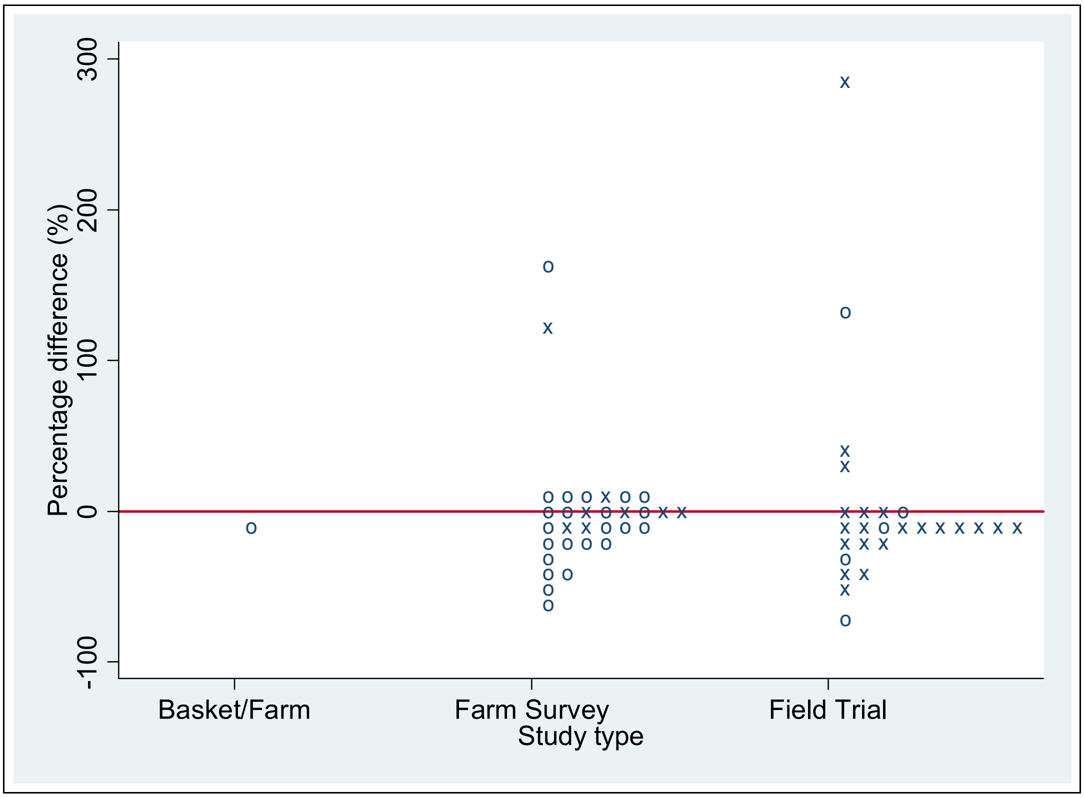
Reported as	Manganese
Reported methods of analysis	Atomic absorption spectrometry, atomic absorption spectrophotometry, flame atomic absorption spectrometry, flame atomic absorption spectrophotometry, flame photometry, high resolution inductively coupled plasma - optical emission spectrometry, plasma emission spectrometry, inductively coupled plasma atomic emission spectrometry, inductively coupled plasma mass spectrometry, colourimetry, open-vessel hot-plate acid digestion, X-ray fluorescence spectroscopy
Reported units of analysis	ppm, μg g^{-1}, μg $100g^{-1}$, μg kg^{-1}, mmol kg^{-1}, mg $100g^{-1}$, mg kg^{-1}, mg L^{-1}, g kg^{-1}
Foods analysed	Cabbage, carrot, celeriac, grapefruit, mandarin, onion, pea, plum, potato, pumpkin, rice, savoury herb, strawberry, sweet pepper, sweet corn, tomato, wheat

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	10	8	0	1	**19**
Satisfactory quality studies	6	3	0	0	**9**
Number of nutrient comparisons reported	26	31	0	1	**58**
Number of nutrient comparisons reported from satisfactory quality studies	21	8	0	0	**29**

Results

Dot plot showing distribution of percentage differences in manganese content by study type



x indicates nutrient comparisons from satisfactory quality studies

Statistical analysis of difference in manganese content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	58	1.1 (se: 6.2)	0.87
All satisfactory quality nutrient comparisons	29	6.6 (se: 8.9)	0.48

Overall Analysis

Analysis suggests that there is no difference in manganese content between organically and conventionally produced crops (p=0.87 for all comparisons; p=0.48 for comparisons from satisfactory quality studies).

NITRATES

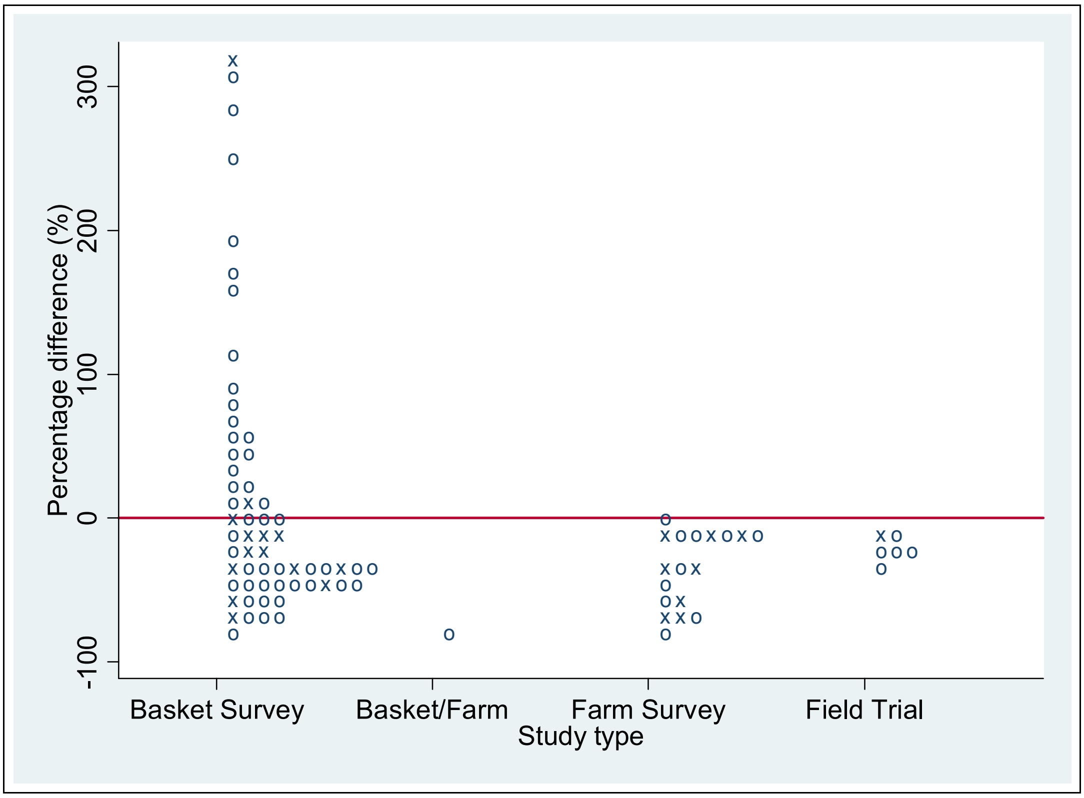
Reported as	Nitrate, nitrates, nitrate ions
Reported methods of analysis	Amylacetate extraction method, capillary zone electrophoresis, colorimetry, Griess colorimetry, Devrada alloy method, distillation method (Bremner Stark modification), flow-injection analysis, analysis following reduction of nitrites, HPLC, ion chromatography, ion chromatography with chemical suppression of eluent conductivity, ion-selective electrode, photometry, selective iron probe
Reported units of analysis	ppm, ppm in serum, mg, mg $100g^{-1}$, mg kg^{-1}, g kg^{-1}
Foods analysed	Beetroot, cabbage, carrot, celeriac, chicory, French bean, grapefruit, lettuce, mango, onion, orange, parsnip, pea, potato, rocket, salad, savoury herb, spinach, tomato, watercress, white cabbage

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	3	9	6	1	**19**
Satisfactory quality studies	1	4	2	0	**7**
Number of nutrient comparisons reported	6	21	63	1	**91**
Number of nutrient comparisons reported from satisfactory quality studies	1	8	14	0	**23**

Results

Dot plot showing distribution of percentage differences in nitrates content by study type



x indicates nutrient comparisons from satisfactory quality studies

Two extreme values (819%, 1195%) excluded

Statistical analysis of difference in nitrates content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	91	0.5 (se: 13.2)	0.97
All satisfactory quality nutrient comparisons	23	-16.0 (se: 10.9)	0.19

Overall Analysis

Analysis suggests that there is no difference in nitrate content between organically and conventionally produced crops (p=0.97 for all comparisons; p=0.19 for comparisons from satisfactory quality studies).

NITROGEN

Reported as Crude protein, protein, Nitrogen, total nitrogen, protein nitrogen, true protein

Reported methods of analysis Atomic absorption spectrometry, inductively coupled plasma atomic emission spectrometry, Berstein method, carbon, hydrogen, nitrogen determinator, nitrogen gas analyser, colorimetrically, combustion (Dumas method), dry combustion method, HPLC, Kjeldahl method, 5.7x Kjeldahl N, 6.25x Kjeldahl N, oxidized with sulphuric acid, treated by alkali, distilled, titrated (ICC Standard Method 105/2), spectrophotometrically, X-ray fluorescence spectroscopy

Reported units of analysis %, % (N x 5.7), % dry matter, % dry weight, % total grain weight, mmol kg^{-1}, mg g^{-1}, mg $100g^{-1}$, mg kg^{-1}, g $100g^{-1}$, g kg^{-1}

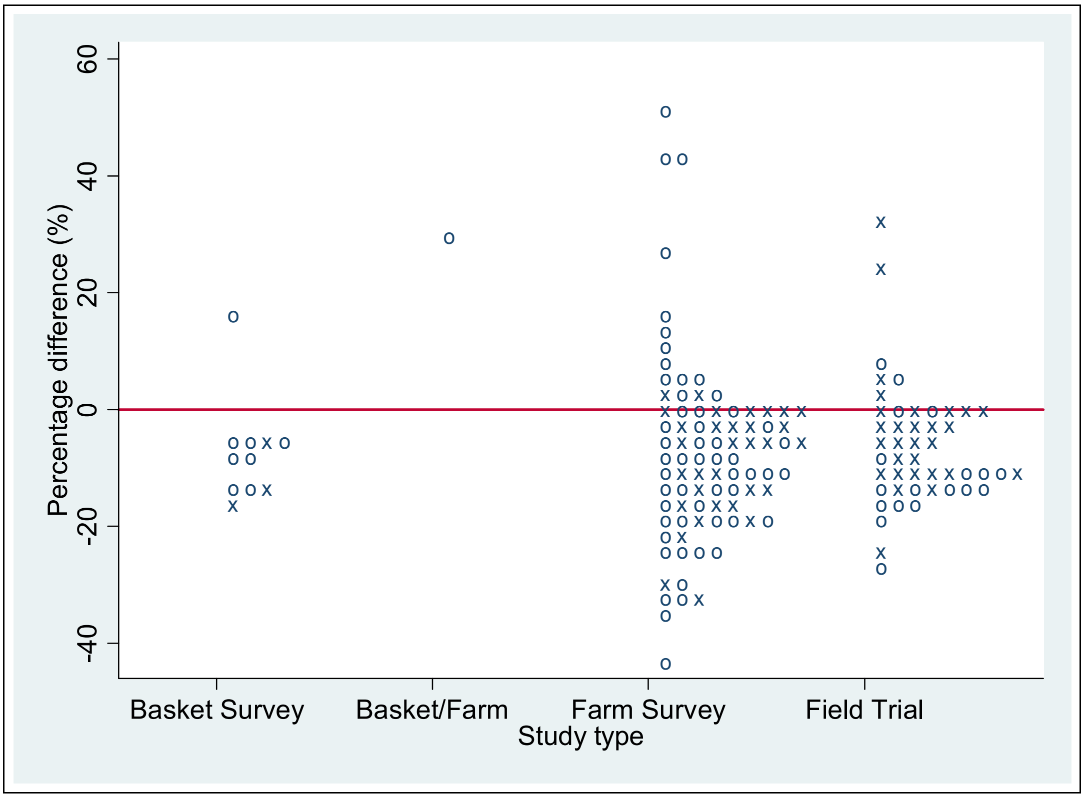
Foods analysed Apple, banana, barley, beetroot, cabbage, carrot, celeriac, grape, grapefruit, kiwifruit, lettuce, maize, malting barley, mango, pea, plum, potato, pumpkin, rice, savoury herb, spinach, sweet potato, sweet corn, tomato, triticale, wheat, wine

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	16	23	2	1	**42**
Satisfactory quality studies	9	7	1	0	**17**
Number of nutrient comparisons reported	47	86	11	1	**145**
Number of nutrient comparisons reported from satisfactory quality studies	29	32	3	0	**64**

Results

Dot plot showing distribution of percentage differences in nitrogen content by study type



x indicates nutrient comparisons from satisfactory quality studies

Statistical analysis of difference in nitrogen content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	145	-6.8 (se: 1.3)	<0.001
All satisfactory quality nutrient comparisons	64	-6.7 (se: 1.9)	0.003

Overall Analysis

Analysis suggests that there is a significantly lower nitrogen content in organically than in conventionally produced crops ($p<0.001$ for all comparisons; $p=0.003$ for comparisons from satisfactory quality studies).

PHENOLIC COMPOUNDS

Reported as

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

Reported methods of analysis

Arnow method, (3,4-dihydroxyphenylethanol as standard), Christa muller method, colorimetrically, Folin-Ciocalteau assay, gallic acid as standard, Folin-Denis method, HPLC, reverse phase-HPLC, refractometry detector, liquid chromatography/mass spectrometry, spectrophotometrically

Reported units of analysis

ng g^{-1}, nmol g^{-1}, µg g^{-1}, µg kg^{-1}, µmol g^{-1}, tannic acid mg/100g chlorogenic acid, catechin equivalent mg L^{-1}, mg $100g^{-1}$, mg GAE mL^{-1}, GAE g^{-1}, mg GAE $100g^{-1}$, mg GAE kg, mg g^{-1}, mg kg^{-1}, mg L^{-1}, mg quercetin equivalent g^{-1}, mg tann.ac $100g^{-1}$, mg L^{-1} of dihydroxytyrosol, min^{-1}/100g, ppm, g kg^{-1}, g L^{-1}

Foods analysed

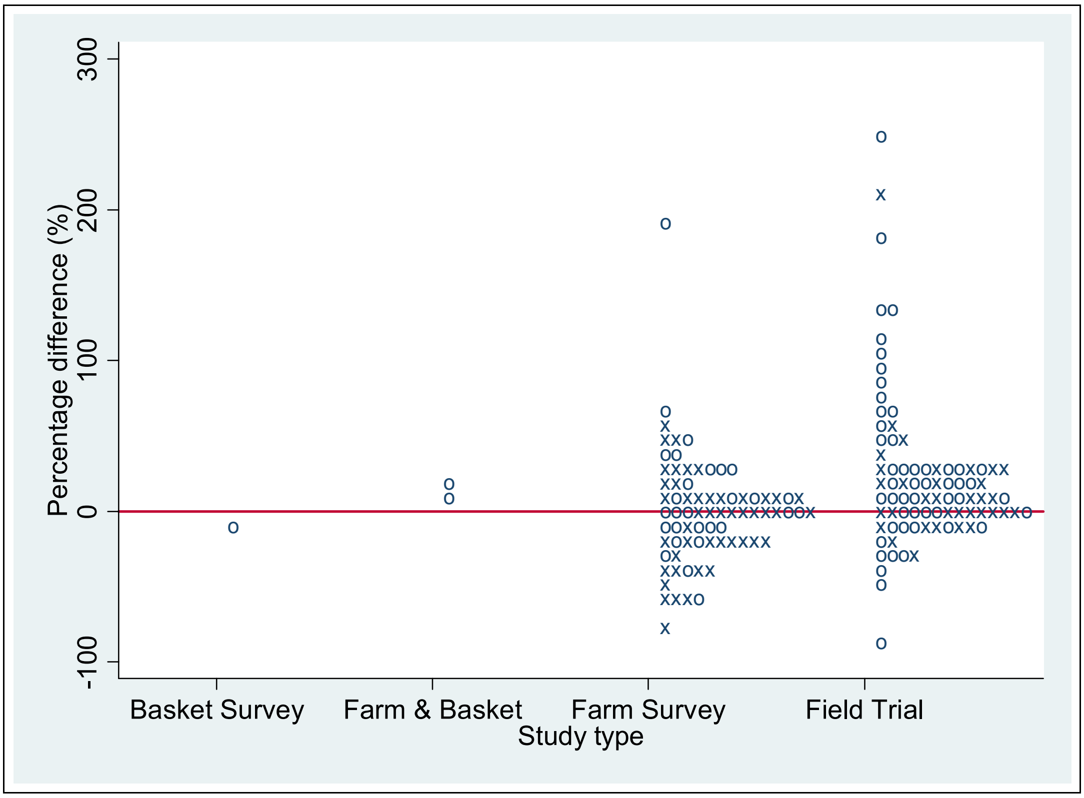
Apple, banana, blackberry, blackcurrant, broccoli, cabbage, collard, corn, grapefruit, kiwifruit, lettuce, oat, olive, pac choi, peach, pear, pepper, plum, potato, qing-gen-cai, red orange, spinach, strawberry, sunflower seed, sweet pepper, tomato, vegetable soup, vine, Welsh onion, wheat, wine

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	16	16	1	1	**34**
Satisfactory quality studies	7	6	0	0	**13**
Number of nutrient comparisons reported	86	75	1	2	**164**
Number of nutrient comparisons reported from satisfactory quality studies	34	46	0	0	**80**

Results

Dot plot showing distribution of percentage differences in phenolic compounds content by study type



x indicates nutrient comparisons from satisfactory quality studies

Statistical analysis of difference in phenolic compounds content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	164	13.2 (se: 6.0)	0.04
All satisfactory quality nutrient comparisons	80	3.4 (se: 6.1)	0.60

Overall Analysis

Analysis suggests that there is a significantly higher phenolic compound content in organically than in conventionally produced crops (p=0.04 for all comparisons). Analysis of data from satisfactory quality studies suggests that there is no difference in phenolic compound content between organically and conventionally produced crops (p=0.60).

PHOSPHORUS

Reported as Phosphorus

Reported methods of analysis Atomic absorption spectrometry, flame atomic absorption spectrometry, flame atomic absorption spectrophotometry, flame photometry, inductively coupled plasma - optical emission spectrometry, inductively coupled plasma atomic emission spectrometry, inductively coupled plasma mass spectrometry, colourimetrically, nitric/hydrogen microwave digestion, open-vessel hot-plate acid digestion, X-ray fluorescence spectroscopy

Reported units of analysis %, ppm, µg g^{-1}, mmol kg^{-1}, mg $100g^{-1}$, mg kg^{-1}, mg L^{-1}, g kg^{-1}

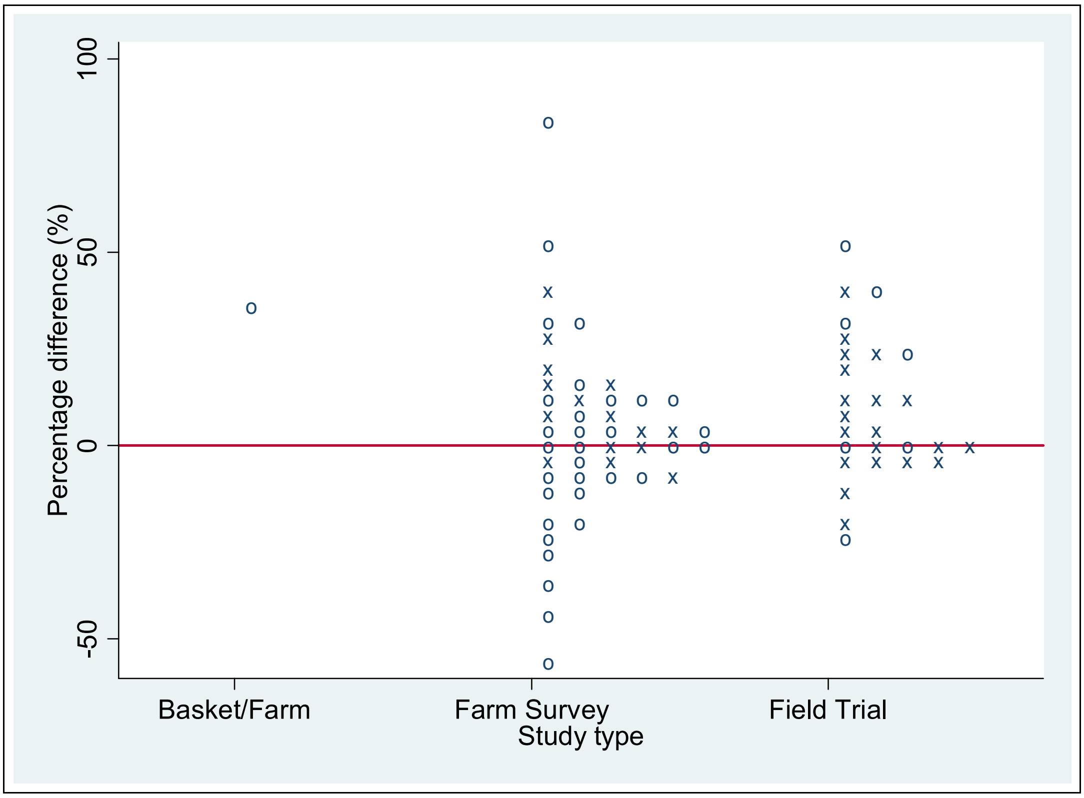
Foods analysed Apple, banana, barley, beetroot, cabbage, carrot, celeriac, grapefruit, kiwifruit, mango, oat, onion, pea, pear, plum, potato, pumpkin, rice, rye, savoury herb, spinach, sweet potato, sweet corn, tomato, wheat, wine

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	11	15	0	1	**27**
Satisfactory quality studies	6	6	0	0	**12**
Number of nutrient comparisons reported	27	47	0	1	**75**
Number of nutrient comparisons reported from satisfactory quality studies	20	15	0	0	**35**

Results

Dot plot showing distribution of percentage differences in phosphorus content by study type



x indicates nutrient comparisons from satisfactory quality studies

Statistical analysis of difference in phosphorus content between organic and conventionally produced foods

	Number of comparisons	**Mean percentage difference**	**p-value**
All nutrient comparisons	75	6.0 (se: 3.1)	0.06
All satisfactory quality nutrient comparisons	35	8.1 (se: 2.6)	0.009

Overall Analysis

Analysis suggests that there is a higher phosphorus content in organically than in conventionally produced crops, this difference approached statistical significant (p=0.06 for all comparisons). Analysis of data from satisfactory quality studies confirmed this finding (p=0.009 for comparisons from satisfactory quality studies).

PLANT NON-DIGESTIBLE CARBOHYDRATES

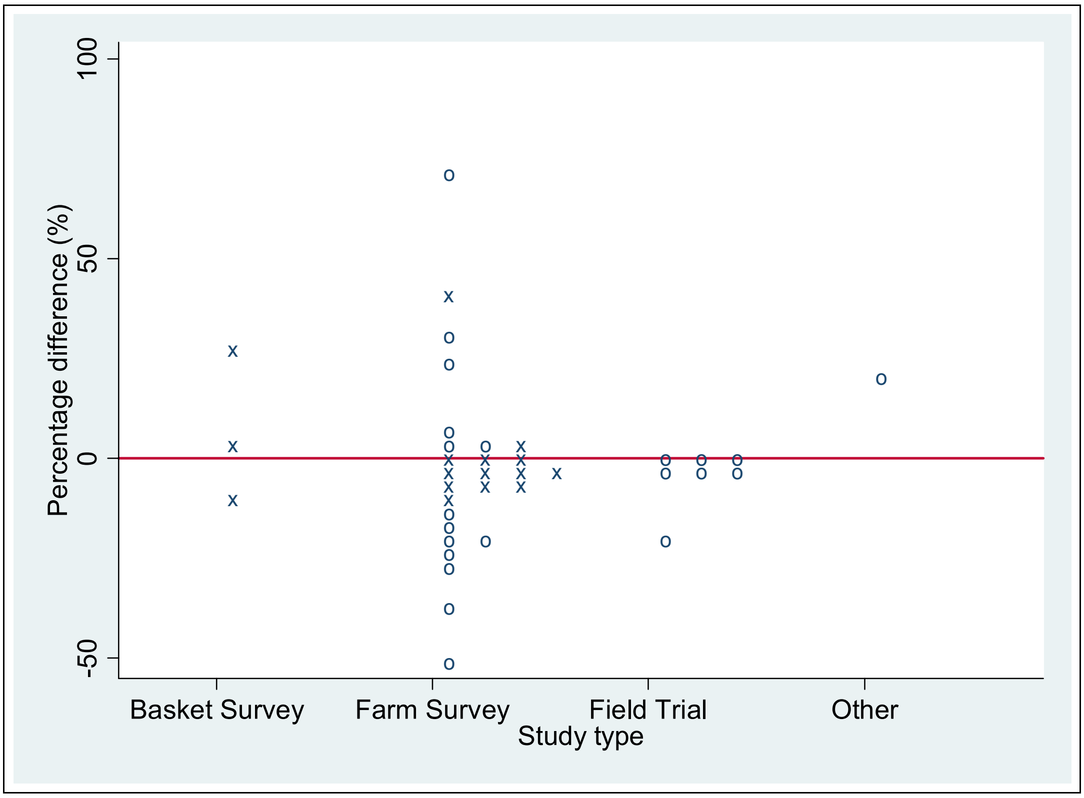
Reported as	Fibre, Insoluble fibre, Soluble fibre, Crude fibre, Total fibre, Dietary fibre, Soluble dietary fibre, Insoluble dietary fibre, Total non-starch polysaccharides
Reported methods of analysis	Enzymatic gravimetric method, gas-liquid chromatography, NIN Lab technique, tecator
Reported units of analysis	%, % dry matter, g 100^{-1}, g kg^{-1}, Ratio
Foods analysed	Banana, carrot, grape, lettuce, mandarin, oat, pea, plum, potato, pumpkin, rye, sweet potato, tomato, wheat

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	4	5	1	1	**11**
Satisfactory quality studies	0	2	1	0	**3**
Number of nutrient comparisons reported	7	29	3	1	**40**
Number of nutrient comparisons reported from satisfactory quality studies	0	15	3	0	**18**

Results

Dot plot showing distribution of percentage differences in plant non-digestible carbohydrates content by study type



x indicates nutrient comparisons from satisfactory quality studies

One extreme value (950%) excluded

Statistical analysis of difference in plant non-digestible carbohydrates content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	40	-1.0 (se: 4.6)	0.83
All satisfactory quality nutrient comparisons	18	2.3 (se: 2.4)	0.44

Overall Analysis

Analysis suggests that there is no difference in plant non-digestible carbohydrates content between organically and conventionally produced crops (p=0.74 for all comparisons; p=0.62 for comparisons from satisfactory quality studies).

POTASSIUM

Reported as Potassium

Reported methods of analysis Atomic absorption spectrometry, flame atomic absorption spectrometry, flame atomic absorption spectrophotometry, flame photometry, inductively coupled plasma - optical emission spectrometry, inductively coupled plasma atomic emission spectrometry, inductively coupled plasma mass spectrometry, infra-red emission spectroscopy, colourimetrically, nitric/hydrogen microwave digestion, open-vessel hot-plate acid digestion, X-ray fluorescence spectroscopy

Reported units of analysis %, ppm, $\mu g\ g^{-1}$, $mmol\ kg^{-1}$, $mg\ 100g^{-1}$, $mg\ kg^{-1}$, $mg\ L^{-1}$, $g\ kg^{-1}$

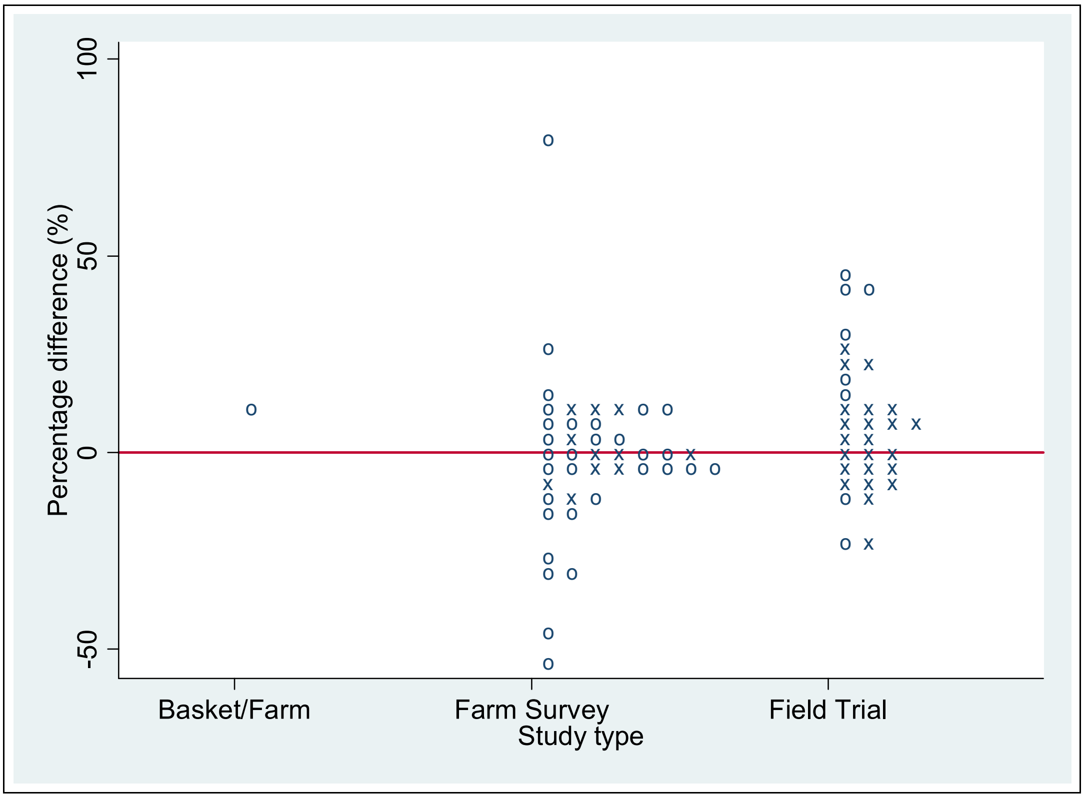
Foods analysed Apple, banana, beetroot, cabbage, carrot, celeriac, grapefruit, kiwifruit, mandarin, mango, onion, pea, pear, plum, potato, pumpkin, rice, savoury herb, spinach, strawberry, sweet pepper, sweet potato, sweet corn, tomato, wheat, wine

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	13	13	0	1	**27**
Satisfactory quality studies	7	5	0	0	**12**
Number of nutrient comparisons reported	31	42	0	1	**74**
Number of nutrient comparisons reported from satisfactory quality studies	23	11	0	0	**34**

Results

Dot plot showing distribution of percentage differences in potassium content by study type



x indicates nutrient comparisons from satisfactory quality studies

Statistical analysis of difference in potassium content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	74	2.5 (se: 2.2)	0.27
All satisfactory quality nutrient comparisons	34	2.7 (se: 2.4)	0.28

Overall Analysis

Analysis suggests that there is no difference in potassium content between organically and conventionally produced crops (p=0.27 for all comparisons; p=0.28 for comparisons from satisfactory quality studies).

SODIUM

Reported as Sodium

Reported methods of analysis Atomic absorption spectrometry, atomic absorption spectrophotometry, flame atomic absorption spectrometry, flame atomic absorption spectrophotometry, flame photometry, high resolution inductively coupled plasma - optical emission spectrometry, plasma emission spectrometry, inductively coupled plasma mass spectrometry, open-vessel hot-plate acid digestion, nitric/hydrogen microwave digestion

Reported units of analysis ppm, mg 100g^{-1}, mg kg^{-1}, mg L^{-1}, g kg^{-1}

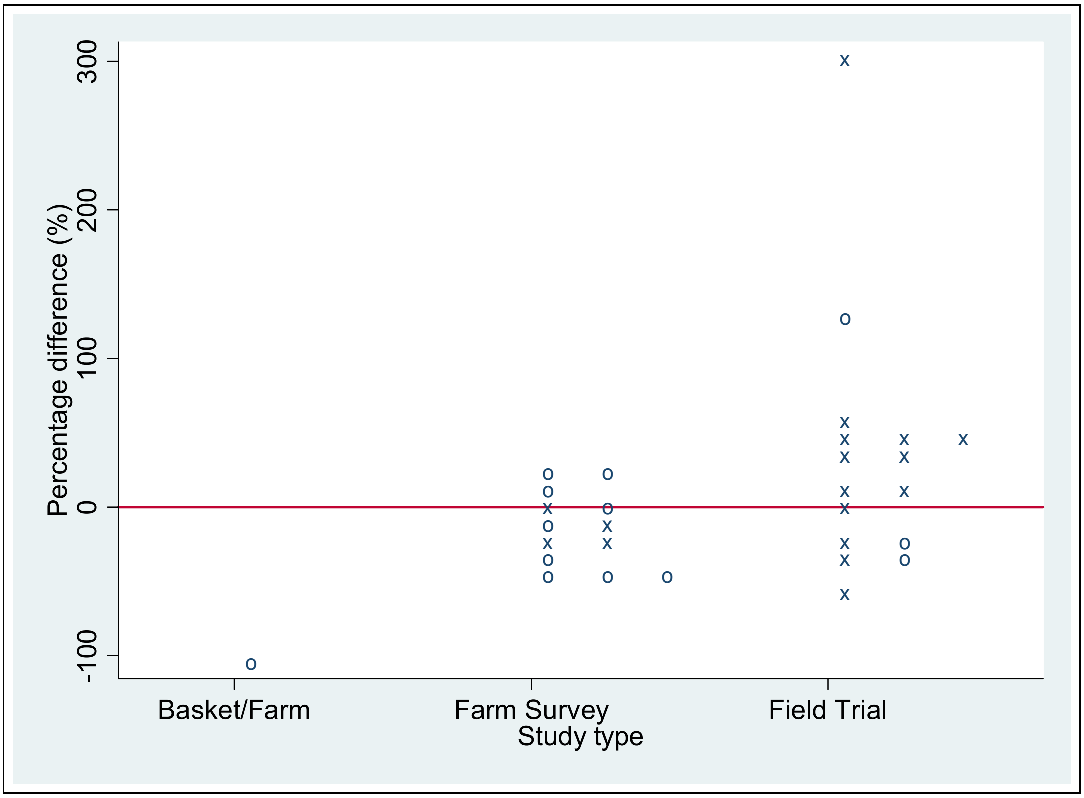
Foods analysed Apple, cabbage, carrot, grapefruit, mandarin, onion, pea, pear, plum, potato, savoury herb, sweet corn, tomato, wheat

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	7	4	0	1	**12**
Satisfactory quality studies	4	2	0	0	**6**
Number of nutrient comparisons reported	16	13	0	1	**30**
Number of nutrient comparisons reported from satisfactory quality studies	13	4	0	0	**17**

Results

Dot plot showing distribution of percentage differences in sodium content by study type



x indicates nutrient comparisons from satisfactory quality studies

Statistical analysis of difference in sodium content between organic and conventionally produced foods

	Number of comparisons	**Mean percentage difference**	**p-value**
All nutrient comparisons	30	8.7 (se: 12.2)	0.49
All satisfactory quality nutrient comparisons	17	24.9 (se: 13.6)	0.13

Overall Analysis

Analysis suggests that there is no difference in sodium content between organically and conventionally produced crops (p=0.49 for all comparisons; p=0.13 for comparisons from satisfactory quality studies).

SPECIFIC PROTEINS

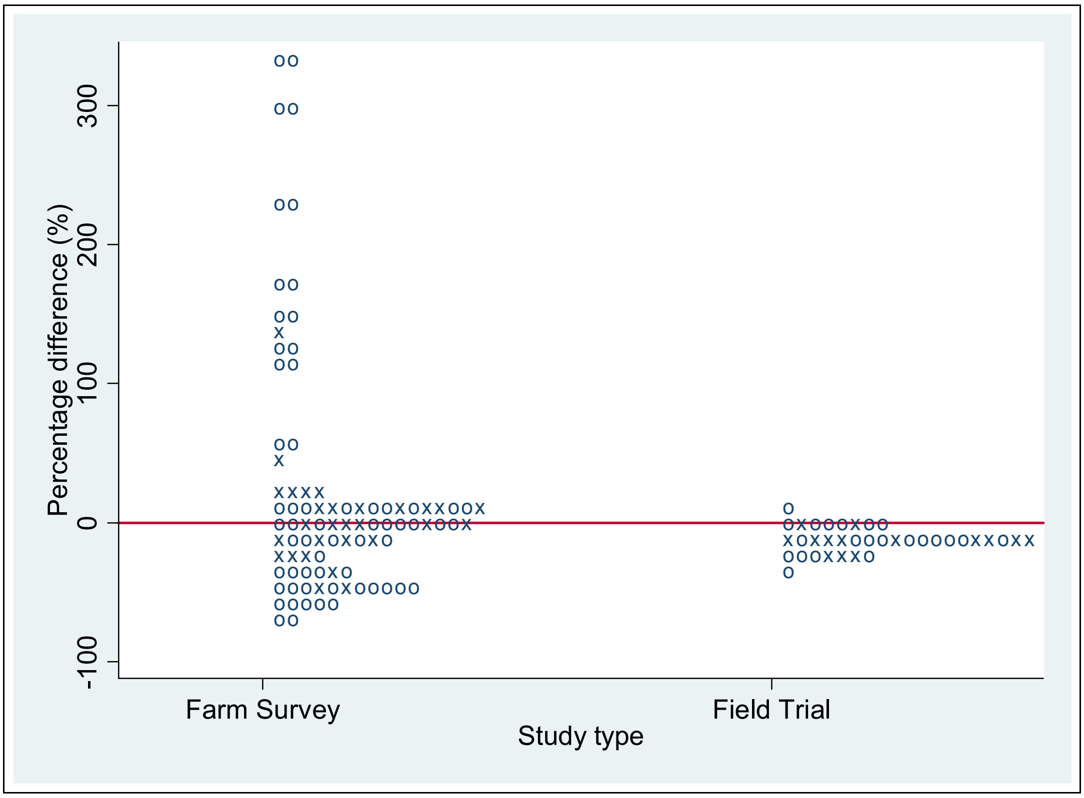
Reported as	Protein, Total Protein, Wholemeal protein, Albumins + Globulins, Glutelins, Prolamins, Residual albumins & globulins, Low molecular weight & gliadins, Gluten, Globulins, Albumins, Wet gluten, Glutenins high molecular weight, Glutenins low molecular weight, Kolbach index
Reported methods of analysis	Gel-electrophoresis (SDS-PAGE), near infrared reflectance spectroscopy, manual washing out method (ISO 5531)
Reported units of analysis	%, % Nitrogen, % Dry matter, g kg^{-1}
Foods analysed	Barley, malting barley, oat, rice, triticale, wheat

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	6	7	0	0	**13**
Satisfactory quality studies	3	4	0	0	**7**
Number of nutrient comparisons reported	37	90	0	0	**127**
Number of nutrient comparisons reported from satisfactory quality studies	14	29	0	0	**43**

Results

Dot plot showing distribution of percentage differences in specific proteins content by study type



x indicates nutrient comparisons from satisfactory quality studies

Statistical analysis of difference in specific proteins content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	127	12.7 (se: 8.0)	0.14
All satisfactory quality nutrient comparisons	43	-2.0 (se: 4.6)	0.68

Overall Analysis

Analysis suggests that there is no difference in specific proteins content between organically and conventionally produced crops (p=0.12 for all comparisons; p=0.68 for comparisons from satisfactory quality studies).

SUGARS

Reported as

Sugars, total sugars, reducing sugars, fructose, glucose, maltose, sucrose, amylose, saccharose, ß-glucan, fructan

Reported methods of analysis

Colourimetry, refractometrically, enzymatically, spectrophotometrically , gas chromatography, liquid chromatography, HPLC, reverse phase-HPLC, Luff-Schoorl method, streamlined & enzymatic method

Reported units of analysis

%, mg 100g^{-1}, mg mL^{-1}, g 100g^{-1}, g kg^{-1}, w/v invert sugar

Foods analysed

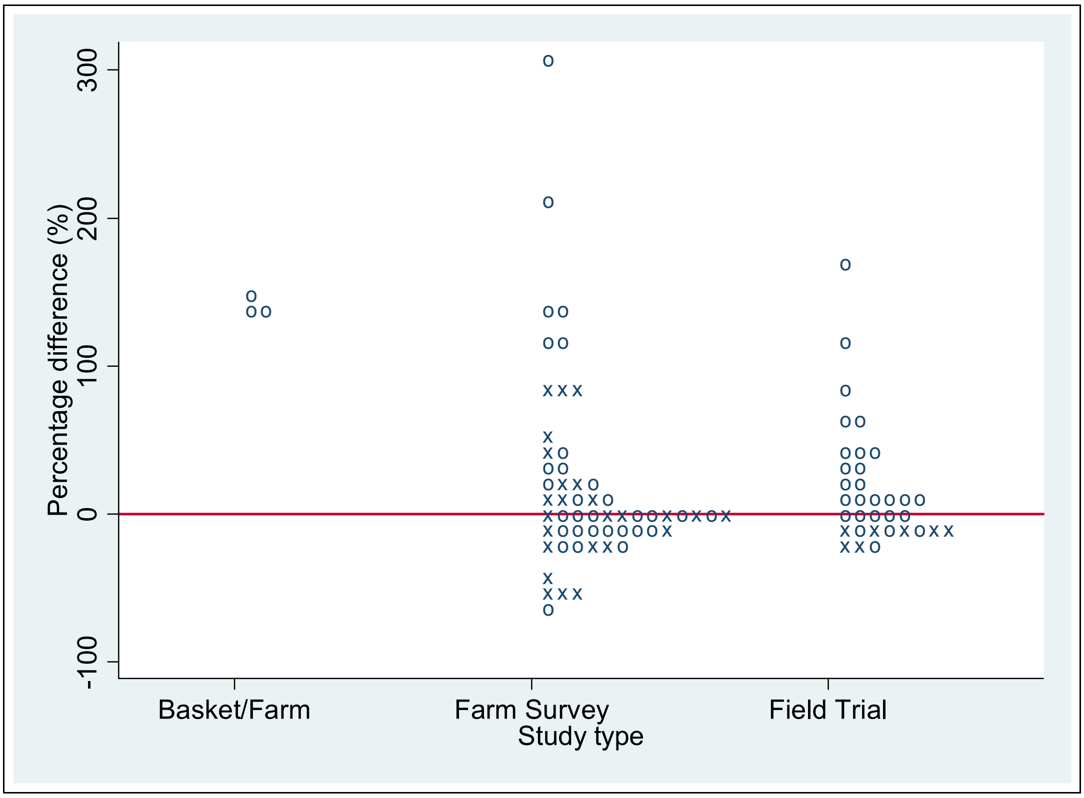
Apple, banana, beetroot, carrot, grapefruit, kiwifruit, mandarin, mango, nectarine, oat, onion, orange, paprika, plum, potato, rice, spinach, sweet corn, tomato, triticale, wheat, wine

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	9	9	0	1	**19**
Satisfactory quality studies	2	5	0	0	**7**
Number of nutrient comparisons reported	35	57	0	3	**95**
Number of nutrient comparisons reported from satisfactory quality studies	7	25	0	0	**32**

Results

Dot plot showing distribution of percentage differences in sugars content by study type



x indicates nutrient comparisons from satisfactory quality studies

Three extreme values (562%, 662%, 689%) excluded

Statistical analysis of difference in sugars content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	95	23.6 (se: 11.2)	0.05
All satisfactory quality nutrient comparisons	32	1.9 (se: 5.5)	0.79

Overall Analysis

Analysis suggests that there is a significantly greater sugar content in organically than in conventionally produced crops (p=0.05 for all comparisons). Analysis of data from satisfactory quality studies suggests that there is no difference in sugar content between organically and conventionally produced crops (p=0.79 for comparisons from satisfactory quality studies).

SULPHUR

Reported as Sulphur

Reported methods of analysis ICP–high resolution mass spectrometry, ICP-optical emission spectrometry, ICP-atomic emission spectrometry -emission spectrophotometry, ICP-mass spectrometry, Open-vessel hot-plate acid digestion, Plasma emission spectrometry, Spectrometry, turbidimetry

Reported units of analysis %, µg g^{-1}, mg $100g^{-1}$, mg kg^{-1}, g kg^{-1}, ppm

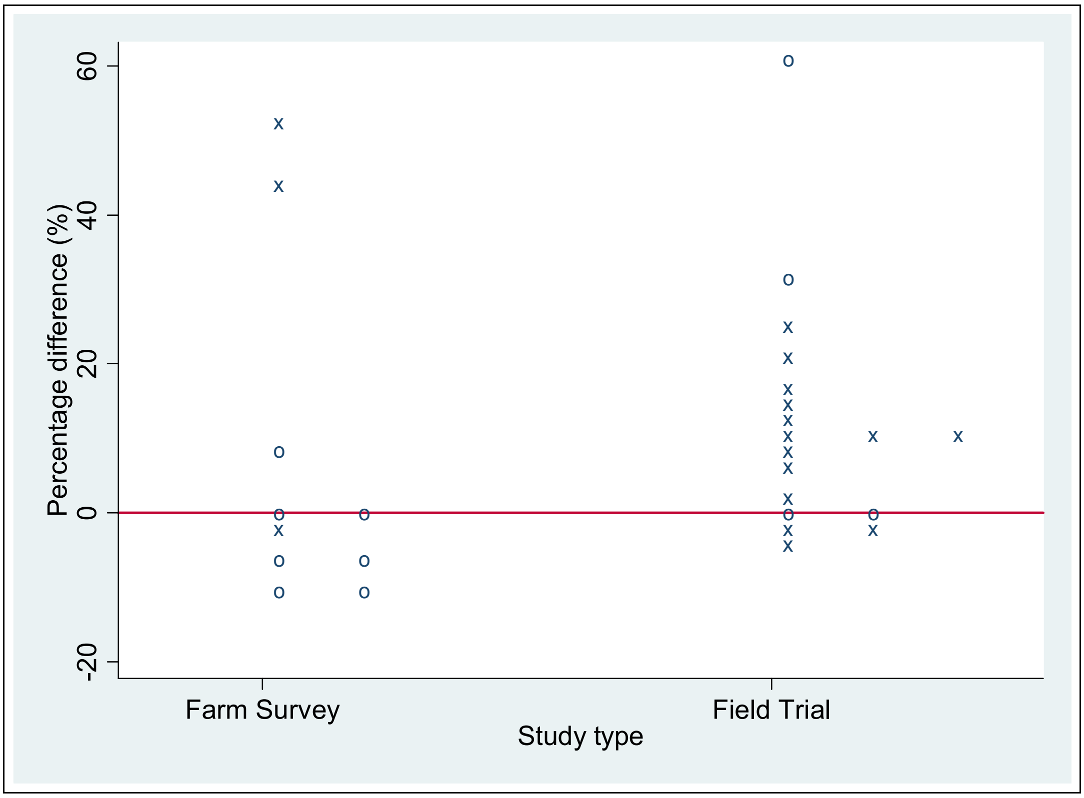
Foods analysed Apple, barley, cabbage, carrot, kiwifruit, onion, pea, pear, potato, sweet potato, sweet corn. tomato, wheat

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	6	4	0	0	**10**
Satisfactory quality studies	4	2	0	0	**6**
Number of nutrient comparisons reported	18	10	0	0	**28**
Number of nutrient comparisons reported from satisfactory quality studies	14	3	0	0	**17**

Results

Dot plot showing distribution of percentage differences in sulphur content by study type



x indicates nutrient comparisons from satisfactory quality studies

One extreme value (464%) excluded

Statistical analysis of difference in sulphur content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	28	10.5 (se: 5.1)	0.07
All satisfactory quality nutrient comparisons	17	13.4 (se: 5.8)	0.07

Overall Analysis

Analysis suggests that there is no difference in sulphur content between organically and conventionally produced crops (p=0.07 for all comparisons; p=0.07 for comparisons from satisfactory quality studies).

TITRATABLE ACIDITY

Reported as Titratable acidity, free acidity

Reported methods of analysis % oleic acid, HPLC, Indicator method, using titrator (AOAC), potentiometric titration, titration

Reported units of analysis %, % citric acid, % oleic acid, mL 0.1 N NaOH, mmol/mL, pH, meq%, mg malic acid equivalents $100ml^{-1}$, mg $100g^{-1}$, g $100g^{-1}$, g kg^{-1}, g anhydrous citric acid kg^{-1}, g anhydrous citric acid $100ml^{-1}$, g L^{-1} malic acid equivalents

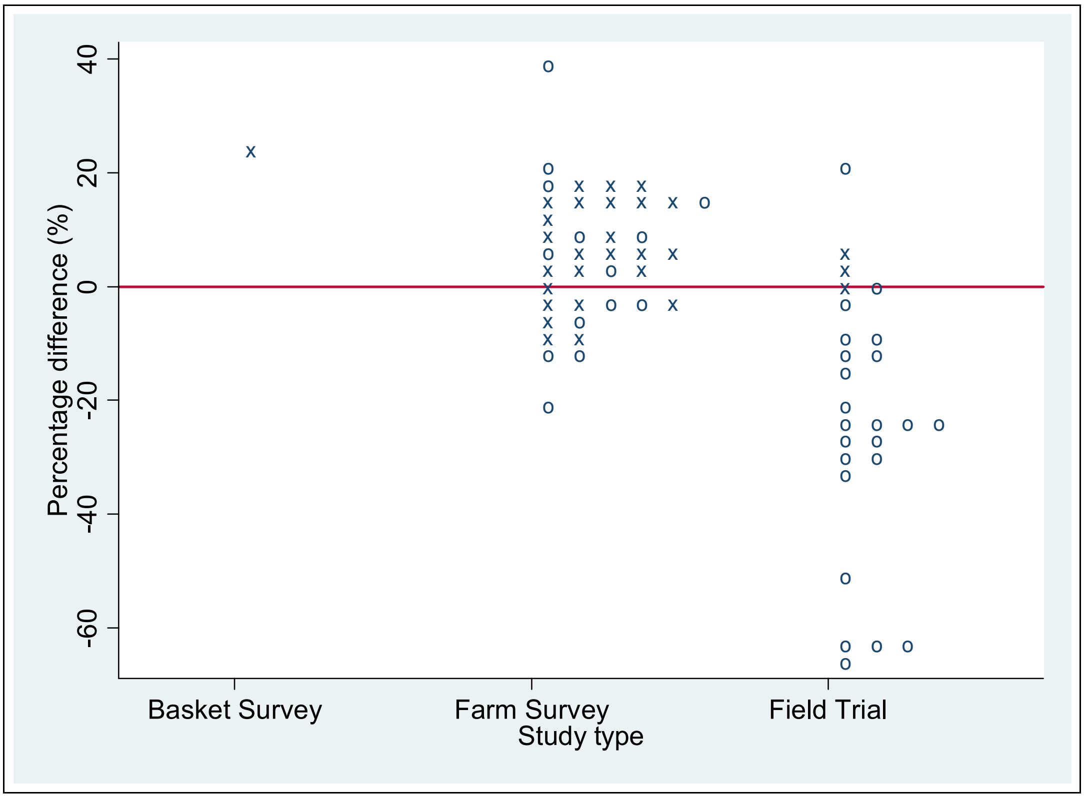
Foods analysed Apple, blackcurrant, carrot, grapefruit, lettuce, mandarin, nectarine, olive, paprika, passion fruit, pineapple, strawberry, sunflower seed, Swiss chard, tomato

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	7	12	2	0	**21**
Satisfactory quality studies	2	7	1	0	**10**
Number of nutrient comparisons reported	26	39	1	0	**66**
Number of nutrient comparisons reported from satisfactory quality studies	3	25	1	0	**29**

Results

Dot plot showing distribution of percentage differences in titratable acidity by study type



x indicates nutrient comparisons from satisfactory quality studies

One extreme value (1658%) excluded

Statistical analysis of difference in titratable acidity between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	66	-5.3 (se: 6.4)	0.42
All satisfactory quality nutrient comparisons	29	6.8 (se: 2. 1)	0.01

Overall Analysis

Analysis suggests that there is no difference in titratable acidity between organically and conventionally produced crops (p=0.42 for all comparisons). Analysis of data from satisfactory quality studies suggests that there is a significantly greater titratable acidity in organically than in conventionally produced crops (p=0.01 for comparisons from satisfactory quality studies).

TOTAL SOLUBLE SOLIDS

Reported as Soluble solids (Brix), total soluble solids, ripened soluble solids

Reported methods of analysis Digital refractometry (Brix), temperature correcting refractometry

Reported units of analysis Brix, Brix %, %, mg kg^{-1}

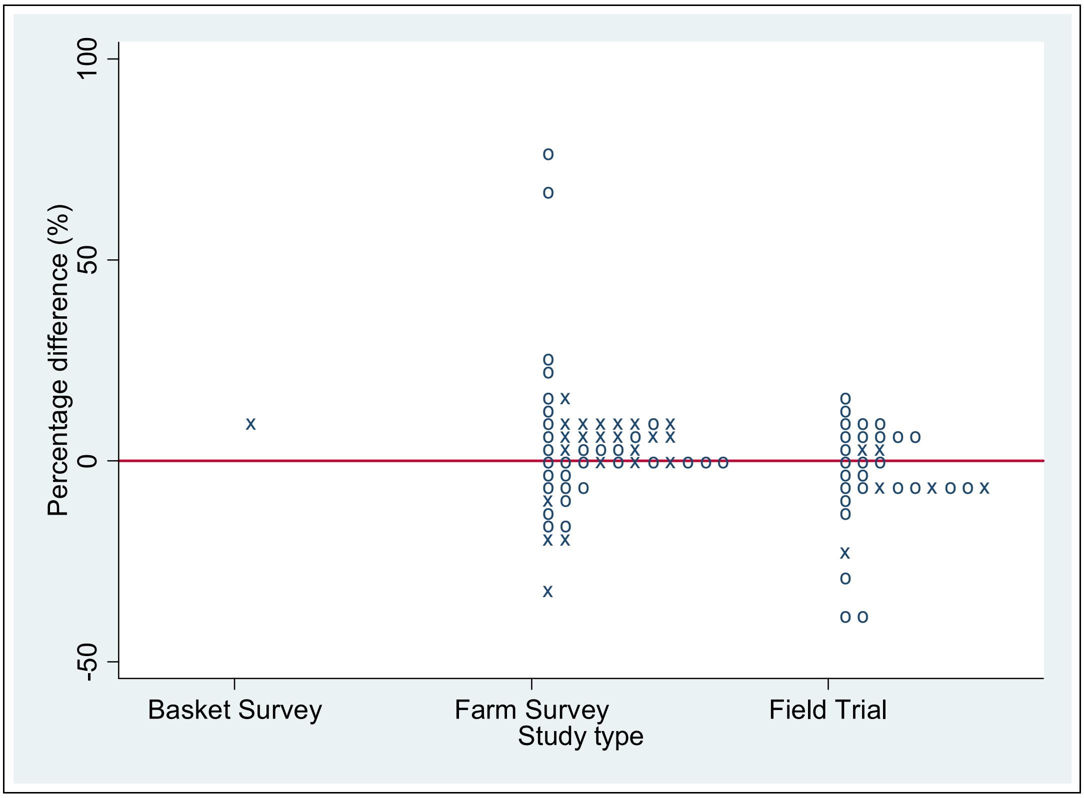
Foods analysed Apple, banana, blackcurrant, carrot, grapefruit, kiwifruit, lettuce, mandarin, mango, nectarine, orange, passion fruit, pepper, pineapple, pumpkin, strawberry, sugar beet, sweet corn, tomato, vine, wine

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	8	13	1	0	**22**
Satisfactory quality studies	4	6	1	0	**11**
Number of nutrient comparisons reported	27	53	1	0	**81**
Number of nutrient comparisons reported from satisfactory quality studies	6	22	1	0	**29**

Results

Dot plot showing distribution of percentage differences in total soluble solids content by study type



x indicates nutrient comparisons from satisfactory quality studies

One extreme value (862%) excluded

Statistical analysis of difference in total soluble solids content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	81	1.1 (se: 3.2)	0.74
All satisfactory quality nutrient comparisons	29	0.4 (se: 4.0)	0.92

Overall Analysis

Analysis suggests that there is no difference in total soluble solids content between organically and conventionally produced crops (p=0.67 for all comparisons; p=0.92 for comparisons from satisfactory quality studies).

VITAMIN C

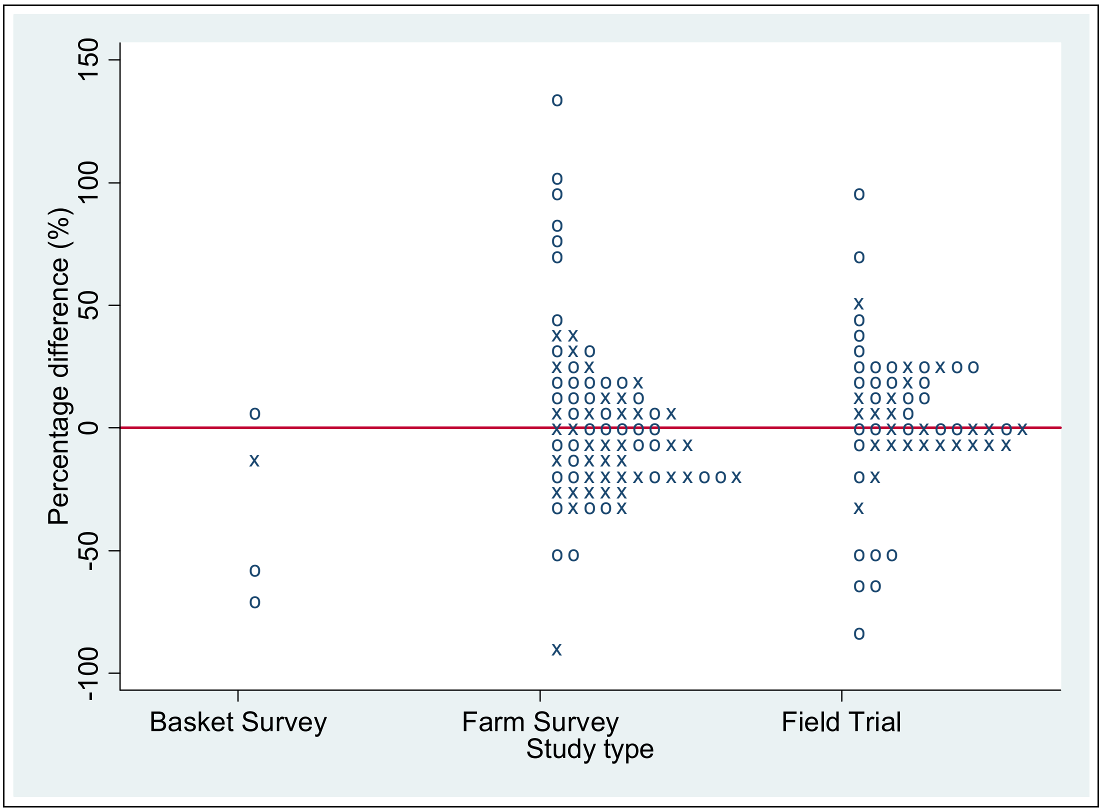
Reported as	Vitamin C, total vitamin C, ascorbic acid, dehydroascorbic acid, ascorbate, dehydroascorbate
Reported methods of analysis	2,6-Dichloroindophenol titrimetric method, titration (Tillmans reagent), amylacetate extraction method, colorimetry, fluorometrically, HPLC, reverse phase-HPLC, Folin-Ciocalteu assay, refractometric detector, Murri titration, polarography, spectrometry, spectrophotometry, Zoecklein method
Reported units of analysis	mg %, µg g^{-1}, mg g^{-1}, mg $80g^{-1}$, mg $100g^{-1}$, mg kg^{-1}, mg L^{-1}, g $100g^{-1}$, g kg^{-1}
Foods analysed	Apple, banana, beetroot, blackberry, broccoli, cabbage, carrot, celeriac, Chinese kale, Chinese mustard, corn, grape, grapefruit, kiwifruit, lettuce, mandarin, marinara pasta sauce, onion, paprika, pea, peach, pear, pepper, plum, potato, pumpkin, red orange, red pepper, spinach, strawberry, swamp cabbage, sweet pepper, sweet corn, Swiss chard, tomato

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	15	19	3	0	**37**
Satisfactory quality studies	5	8	1	0	**14**
Number of nutrient comparisons reported	58	81	4	0	**143**
Number of nutrient comparisons reported from satisfactory quality studies	25	39	1	0	**65**

Results

Dot plot showing distribution of percentage differences in vitamin C content by study type



x indicates nutrient comparisons from satisfactory quality studies

Statistical analysis of difference in vitamin C content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	143	2.8 (se: 4.5)	0.54
All satisfactory quality nutrient comparisons	65	-2.7 (se: 5.9)	0.84

Overall Analysis

Analysis suggests that there is no difference in vitamin C content between organically and conventionally produced crops (p=0.54 for all comparisons; p=0.58 for comparisons from satisfactory quality studies).

ZINC

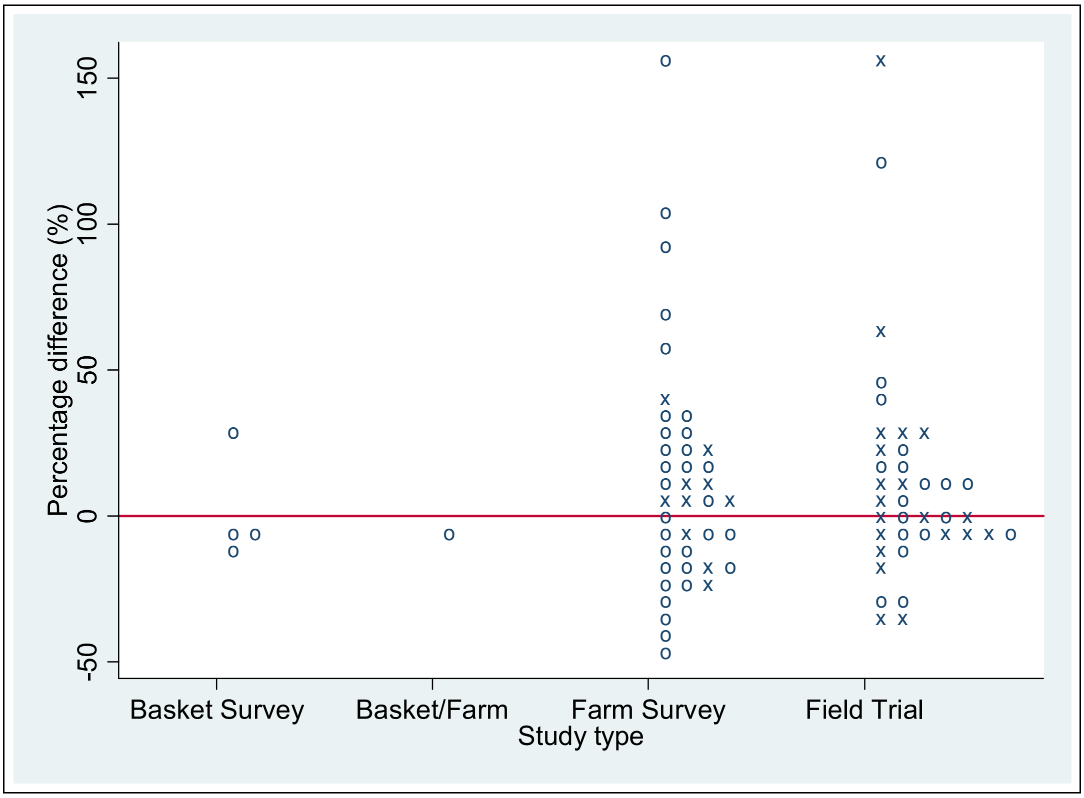
Reported as	Zinc
Reported methods of analysis	Atomic absorption spectrometry, atomic absorption spectrophotometry, flame atomic absorption spectrometry, flame atomic absorption spectrophotometry, flame photometry, inductively coupled plasma - optical emission spectrometry, inductively coupled plasma atomic emission spectrometry, inductively coupled plasma mass spectrometry, colourimetry, nitric/hydrogen microwave digestion, open-vessel hot-plate acid digestion, titrimetric method, X-ray fluorescence spectroscopy
Reported units of analysis	ppm, µg $100g^{-1}$, µg g^{-1}, mg $100g^{-1}$, mg kg^{-1}, mg L^{-1}, g kg^{-1}
Foods analysed	Apple, barley, cabbage, carrot, celeriac, chicory, corn meal, grapefruit, lentil, mandarin, onion, pea, pear, plum, potato, pumpkin, rice, rocket, rye, salad, savoury herb, strawberry, sweet pepper, sweet corn, tomato, wheat

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	12	11	1	1	**25**
Satisfactory quality studies	7	4	0	0	**11**
Number of nutrient comparisons reported	38	41	4	1	**84**
Number of nutrient comparisons reported from satisfactory quality studies	20	10	0	0	**30**

Results

Dot plot showing distribution of percentage differences in zinc content by study type



x indicates nutrient comparisons from satisfactory quality studies

One extreme value (340%) excluded

Statistical analysis of difference in zinc content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	84	11.3 (se: 4.9)	0.03
All satisfactory quality nutrient comparisons	30	10.1 (se: 5.6)	0.11

Overall Analysis

Analysis suggests that there is a significantly greater zinc content in organically than in conventionally produced crops (p=0.03 for all comparisons). Analysis of data from satisfactory quality studies suggests that there is no difference in zinc content between organically and conventionally produced crops (p=0.11).

Appendix13: Individual Nutrient Comparisons for Livestock Product Studies

Results of the analysis for the 10 most frequently reported nutrients or nutrient categories in livestock product studies are presented below in alphabetical order. Numercal information presented relates only to numerically reported results (excluding extreme outliers).

ASH

Reported as Ash

Reported methods of analysis 550˚C muffle furnace, gravimetric method

Reported units of analysis %, % of egg, weight %

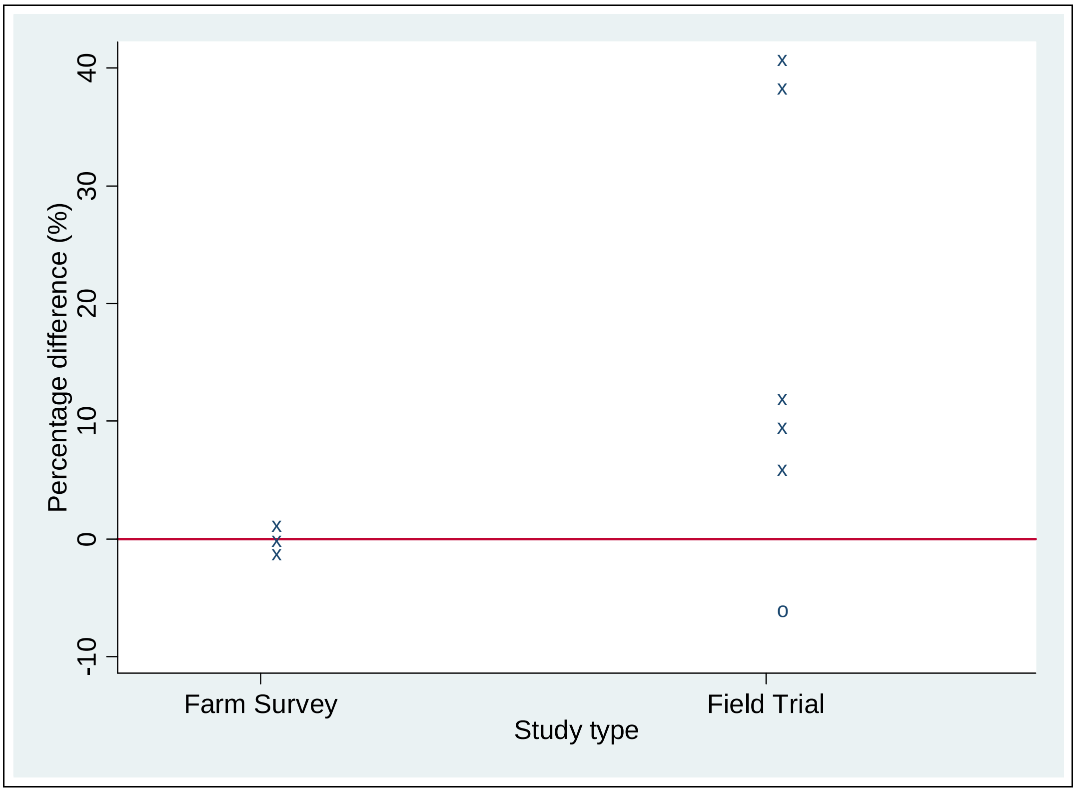
Foods analysed Cow’s milk, chicken egg, chicken breast, chicken drumstick, beef longissimus dorsi, pork longissimus dorsi

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	3	2	0	0	**5**
Satisfactory quality studies	2	2	0	0	**4**
Number of nutrient comparisons reported	6	3	0	0	**9**
Number of nutrient comparisons reported from satisfactory quality studies	5	3	0	0	**8**

Results

Dot plot showing distribution of percentage differences in ash content by study type



x indicates nutrient comparisons from satisfactory quality studies

Statistical analysis of difference in ash content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	9	11.5 (se: 7.6)	0.21
All satisfactory quality nutrient comparisons	8	13.7 (se: 7.8)	0.18

Overall Analysis

Analysis suggests that there is no difference in ash content between organically and conventionally produced livestock products (p=0.21 for all comparisons; p=0.18 for comparisons from satisfactory quality studies).

FATS (UNSPECIFIED)

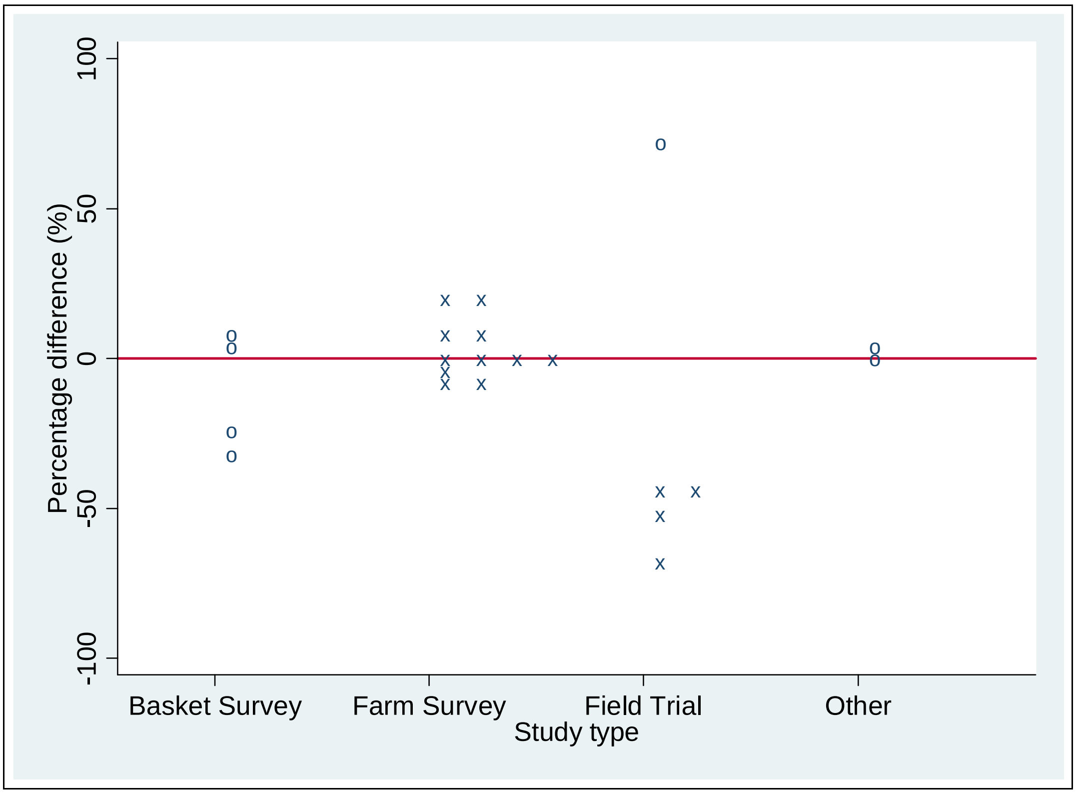
Reported as	Total fat, fat, total lipids, lipids
Reported methods of analysis	Gas chromatography, capillary gas chromatography, gas-liquid chromatography, automated, integrated microwave system, chloroform/methanol procedure, gravimetrically
Reported units of analysis	%, % of egg, weight %, g $100g^{-1}$, g kg^{-1}
Foods analysed	Cow's milk, beef longissimus dorsi, sausages, chicken breast, chicken leg, chicken drumstick, chicken egg, buffalo milk, buffalo mozzarella

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	2	5	4	1	**12**
Satisfactory quality studies	1	5	0	0	**6**
Number of nutrient comparisons reported	5	9	4	2	**20**
Number of nutrient comparisons reported from satisfactory quality studies	4	9	0	0	**13**

Results

Dot plot showing distribution of percentage differences in fats (unspecified) content by study type



x indicates nutrient comparisons from satisfactory quality studies

Statistical analysis of difference in fats (unspecified) content between organic and conventionally produced foods

	Number of comparisons	**Mean percentage difference**	**p-value**
All nutrient comparisons	20	-7.1 (se: 10.8)	0.53
All satisfactory quality nutrient comparisons	13	-13.0 (se: 14.6)	0.42

Overall Analysis

Analysis suggests that there is no difference in fats (unspecified) content between organically and conventionally produced livestock products (p=0.53 for all comparisons; p=0.42 for comparisons from satisfactory quality studies).

FATTY ACIDS (UNSPECIFIED)

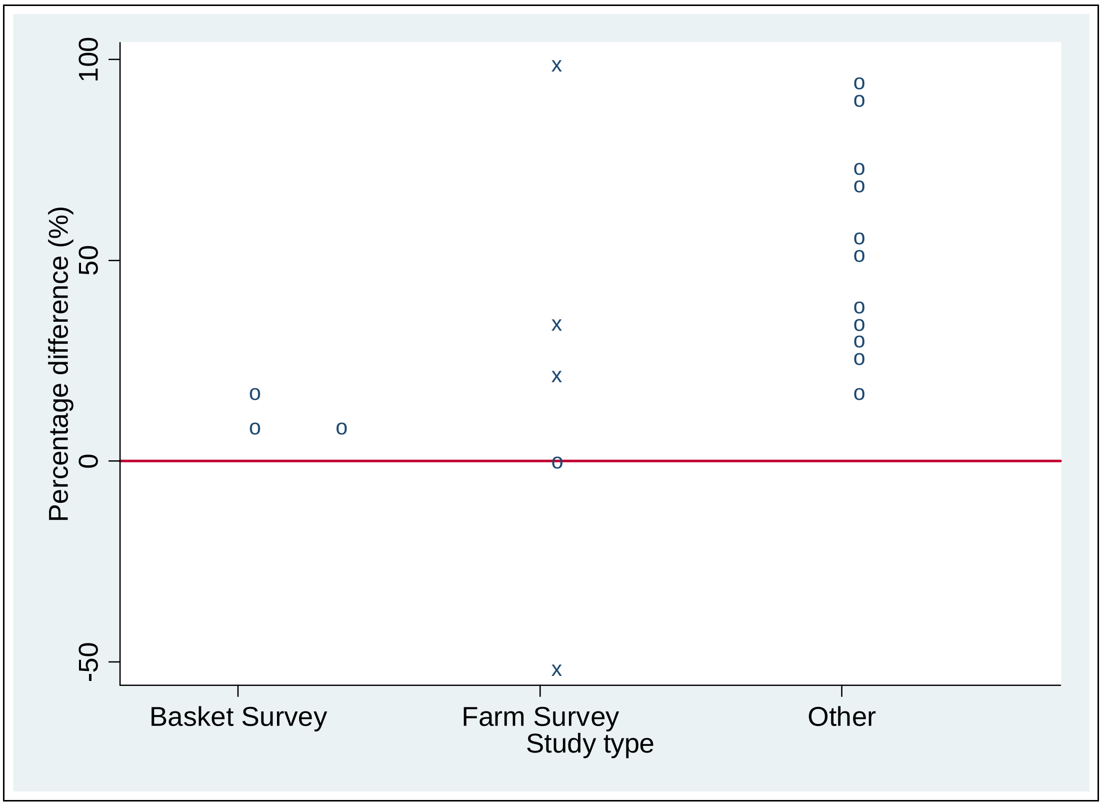
Reported as	Total fatty acids, branched fatty acids, linolenic acid, other fatty acids, C18:3
Reported methods of analysis	Gas chromatography, gas-liquid chromatography
Reported units of analysis	% milk fat, weight % of fat, mg g^{-1} fat, mg $100g^{-1}$
Foods analysed	Cow's milk, cow's UHT milk, buffalo milk, buffalo mozzarella, cow butter, cow crescenza, cow parmigiano cheese, cow ricotta, chicken egg, lamb loin chops

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	0	2	2	1	**5**
Satisfactory quality studies	0	1	0	0	**1**
Number of nutrient comparisons reported	0	5	3	11	**19**
Number of nutrient comparisons reported from satisfactory quality studies	0	4	0	0	**4**

Results

Dot plot showing distribution of percentage differences in fatty acids (unspecified) content by study type



x indicates nutrient comparisons from satisfactory quality studies

Statistical analysis of difference in fatty acids (unspecified) content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	19	37.8 (se: 11.0)	0.03
All satisfactory quality nutrient comparisons	4	26.6 (se: 30.7)	All from same study

Overall Analysis

Analysis suggests that there is significantly greater fatty acids (unspecified) content in organically than in conventionally produced livestock products (p=0.03 for all comparisons). Data from satisfactory quality studies could not be analysed as all nutrient comparisons were reported in the same study.

MONOUNSATURATED FATTY ACIDS (CIS)

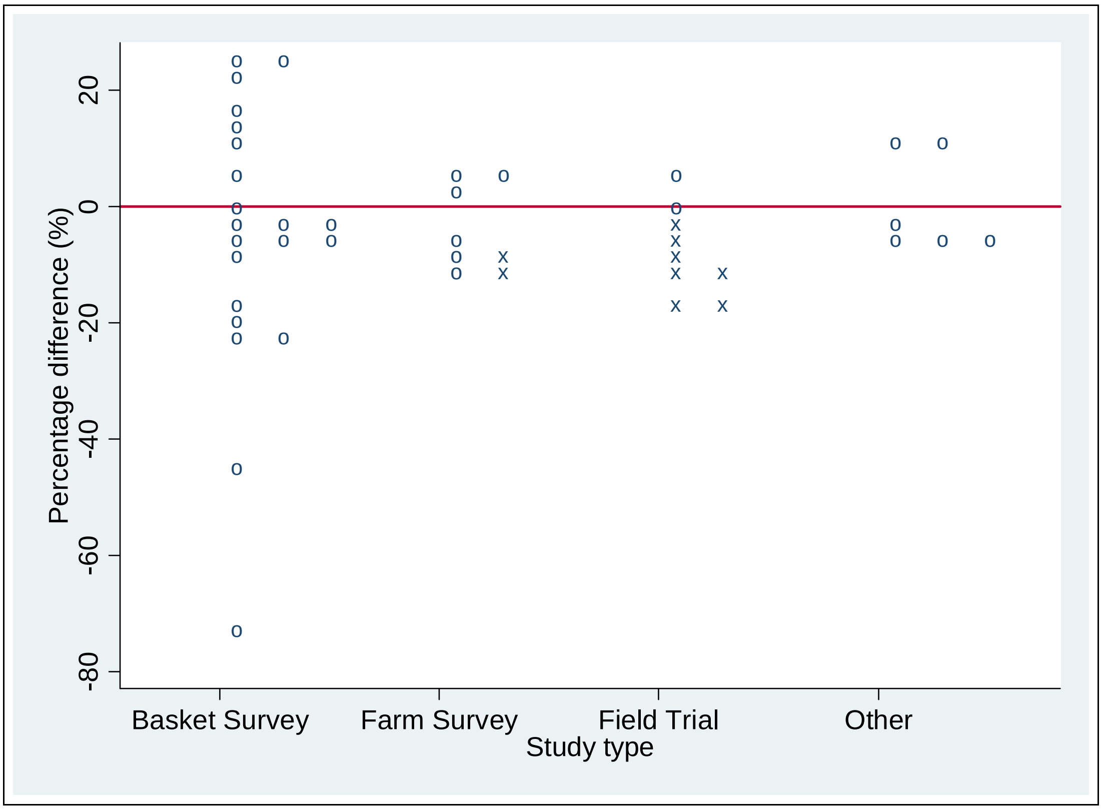
Reported as	Monounsaturated fatty acids, C14:1, C14:1 (n-5), C16:1, C16:1 cis, C16:1 (n-7), C16:1 (n-9), C17:1 (n-8), C18:1, C18:1 cis-9, C18:1 cis-11, C18:1 (n-3), C18:1 (n-7), C18:1 (n-9), C20:1
Reported methods of analysis	Gas chromatography, gas-liquid chromatography, capillary gas chromatography, flame ionisation detector
Reported units of analysis	%, % milk fat, % of fatty acid, % of TFA, Weight % of fat, mg g^{-1} fat, g $100g^{-1}$ fat, mg $100g^{-1}$
Foods analysed	Cow's milk, beef longissimus dorsi, lamb loin chop, chicken egg, chicken breast, chicken drumstick, buffalo milk, buffalo mozzarella, pork backfat

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	3	4	5	1	**13**
Satisfactory quality studies	2	1	0	0	**3**
Number of nutrient comparisons reported	9	8	21	4	**42**
Number of nutrient comparisons reported from satisfactory quality studies	7	2	0	0	**9**

Results

Dot plot showing distribution of percentage differences in monounsaturated fatty acids (cis) content by study type



x indicates nutrient comparisons from satisfactory quality studies

Statistical analysis of difference in monounsaturated fatty acids (cis) content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	42	-4.7 (se: 3.2)	0.17
All satisfactory quality nutrient comparisons	9	-10.1 (se: 2.6)	0.06

Overall Analysis

Analysis suggests that there is no difference in monounsaturated fatty acids (cis) content between organically and conventionally produced livestock products (p=0.17 for all comparisons; p=0.06 for comparisons from satisfactory quality studies).

n-3 POLYUNSATURATED FATTY ACIDS

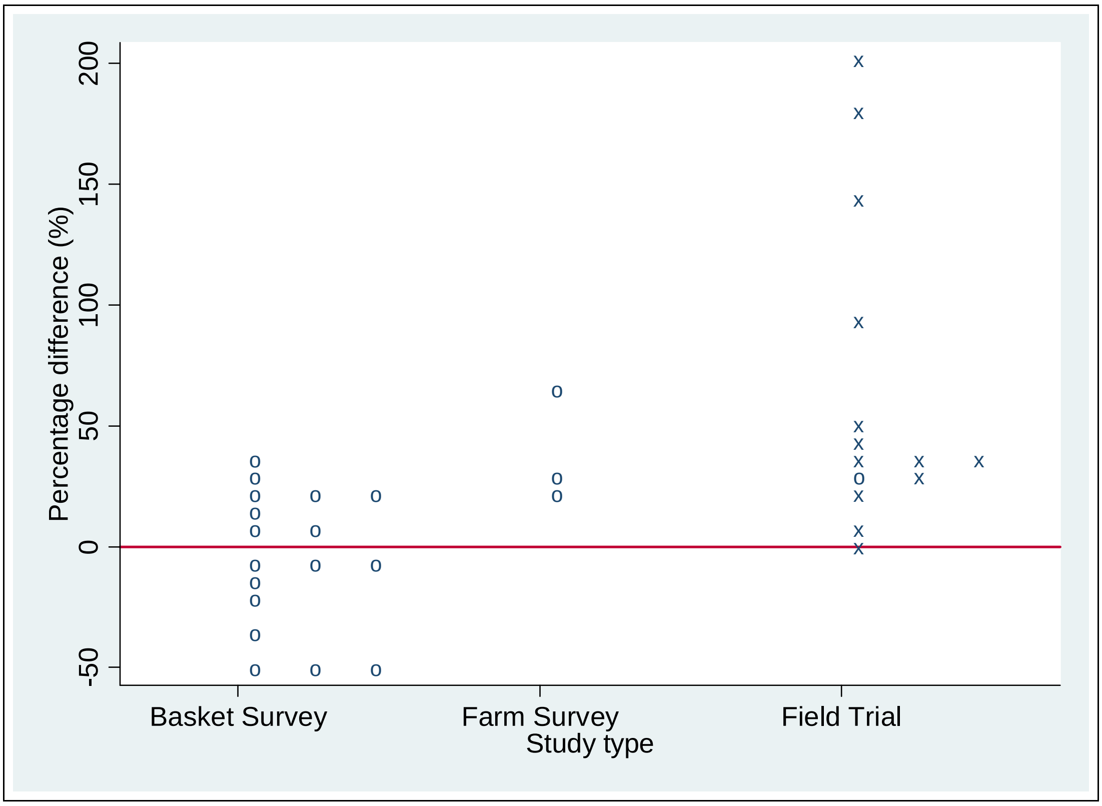
Reported as	n-3 fatty acids, n-3 fatty acids (EPA), n-3 fatty acids (DHA), C18:3 (n-3), C20:5 (n-3), C22:5 (n-3), C22:6 (n-3)
Reported methods of analysis	Gas chromatography, capillary gas chromatography, gas-liquid chromatography, flame ionisation detector
Reported units of analysis	%, % of fatty acid, % of TFA, mg g^{-1} fat, g $100g^{-1}$ fat, g kg^{-1} milk fat, mg $100g^{-1}$
Foods analysed	Cow's milk, beef longissimus dorsi, chicken egg, chicken breast, chicken drumstick, pork backfat, lamb loin chops

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	3	2	4	0	**9**
Satisfactory quality studies	2	0	0	0	**2**
Number of nutrient comparisons reported	14	3	17	0	**34**
Number of nutrient comparisons reported from satisfactory quality studies	13	0	0	0	**13**

Results

Dot plot showing distribution of percentage differences in n-3 polyunsaturated fatty acids content by study type



x indicates nutrient comparisons from satisfactory quality studies

Statistical analysis of difference in n-3 polyunsaturated fatty acids content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	34	27.8 (se: 19.9)	0.20
All satisfactory quality nutrient comparisons	13	67.3 (se: 10.4)	0.10

Overall Analysis

Analysis suggests that there is no difference in n-3 polyunsaturated fatty acids content between organically and conventionally produced foods (p=0.20 for all comparisons; p=0.10 for comparisons from satisfactory quality studies).

n-6 POLYUNSATURATED FATTY ACIDS

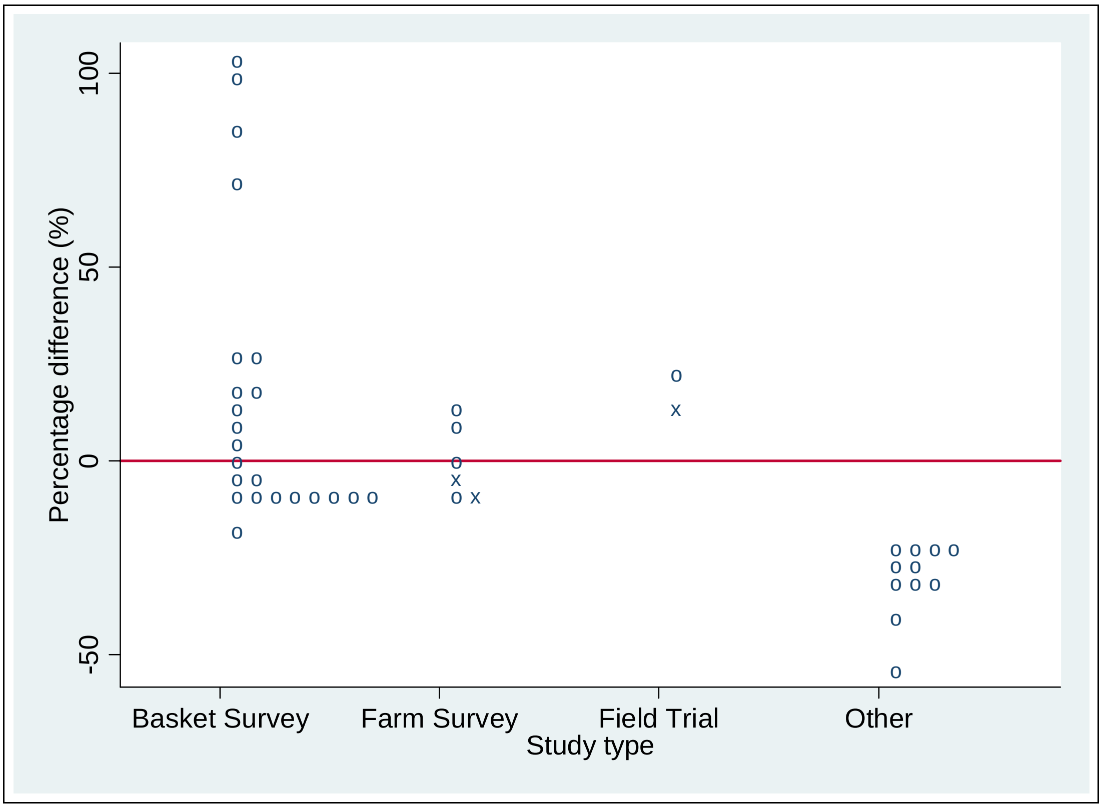
Reported as	n-6 fatty acids, C18:2, C18:2 (n-6), C18:3 (n-6), C20:2 (n-6), C20:3 (n-6), C20:4 (n-6), C22:4 (n-6), C22:5 (n-6), Linoleic acid
Reported methods of analysis	Gas chromatography, capillary gas chromatography, gas-liquid chromatography, flame ionisation detector
Reported units of analysis	%, % milk fat, % of fatty acid, % of TFA, Weight % of fat, mg g^{-1} fat, g $100g^{-1}$ fat, mg $100g^{-1}$
Foods analysed	Cow's milk, cow's UHT milk, buffalo milk, buffalo mozzarella, cow butter, cow crescenza, cow parmigiano, cow ricotta, beef longissimus dorsi, chicken egg, chicken breast, pork backfat, lamb loin chops

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	2	4	5	1	**12**
Satisfactory quality studies	1	1	0	0	**2**
Number of nutrient comparisons reported	2	6	23	11	**42**
Number of nutrient comparisons reported from satisfactory quality studies	1	2	0	0	**3**

Results

Dot plot showing distribution of percentage differences in n-6 polyunsaturated fatty acids content by study type



x indicates nutrient comparisons from satisfactory quality studies

One extreme value (442%) excluded

Statistical analysis of difference in n-6 polyunsaturated fatty acids content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	42	2.1 (se: 11.6)	0.86
All satisfactory quality nutrient comparisons	3	0.2 (se: 9.8)	0.99

Overall Analysis

Analysis suggests that there is no difference in n-6 polyunsaturated fatty acids content between organically and conventionally produced livestock products (p=0.86 for all comparisons; p=0.99 for comparisons from satisfactory quality studies).

NITROGEN

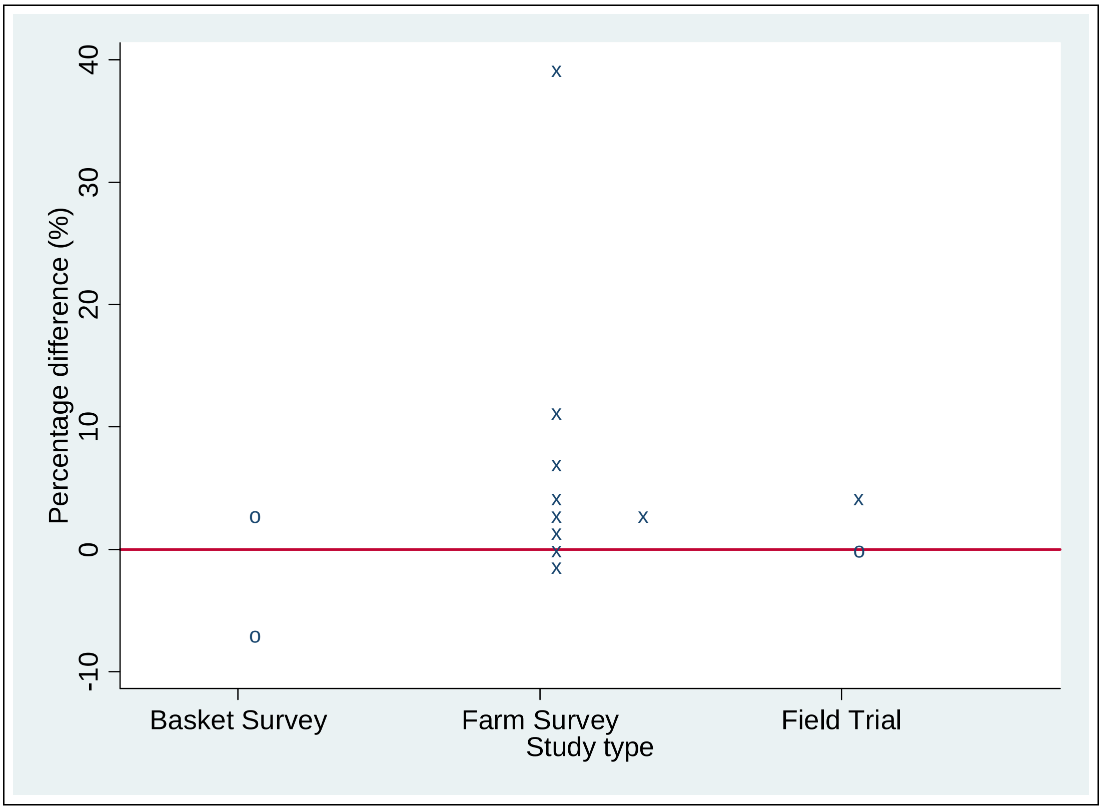
Reported as	Protein, crude protein, casein nitrogen, non-protein nitrogen, whey protein
Reported methods of analysis	Kjeldahl method, IDF Standard (no29), difference: total protein & casein + non-protein nitrogen
Reported units of analysis	%, % of egg, % weight g $100g^{-1}$
Foods analysed	Cow's milk, beef longissimus dorsi, pork longissimus dorsi, chicken eggs

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	2	2	2	0	**6**
Satisfactory quality studies	1	2	0	0	**3**
Number of nutrient comparisons reported	2	9	2	0	**13**
Number of nutrient comparisons reported from satisfactory quality studies	1	9	0	0	**10**

Results

Dot plot showing distribution of percentage differences in nitrogen content by study type



x indicates nutrient comparisons from satisfactory quality studies

Statistical analysis of difference in nitrogen content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	13	5.2 (se: 2.4)	0.08
All satisfactory quality nutrient comparisons	10	7.2 (se: 1.2)	0.03

Overall Analysis

Analysis suggests that there is no difference in nitrogen content between organically and conventionally produced livestock products (p=0.08 for all comparisons). Comparisons from satisfactory quality studies found a significantly greater nitrogen content in organically than in conventionally produced livestock products (p=0.03).

POLYUNSATURATED FATTY ACIDS

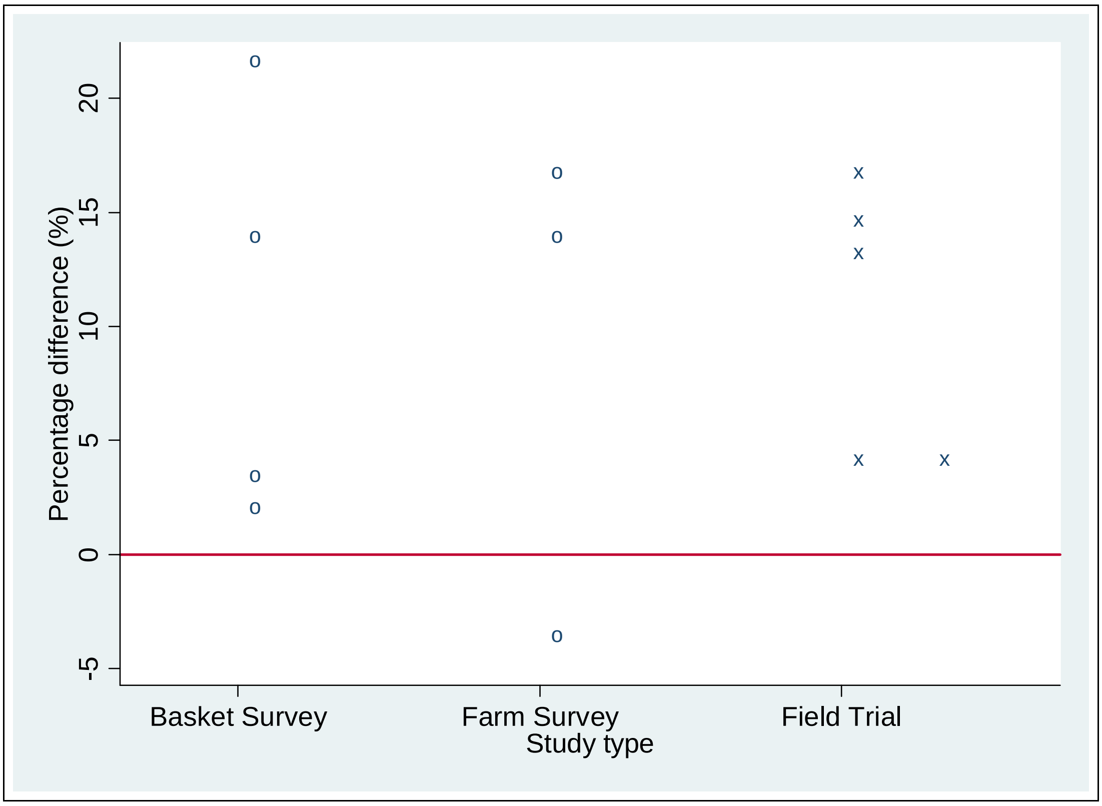
Reported as	Polyunsaturated fatty acids
Reported methods of analysis	Gas chromatography, capillary gas chromatography, gas-liquid chromatography, flame ionisation detector
Reported units of analysis	%, % of fatty acid, % of TFA, mg g^{-1} fat, g kg^{-1} milk fat, mg $100g^{-1}$
Foods analysed	Cow's milk, chicken egg, chicken breast, chicken drumstick, pork backfat, lamb loin chops

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	2	2	4	0	**8**
Satisfactory quality studies	2	0	0	0	**2**
Number of nutrient comparisons reported	5	3	4	0	**12**
Number of nutrient comparisons reported from satisfactory quality studies	5	0	0	0	**5**

Results

Dot plot showing distribution of percentage differences in polyunsaturated fatty acids content by study type



x indicates nutrient comparisons from satisfactory quality studies

Statistical analysis of difference in polyunsaturated fatty acids content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	12	10.0 (se: 1.8)	0.001
All satisfactory quality nutrient comparisons	5	10.5 (se: 1.1)	0.07

Overall Analysis

Analysis suggests that there is a significantly greater polyunsaturated fatty acid content in organically than in conventionally produced livestock products (p=0.001 for all comparisons). Analysis of data from satisfactory quality studies suggests that there is no difference in polyunsaturated fatty acid content between organically and conventionally produced livestock products (p=0.07).

SATURATED FATTY ACIDS

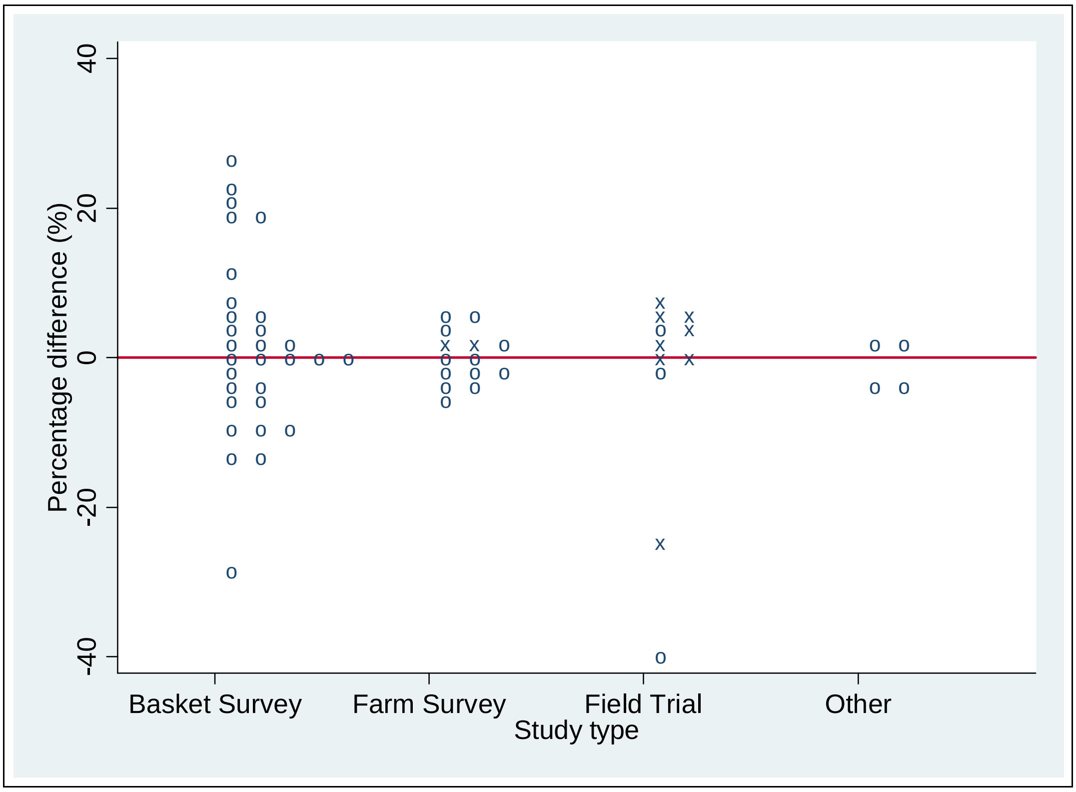
Reported as	Saturated fatty acids, C4:0, C6:0, C8:0, C10:0, C12:0, C14:0, C15:0, C16:0, C17:0, C18:0, C20:0, C22:0
Reported methods of analysis	Gas chromatography, capillary gas chromatography, gas-liquid chromatography, flame ionisation detector
Reported units of analysis	%, % milk fat, % of TFA, weight % of fat, % of fatty acid, mg $100g^{-1}$, mg/g fat, g $100g^{-1}$ fat
Foods analysed	Cow's milk, beef longissimus dorsi, lamb loin chops, chicken eggs, chicken breast, chicken drumstick, pork backfat, buffalo milk, buffalo mozzarella

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	3	4	5	1	**13**
Satisfactory quality studies	2	1	0	0	**3**
Number of nutrient comparisons reported	11	14	30	6	**61**
Number of nutrient comparisons reported from satisfactory quality studies	8	2	0	0	**10**

Results

Dot plot showing distribution of percentage differences in saturated fatty acids content by study type



x indicates nutrient comparisons from satisfactory quality studies

Statistical analysis of difference in saturated fatty acids content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	61	0.1 (se: 1.4)	0.98
All satisfactory quality nutrient comparisons	10	0.2 (se: 4.2)	0.97

Overall Analysis

Analysis suggests that there is no difference in saturated fatty acids content between organically and conventionally produced livestock products (p=0.98 for all comparisons; p=0.97 for comparisons from satisfactory quality studies).

TRANS FATTY ACIDS

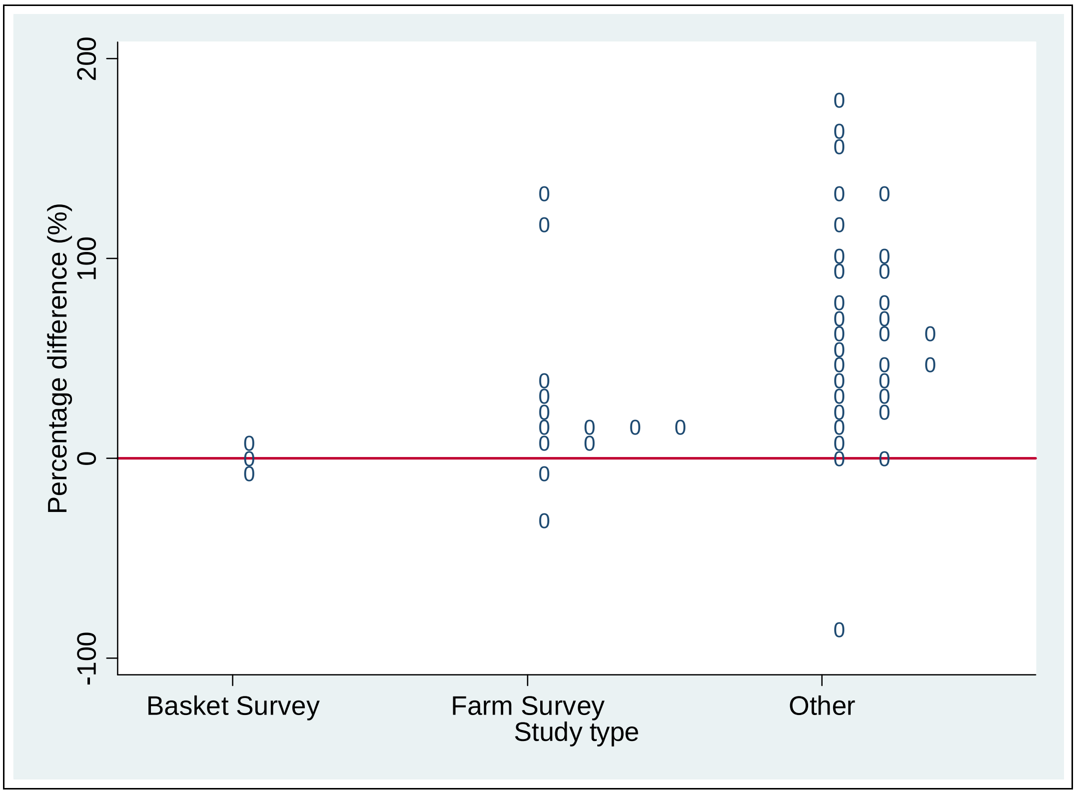
Reported as	Conjugated linoleic acid, TVA, CLA/LA, Myristelaidic acid (C14:1 t9), C16:1 t7, C16:1 t9, C18:1 trans, Elaidic acid (C18:1 t9), C18:1n-9trans C18:1 t11, C18:1 c14+t16, C18:1 c16, C18:2 cis 9, trans-11, C18:2 c9, t11 + C18:2 t9, c11, C18:2 t9, 12 + C18:2 t9, c12, C18:2 c9, t12
Reported methods of analysis	Gas chromatography, gas-liquid chromatography, flame ionisation detector
Reported units of analysis	%, % TFA, % total methyl esters, % fatty acids, mg g^{-1} fat, g kg^{-1} milk fat, mg $100g^{-1}$
Foods analysed	Cow's milk, cow's UHT milk, cow butter, cow crescenza, cow fontina, cow mozzarella, cow parmigiano, cow ricotta, buffalo milk, buffalo mozzarella, chicken egg, lamb loin chops

Studies included in the review

	Field trials	Farm surveys	Basket surveys	Other	Total
Number of studies	0	3	2	1	**6**
Satisfactory quality studies	0	0	0	0	**0**
Number of nutrient comparisons reported	0	13	3	32	**48**
Number of nutrient comparisons reported from satisfactory quality studies	0	0	0	0	**0**

Results

Dot plot showing distribution of percentage differences in trans fatty acids content by study type



x indicates nutrient comparisons from satisfactory quality studies

Two extreme values (400%, 5800%) excluded

Statistical analysis of difference in trans fatty acids content between organic and conventionally produced foods

	Number of comparisons	Mean percentage difference	p-value
All nutrient comparisons	48	52.0 (se: 10.9)	0.005
All satisfactory quality nutrient comparisons	0	N/A	N/A

Overall Analysis

Analysis suggests that there is a significantly greater trans fatty acids content in organically than in conventionally produced livestock products (p=0.005 for all comparisons). No data are available from satisfactory quality studies.

Appendix 14: Included and Excluded Nutrient Comparisons from Crops Studies

Nutrient	Comparisons included in analysis†	Comparisons excluded from analysis†	
		Insufficient or graphical data	Outliers
Ash	(Shier 1984; Cayuela 1997; Haglund 1998; Petr 1998; Strobel 2001; Forster 2002; Lombardi-Boccia 2004; Igbokwe 2005; Stertz 2005b; Carcea 2006; Petr 2006; Rodríguez 2006; Acharya 2007; Dani 2007; Mäder 2007; Hernández Suárez 2008b)	(Rodríguez 2006)	NA
β-carotene	(Leclerc 1991; Hogstad 1997; Warman 1997; Danilchenko 2002; Caris-Veyrat 2004; Lombardi-Boccia 2004; Borguini 2007; Hallmann 2007b; Pérez-López 2007b; Hallmann 2007c; Koh 2008)	(Ismail 2003)	(Hallmann 2007b)
Calcium	(Clarke 1979; Leclerc 1991; DeEll 1993; Mäder 1993; Cayuela 1997; Warman 1997; Warman 1998; Benge 2000; Gundersen 2000; Nakagawa 2000; Nyanjage 2001; Strobel 2001; Danilchenko 2002; Hakala 2003; Lombardi-Boccia 2004; Ryan 2004; Igbokwe 2005; Stertz 2005; Wszelaki 2005; Peck 2006; Acharya 2007; Amodio 2007; Borguini 2007; Hernández Suárez 2007; Lester 2007; Mäder 2007; Seidler-Lożykowska 2007; Pérez-López 2007b; Pérez-López 2007c)	(Smith 1993; Colla 2002)	(Warman 1998)
Copper	(Chang 1977; Leclerc 1991; Warman 1996; Cayuela 1997; Warman 1997; Warman 1998; Gundersen 2000; Nakagawa 2000; Danilchenko 2002; Hakala 2003; Lombardi-Boccia 2004; Ryan 2004; Hajslova 2005; Wszelaki 2005; Borguini 2007; Hernández Suárez 2007; Lester 2007; Mäder 2007; Seidler-Lożykowska 2007; Pérez-López 2007b; Pérez-López 2007c)	(Smith 1993; Warman 1997)	NA

Nutrient	Comparisons included in analysis†	Comparisons excluded from analysis†	
		Insufficient or graphical data	Outliers
Dry matter	(Leclerc 1991; Cayuela 1997; Hogstad 1997; Rembialkowska 1998; Rembialkowska 1999; Nyanjage 2001; Danilchenko 2002; Caris-Veyrat 2004; Hamouz 2005; Igbokwe 2005; Stertz 2005; Hallmann 2006; Hallmann 2007a; Hallmann 2007b; Hallmann 2007c)	(Meyer 2008)	NA
Flavonoids	(Häkkinen 2000; Mikkonen 2001; Ren 2001; Miceli 2003; Verde Méndez 2003; Caris-Veyrat 2004; Lombardi-Boccia 2004; Young 2005; Anttonen 2006; Chassy 2006; Hallmann 2006; Olsson 2006; Briviba 2007; Dani 2007; Keukeleire 2007; Mitchell 2007; Hallmann 2007a; Hallmann 2007b; Hallmann 2007c; Koh 2008)	(Ren 2001; Young 2005; Hallmann 2006; Vian 2006; Hallmann 2007b)	(Ren 2001; Dani 2007)
Iron	(Chang 1977; Clarke 1979; Leclerc 1991; Cayuela 1997; Warman 1997; Warman 1998; Gundersen 2000; Danilchenko 2002; Hakala 2003; Lombardi-Boccia 2004; Ryan 2004; Hajslova 2005; Stertz 2005; Wszelaki 2005; Borguini 2007; Hernández Suárez 2007; Lester 2007; Seidler-Lożykowska 2007; Pérez-López 2007b; Pérez-López 2007c)	(Smith 1993)	NA
Magnesium	(Clarke 1979; Leclerc 1991; DeEll 1993; Mäder 1993; Warman 1996; Cayuela 1997; Warman 1997; Warman 1998; Benge 2000; Gundersen 2000; Nakagawa 2000; Nyanjage 2001; Danilchenko 2002; Hakala 2003; Lombardi-Boccia 2004; Ryan 2004; Hajslova 2005; Igbokwe 2005; Stertz 2005; Wszelaki 2005; Peck 2006; Acharya 2007; Amodio 2007; Garnweidner 2007; Hernández Suárez 2007; Lester 2007; Mäder 2007; Seidler-Lożykowska 2007; Pérez-López 2007b; Pérez-López 2007c)	(Smith 1993; Colla 2002)	NA

Nutrient	Comparisons included in analysis†	Comparisons excluded from analysis†	
		Insufficient or graphical data	Outliers
Manganese	(Leclerc 1991; Warman 1996; Cayuela 1997; Warman 1997; Warman 1998; Gundersen 2000; Nakagawa 2000; Danilchenko 2002; Hakala 2003; Lombardi-Boccia 2004; Ryan 2004; Stertz 2005; Wszelaki 2005; Hernández Suárez 2007; Lester 2007; Mäder 2007; Seidler-Lożykowska 2007; Pérez-López 2007b; Pérez-López 2007c)	(Smith 1993)	NA
Nitrates	(Stopes 1988; Leclerc 1991; Basker 1992; Leszczynska 1996; Pérez-Llamas 1996; Varis 1996; Hogstad 1997; Wawrzyniak 1997; Rembialkowska 1998; Rembialkowska 1999; Hamouz 1999a; Rutkowska 2001; De Martin 2003; Guadagnin 2005; Hajslova 2005; Hamouz 2005; Stertz 2005; Lester 2007; Seidler-Lożykowska 2007)	(Stopes 1988; Basker 1992; Mäder 1993; Malmauret 2002; Guadagnin 2005)	(Stopes 1988; De Martin 2003)
Nitrogen	(Clarke 1979; Lockeretz 1980; Wolfson 1981; Shier 1984; Leclerc 1991; Basker 1992; DeEll 1993; Nguyen 1995; Pérez-Llamas 1996; Warman 1996; Hogstad 1997; Warman 1997; Wawrzyniak 1997; Haglund 1998; Petr 1998; Wang 1998; Warman 1998; Benge 2000; Nakagawa 2000; Petr 2000; Nyanjage 2001; Danilchenko 2002; Forster 2002; Hanell 2004; L-Baeckström 2004; Lombardi-Boccia 2004; Ryan 2004; Igbokwe 2005; Stertz 2005; Carcea 2006; Krejčířová 2006; L-Baeckström 2006; Peck 2006; Petr 2006; Amodio 2007; Dani 2007; Krejčířová 2007; Lester 2007; Mäder 2007; Seidler-Lożykowska 2007; Krejčířová 2008; Hernández Suárez 2008b)	(Basker 1992; Colla 2002; Langenkämper 2006)	NA

Nutrient	Comparisons included in analysis†	Comparisons excluded from analysis†	
		Insufficient or graphical data	Outliers
Phenolic compounds	(Hamouz 1997; Gutiérrez 1999; Hamouz 1999b; Häkkinen 2000; Carbonaro 2001; Ren 2001; Carbonaro 2002; Asami 2003; Miceli 2003; Verde Méndez 2003; Akcay 2004; Caris-Veyrat 2004; Lombardi-Boccia 2004; Perretti 2004; Dimberg 2005; Ferreres 2005; Hajslova 2005; Hamouz 2005; Robbins 2005; Sousa 2005; Young 2005; Anttonen 2006; Chassy 2006; Olsson 2006; Otreba 2006; Rodríguez 2006; Amodio 2007; Barrett 2007; Briviba 2007; Garnweidner 2007; Lester 2007; Perez-Lopez 2007a; Hallmann 2007b; Pérez-López 2007b; Ninfali 2008)	(Hamouz 1999b; Baxter 2001; Ren 2001; Carbonaro 2002; Asami 2003; Yildirim 2004; Langenkämper 2006; Rodríguez 2006; del Amor 2008)	NA
Phosphorus	(Clarke 1979; Leclerc 1991; Basker 1992; DeEll 1993; Mäder 1993; Nguyen 1995; Warman 1996; Warman 1997; Warman 1998; Benge 2000; Gundersen 2000; Nakagawa 2000; Nyanjage 2001; Strobel 2001; Danilchenko 2002; Lombardi-Boccia 2004; Ryan 2004; Igbokwe 2005; Stertz 2005; Wszelaki 2005; Peck 2006; Amodio 2007; Borguini 2007; Hernández Suárez 2007; Lester 2007; Mäder 2007; Seidler-Ložykowska 2007)	(Basker 1992; Smith 1993; Colla 2002)	
Plant non digestible carbohydrates	(Pérez-Llamas 1996; Haglund 1998; Strobel 2001; Danilchenko 2002; Forster 2002; Lombardi-Boccia 2004; Igbokwe 2005; Stertz 2005; Acharya 2007; Dani 2007; Hernández Suárez 2008b)	(Langenkämper 2006)	(Dani 2007)

Nutrient	Comparisons included in analysis†	Comparisons excluded from analysis†	
		Insufficient or graphical data	Outliers
Potassium	(Leclerc 1991; Basker 1992; DeEll 1993; Mäder 1993; Warman 1997; Warman 1998; Benge 2000; Gundersen 2000; Nakagawa 2000; Nyanjage 2001; Danilchenko 2002; Hakala 2003; Lombardi-Boccia 2004; Ryan 2004; Igbokwe 2005; Wszelaki 2005; Stertz 2005b; Peck 2006; Acharya 2007; Amodio 2007; Borguini 2007; Hernández Suárez 2007; Lester 2007; Mäder 2007; Seidler-Lożykowska 2007; Pérez-López 2007b; Pérez-López 2007c)	(Basker 1992; Smith 1993; Colla 2002)	NA
Sodium	(Clarke 1979; Warman 1996; Warman 1997; Warman 1998; Gundersen 2000; Lombardi-Boccia 2004; Stertz 2005; Acharya 2007; Hernández Suárez 2007; Lester 2007; Seidler-Lożykowska 2007; Pérez-López 2007c)	(Smith 1993; Warman 1998; Colla 2002)	NA
Specific proteins	(Eltun 1996; Petr 1998; Petr 2000; Strobel 2001; L-Baeckström 2004; Dimberg 2005; Bicanová 2006; Krejčířová 2006; Lanzanova 2006; Petr 2006; Annett 2007; Krejčířová 2007; Krejčířová 2008)	(Starling 1990; Starling 1993; Krejčířová 2007)	NA
Sugars	(Basker 1992; Varis 1996; Hogstad 1997; Wang 1998; Nakagawa 2000; Strobel 2001; Forster 2002; Lombardi-Boccia 2004; Saastamoinen 2004; Hamouz 2005; Stertz 2005; Hallmann 2006; Petr 2006; Acharya 2007; Amodio 2007; Lester 2007; Hallmann 2007b; Hallmann 2007c; Hernández Suárez 2008b)	(Mäder 1993; Saastamoinen 2004; Langenkämper 2006)	(Hallmann 2006; Hallmann 2007b)
Sulphur	(Nguyen 1995; Warman 1996; Warman 1997; Warman 1998; Gundersen 2000; Ryan 2004; Igbokwe 2005; Wszelaki 2005; Amodio 2007; Borguini 2007)	(Smith 1993)	(Warman 1998)

Nutrient	Comparisons included in analysis†	Comparisons excluded from analysis†	
		Insufficient or graphical data	Outliers
Titratable acidity	(DeEll 1992; Alvarez 1993; Cayuela 1997; Hogstad 1997; Matallana González 1998; Gutiérrez 1999; Moreira 2003; Perretti 2004; Borguini 2005; Anttonen 2006; Peck 2006; Rodríguez 2006; Barrett 2007; Fischer 2007; Lester 2007; Macit 2007; Hallmann 2007b; Hallmann 2007c; Pérez-López 2007c; Ninfali 2008; Hernández Suárez 2008a)	(Basker 1992)	(Perretti 2004)
Total soluble solids	(Basker 1992; DeEll 1992; Alvarez 1993; Cayuela 1997; Hasey 1997; Matallana González 1998; Benge 2000; Colla 2000; Nyanjage 2001; Danilchenko 2002; Borguini 2005; Anttonen 2006; Chassy 2006; Peck 2006; Rodríguez 2006; Amodio 2007; Barrett 2007; Fischer 2007; Lester 2007; Macit 2007; Pérez-López 2007c; Hernández Suárez 2008b)	(Caussiol 2004; Rodríguez 2006)	(DeEll 1992)
Vitamin C	(Clarke 1979; Leclerc 1991; Varis 1996; Cayuela 1997; Warman 1997; Matallana González 1998; Rembialkowska 1998; Warman 1998; Rembialkowska 1999; Hamouz 1999b; Danilchenko 2002; Forster 2002; Asami 2003; Hakala 2003; Ismail 2003; Moreira 2003; Caris-Veyrat 2004; Lombardi-Boccia 2004; Hajslova 2005; Sousa 2005; Chassy 2006; Hallmann 2006; Olsson 2006; Rodríguez 2006; Acharya 2007; Amodio 2007; Barrett 2007; Borguini 2007; Dani 2007; Hernández Suárez 2007; Lester 2007; Hallmann 2007a; Hallmann 2007b; Pérez-López 2007b; Hallmann 2007c; Pérez-López 2007c; Koh 2008)	(Mäder 1993; Warman 1997; Warman 1998; Carbonaro 2002; Asami 2003; Ismail 2003; Sousa 2005; Daood 2006; Hallmann 2006; Rodríguez 2006; Hallmann 2007b; Wunderlich 2008)	

Nutrient	Comparisons included in analysis[†]	Comparisons excluded from analysis[†]	
		Insufficient or graphical data	Outliers
Zinc	(Chang 1977; Clarke 1979; Leclerc 1991; Warman 1996; Cayuela 1997; Warman 1997; Procida 1998; Warman 1998; Gundersen 2000; Jorhem 2000; Nakagawa 2000; Danilchenko 2002; Hakala 2003; Lombardi-Boccia 2004; Ryan 2004; Hajslova 2005; Stertz 2005; Wszelaki 2005; Peck 2006; Lester 2007; Mäder 2007; Seidler-Lożykowska 2007; Pérez-López 2007b; Pérez-López 2007c; Hernández Suárez 2008b)	(Smith 1993; Procida 1998)	(Warman 1998)

[†] Studies with multiple comparisons per nutrient may be duplicated in this table, as not all reported comparisons met the criteria for inclusion.

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Appendix 15: Included and Excluded Nutrient Comparison from Livestock Product Studies

Nutrient	Comparisons included in analysis[†]	Comparisons omitted from analysis[†]	
		Insufficient or graphical data	Outliers
Ash	(Lund 1991; Castellini 2002; Olsson 2003; Walshe 2006; Minelli 2007)	(Arnold 1984)	NA
Fats (unspecified)	(Arnold 1984; Lund 1991; Castellini 2002; Toledo 2002; Bergamo 2003; Ristic 2003; Jahan 2004; Ludewig 2004; Walshe 2006; Minelli 2007; Ristic 2007; Hidalgo 2008)	NA	NA
Fatty acids (unspecified)	(Arnold 1984; Knöppler 1986; Lund 1991; Bergamo 2003; Angood 2008)	NA	NA
Monounsaturated fatty acids (cis)	(Arnold 1984; Knöppler 1986; Lund 1991; Castellini 2002; Bergamo 2003; Jahan 2004; Ellis 2006; Hansen 2006; Walshe 2006; Jahan 2007; Lavrencic 2007; Angood 2008; Hidalgo 2008)	NA	NA
n-3 polyunsaturated fatty acids	(Castellini 2002; Jahan 2004; Ellis 2006; Hansen 2006; Walshe 2006; Jahan 2007; Lavrencic 2007; Angood 2008; Hidalgo 2008)	NA	NA
n-6 polyunsaturated fatty acids	(Arnold 1984; Knöppler 1986; Lund 1991; Bergamo 2003; Jahan 2004; Ellis 2006; Hansen 2006; Walshe 2006; Jahan 2007; Lavrencic 2007; Angood 2008; Hidalgo 2008)	NA	(Jahan 2004)
Nitrogen	(Arnold 1984; Lund 1991; Olsson 2003; Walshe 2006; Minelli 2007; Hidalgo 2008)	NA	NA

Nutrient	Comparisons included in analysis[†]	Comparisons omitted from analysis[†]	
		Insufficient or graphical data	Outliers
Polyunsaturated fatty acids	(Castellini 2002; Jahan 2004; Ellis 2006; Hansen 2006; Jahan 2007; Lavrencic 2007; Angood 2008; Hidalgo 2008)	NA	NA
Saturated fatty acids	(Arnold 1984; Knöppler 1986; Lund 1991; Castellini 2002; Bergamo 2003; Jahan 2004; Ellis 2006; Hansen 2006; Walshe 2006; Jahan 2007; Lavrencic 2007; Angood 2008; Hidalgo 2008)	NA	NA
Trans fatty acids	(Jahreis 1997; Bergamo 2003; Ellis 2006; Lavrencic 2007; Angood 2008; Hidalgo 2008)	NA	(Jahreis 1997; Bergamo 2003)

[†] Studies with multiple comparisons per nutrient may be duplicated in this table, as not all reported comparisons met the criteria for inclusion.

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