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Joint Bachelor Course on Organic Agriculture 2014

Lecture 10: Food quality and food processing, Part I

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Quality of organic food

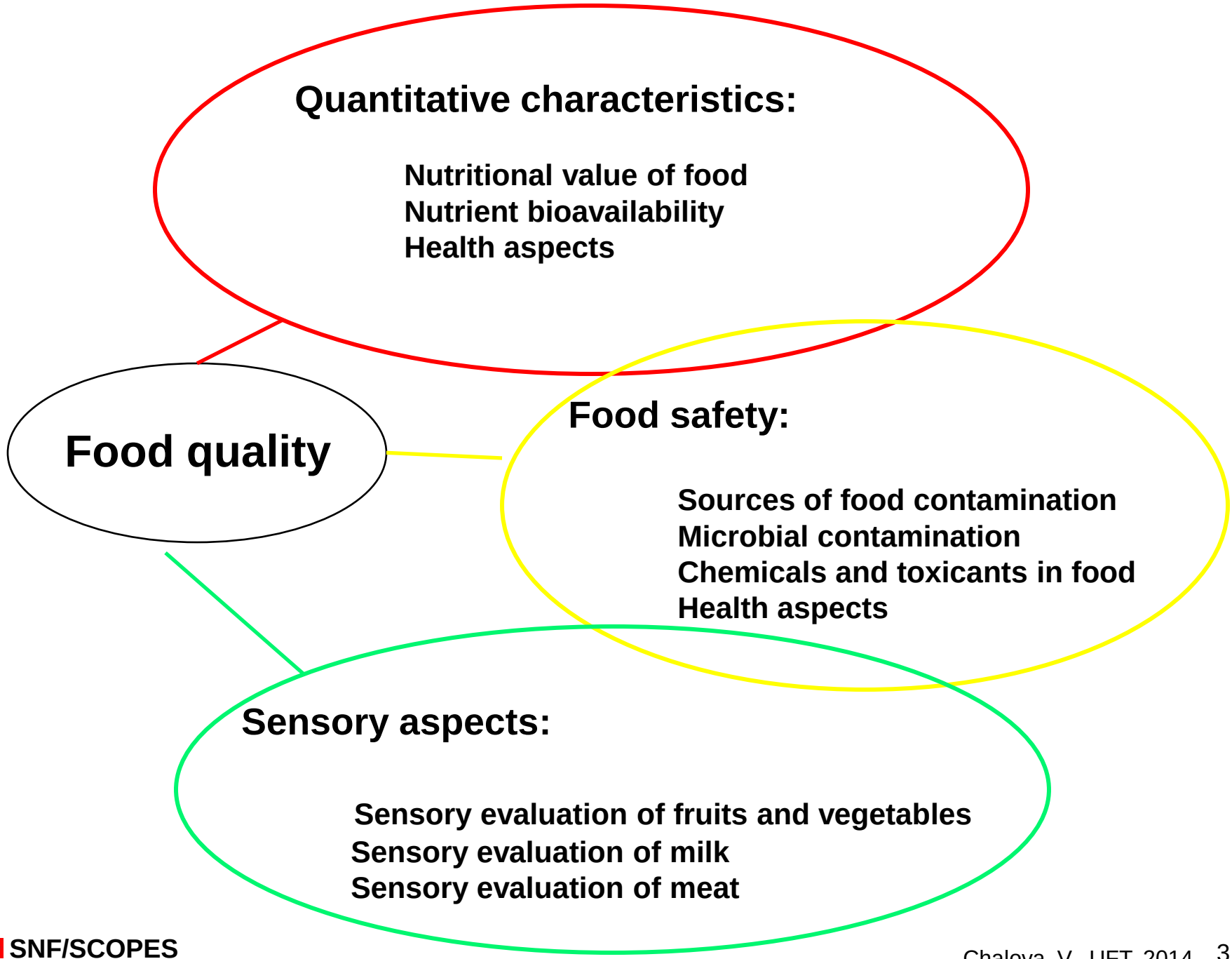
- “The totality of features and characteristics of a product, process or service that bear on its ability to satisfy stated or implied needs”

  (FAO 2004, Twenty-fourth FAO regional conference for Europe)

- «Food quality has an objective and a subjective dimension. Objective quality refers to the physical characteristics...(...). Subjective quality is the quality as perceived by consumers.»

  (Grunert 2005, European Review of Agricultural Economics, 369-391)

- Still no general agreement on the definition of food quality


Quantitative characteristics:
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Health aspects
Sensory aspects:
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Sensory evaluation of milk
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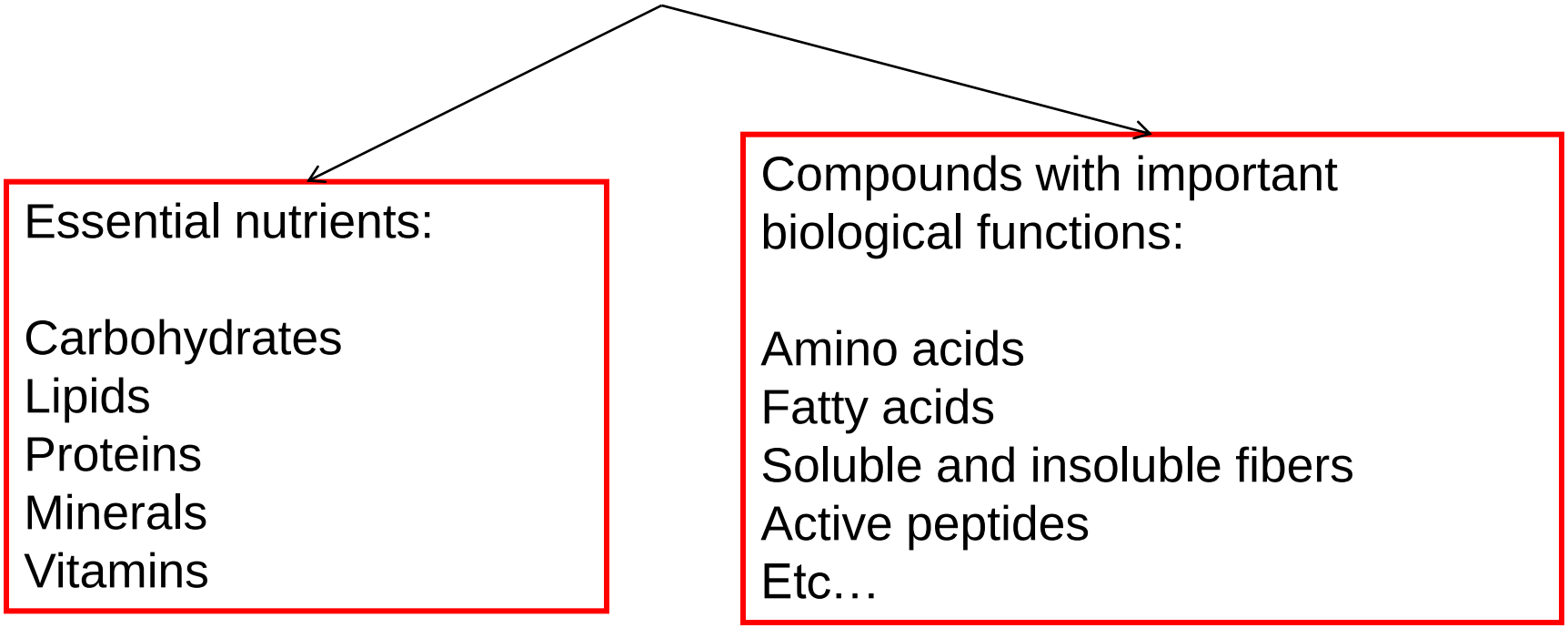
Quantitative characteristics

Nutritional value of food



Nutritional value of plant produce

Variable and controversial results on nutritional value of organically versus conventionally grown agricultural produce

Table 1. Comparison of protein, nitrate and selected vitamin and mineral contents of organic *v.* conventionally-grown crops (derived from Worthington, 1998)

Nutrient	Increased	Same	Decreased
Protein quality	3	0	0
Nitrate	5	10	25
Vitamin C	21	12	3
β-carotene	5	5	3
B vitamins	2	12	2
Ca	21	20	6
Mg	17	24	4
Fe	15	14	6
Zn	4	9	3

(No. of studies of organic crops shown to have increased, decreased or same nutrient content compared with conventionally-grown crops)

Source: Worthington V. 1998 Alt. Therapies 4, 58-69;
Williams C. M. 2002 Proc. Nutr. Soc. 61, 19-24

Systematic review: Nutritional quality of organic foods

TABLE 1

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

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

[1] Nutrient categories are listed by numeric order of the included studies.

[2] All values are means ± SEs (robust).

Source: Dangour et al. 2009, Am. J. Clin. Nutr. 90, 680-685

Main findings

- Organic crops are **as nutritious as** conventional crops.
- Organically grown agricultural produce may be **higher** in **vitamin C** and **phosphorus**.
- Organic crops are **lower in nitrates** than conventional crops.
- Superiority of carbohydrate and protein levels in organic foods are insufficiently documented.

Bioactive non-nutritive compounds: Phytochemicals

Phytochemicals
Secondary metabolites that protect plants from diseases and pests. Scientific evidences demonstrate the presence of **higher amounts** of phytochemicals in organic plants.

Polyphenols
Phytochemicals with strong activity. Play a role in the prevention of cardivascular deseases, cancers, and osteoporosis. (Scalbert *et al.* 2005)

Flavonoids
The most common group of polyphenols in human diet. Typical plant sources are apples, tea, onions etc.

Many studies show that levels of polyphenols (*e.g.* flavanoids) are higher in organic plant products.

Source: Matt *et al.* 2011, ISBN 978-9949-484-06-5

Nutritional value of livestock products

Milk

- Beneficial fatty acid composition:
  - Higher contents of conjugated linoleic acid and polyunsaturated fatty acids (PUFA)
  - Lower ratio of omega-6/omega-3 fatty acids
  - Higher ratio of conjugated linoleic acid/linoleic acid
- Evidence of higher vitamin and antioxidant concentration
- Some deficiency of specific macro-and microelements since mineral supplements and fertilizers in organic farming are not allowed.

Source: Matt *et al.* 2011

Meat

Meat from organic farms

- Higher content of omega-3 acids
- Lower content of saturated fats
- Evidence of higher total fat content in beef and pork

Eggs

Eggs from organic farms

- Carotenoids' profile of the yolk of organic eggs differs from that of conventionally produced eggs; Darker yolk color

Inconsistent research data on superiority of nutritive value of organic eggs and meat compared to conventional products.

Source: Matt *et al.* 2011

Nutrient bioavailability

Bioavailability of nutrients is defined by their potential to be released and efficiently used for metabolic purposes.

Factors influencing nutrient bioavailability:

- Chemical nature of the nutrient e.g. cations, protein conformation etc.
- Physicochemical environment during the digestive process e.g. pH, presence of complex carbohydrates, condensed tannins, etc.
- Food processing techniques and parameters.
- Presence of anti-nutritional factors.

No scientific data support better bioavailability of nutrients in organic food when compared to conventionally produced food.

Summary of health benefits

- Organic vegetables contain less nitrate (- 30-90%)
  (Matt *et al.* 2011, Hansen *et al.* 2002)
- Organic fruits and vegetables feature a higher content of antioxidants such as polyphenols, flavonoids and ascorbic acid, which may reduce the risk of cancer and cardiovascular diseases.
  (Matt *et al.* 2011)
- Organic animal products show a healthier fatty acid profile
  (Matt *et al.* 2011)
- Mineral levels of organic plant products are similar to conventional products (Dangour *et al.* 2009, Mäder *et al.* 2007, Ryan *et al.* 2004)

Experienced health effects of consumers of organic food

A total of 566 respondents participated.

Outcomes:

- no health effects (30%)
- feeling more energetic and having better resistance to illness (70%)
- positive effect on mental well-being (30%)
- improved stomach and bowel function (24%)
- improved condition of skin, hair and/or nails (19%)
- fewer allergic complaints (14%)
- improved satiety (14%)

In addition, the switch to organic food was often accompanied by the use of more freshly prepared foods and other lifestyle changes.

Source: van de Vijver *et al.* 2012

Problems

Research data on the influence of organic food on human health are insufficient to formulate clear and straightforward conclusion.

Various factors may preclude the performance of well controlled experiments with human subjects:

- Nutrient bioavailability dependence on individual physiology.
- Differences in health status of each individual during an experiment.
- Factors other than eating habits may affect results.

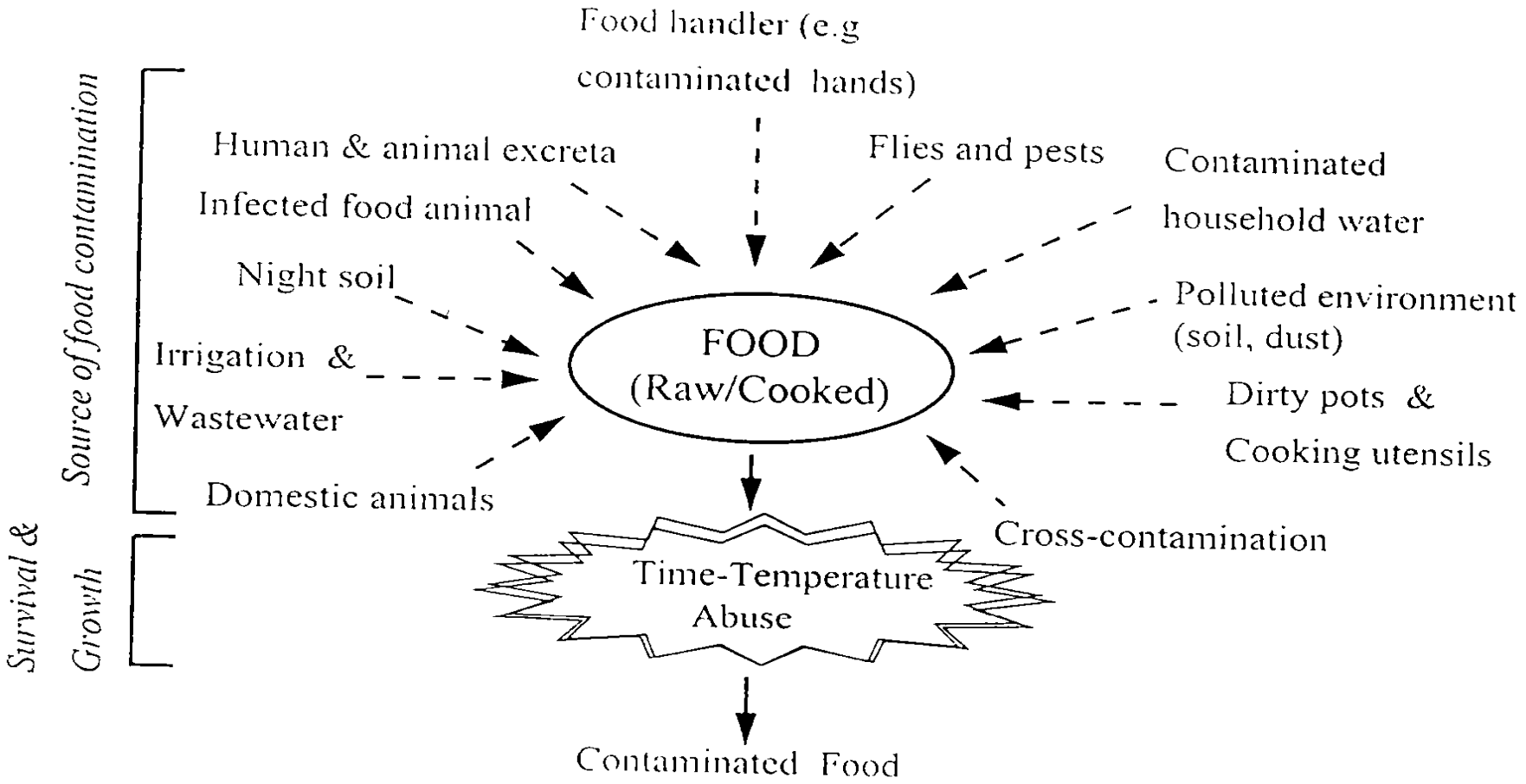
Food safety

Definition: Safety of foods is the certainty that they will not cause harm or illness to humans.

Broader meaning: Food safety encompasses a set of conditions and practices during production, processing, distribution, storage and preparation of foods which are necessary to protect them from pathogenic microorganisms, exogenous chemical contaminants, naturally occurring toxic substances and newly formed toxic compounds during processing or preparation.

Source: Brown *et al.* 1998. Complementary feeding of young children in developing countries: a review of current scientific knowledge, WHO/NUT/98. Geneva, WHO.

Sources of food contamination



Source: Brown *et al.* 1998

Microbial contamination

- **Bacterial contamination**

- Use of farmyard manure and other animal wastes may increase the risk of contamination of agricultural produce with pathogens such as *E. coli* O157.
- Composting do not prevent growth of spore-formers such as *Clostridium perfringens* and *Clostridium botulinum.*
- Frequency and durability of *Salmonella* and *Campylobacter* infections in organically raised animals may be higher due to extended exposure of animals to out-door conditions and ban of antibiotics. Respectively, higher dissemination of foodborne pathogens of livestock products (meat, milk, and eggs) could be expected.

Magkos *et al.* 2006. Crit Rev Food Sci Nutr, 46:23–56
Doyle ME 2006. http://fri.wisc.edu/docs/pdf/FRIBrief_NaturalOrgFoods.pdf

Microbiological examination of organic vegetables

Microbiological results of ready-to-eat organic vegetables (*n* = 3200)

- Escherichia coli detected in 48 samples (out of 3200 samples)
- Listeria spp. (excluding L. monocytogenes) detected in 6 samples
- Listeria monocytogenes not detected
- Salmonella spp. not detected
- Campylobacter spp. not detected
- E. coli O157 not detected

«The vast majority (99.5%) of uncooked ready-to-eat organic vegetables (…) were of satisfactory/acceptable microbiological quality.»

«(…) the absence of pathogens (…) indicates that overall agricultural, hygiene, harvesting and production practices were good.»

Sagoo *et al.* 2001. Lett Appl Microbiol 33, 434-439.

Food-borne pathogen prevalence in organic and conventional cattle or beef products

Food-borne pathogen	Study population	Results	Reference
Escherichia coli O157	Beef cattle	No difference in prevalence between organic and conventional cattle at harvest	Reinstein et al. 2009
E. coli O157	Dairy cattle	No difference in percentage of positive samples in organic and conventional dairy farms	Cho et al. 2006a
E. coli O157 and Shiga toxin-producing *E. coli* (STEC)	Dairy cattle	No difference in prevalence or risk of carrying *E. coli* O157 or STEC	Kuhnert et al. 2005
Salmonella	Dairy cattle	No difference in prevalence between organic and conventional dairy farms	Fossler et al. 2005a 2005b
Salmonella	Beefsteak	No positive samples detected	Miranda et al. 2009
Campylobacter	Dairy cattle	No difference in prevalence between organic and conventional dairy farms	Sato et al. 2004
Listeria monosytogenes	Beefsteak	No difference in percentage of positive samples in organic and conventional products	Miranda et al. 2009

Source: Ricke *et al.* (Eds) Organic Meat Production and Processing, p. 285-299

The UK Food Standards Agency's (FSA)

› "There is currently no firm evidence to support the assertion that organic produce is more or less microbiologically safe than conventional food"

Source: Food Standards Agency (FSA) 2000. *Position Paper: Food Standards Agency View on Organic Foods*, London: FSA.

The UK Ministry of Agriculture, Fisheries and Food (MAFF)

› "There is insufficient information at present to state categorically whether the risk of pathogen transfer to produce on organic farms differs significantly from that associated with conventional farming practices"

Source: Nicholson *et al*. 2000. A Study of Farm Manure Applications to Agricultural Land and an Assessment of the Risks of Pathogen Transfer into the Food Chain, London: HMSO/MAFF Publications.

Chemicals and toxicants in foods

Effect of ban on pesticides on product safety in organic farming compared to conventional farming

Compound	Product	Prevalence	Impact on human health
Pesticides	Fruits, vegetables, cereals	None or very low concentrations in organic products	Positive
Ochratoxin (mycotoxin)	Cereals	Higher than in conventional products	Negative
Aflatoxin (mycotoxin)	Milk	Absent	Positive

Mycotoxins: Secondary metabolism products of *Aspergillus*, *Penicillium*, and *Fusarium* which have carcinogenic and immunosuppressive effects on human health.

No evidence to indicate that organic food is more prone to mycotoxin contamination than conventional food (FAO, 2000)

Source: Hansen *et al.* 2002

Chemicals and toxicants in foods (cont.)

Effect of ban on synthetic fertilizers and growth promoters on product safety in organic farming compared to conventional farming

Compound	Product	Prevalence	Impact on human health
Heavy metals	Cereals, carrots, potatoes	Same or lower than in conventional products	Positive
Residues of growth regulators	Cereals	Not present in organic products	Positive

Effect of lower nitrogen levels on product safety in organic farming compared to conventional farming

Compound	Product	Prevalence	Impact on human health
Nitrate	Spinach, potatoes, beetroots	30-90% lower than in conventional products	Positive

Source: Hansen *et al.* 2002

Summary of food hazards

Table 6 Comparison of organic and conventional products with respect to food hazards

Organic < Conventional	Organic = Conventional	Unknown
Synthetic agrochemicals[a]	Environmental pollutants[d]	Natural plant toxins
Nitrate[b]		Biological pesticides
Contaminants in feedstuffs[c]		Pathogenic microbes
Veterinary drugs[c]		Mycotoxins

[a] vegetables and fruits.
[b] nitrophillic vegetables.
[c] foods of animal origin.
[d] heavy metals (e.g. cadmium, lead), dioxins, polychlorinated biphenyls, radioactive nuclides.

Source: Magkos *et al.* 2006. Crit Rev Food Sci Nutr 46: 23-56

Health aspects of chemicals and toxicants

Benefits of organic foods for human health as a consequence of the strict regulation of organic plant and animal production:

Organic plant production

- a ban on genetic engineering and GMOs
- lower nitrogen levels: maximum limits for manure application of 170 kg N $ha^{-1}yr^{-1}$
- a ban on synthetic pesticides
- a ban on synthetic mineral fertilisers
- a ban on growth promoters

Organic animal production

- extended access to out-door areas with a lower stocking density
- restrictions on animal feeds:
  - compulsory use of roughage feeds
  - ban on antibiotics, growth promoters and additives
  - ban on GMOs
  - ban on meat and bone meal
- double retention time after medicine treatment

Sensory aspects

Sensory attributes:

External appearance:

Shape,
Color,
Size,
Freshness,
Firmness

Organoleptic properties:

Taste,
Flavor,
Texture

Sensory evaluation of fruits and vegetables

Nine studied objects,
Six sample batches of each food,
three organic and three conventional:

carrots (raw and cooked),
onions, broccoli,
vine tomatoes, cherry tomatoes,
apples, potatoes,
bananas and oranges.

Descriptors:

Color
Aroma
Hardness
Moistness
Crunch
Sweetness
Bitterness (aftertaste)

Conclusion:

No significant differences between the sensory properties of organically and conventionally grown fresh fruits and vegetables.

Source: Tobin *et al.* 2013. Int. J. Food Sci. & Tech. 48, 157-162

Controversial results on sensory evaluation of fruits and vegetables

Table 1. Recent studies on the sensory comparison of organic and conventional foods and their findings.

References	Food tested	Findings
Haglund et al., 1999	Carrots	Conventional carrots higher in carrot taste, sweetness and crunchness. Organic carrots higher in hardness and pronounced after-taste (P<0.01 or less).
Wszelaki et al., 2005	Red skin potatoes	In a triangel test, panelists could distinguish between organic and conventional samples only when the skin was left on.
Gilsenan et al., 2008	Carrots and Mashrooms	Descriptive analysis of carrots for appearence, aroma, texture and taste found no significant difference (P<0.05). Analysis of mashrooms for the same discriptors also showed no significant difference; however, it was indicated that organic mashrooms had darker gills and stronger aroma (P<0.05).
Gilsenan et al., 2010	Potatoes	No significant difference in appearance, aroma and taste was observed. However, baked conventional samples were percieved to be significantly softer, less adhesieve and wetter than organic baked samples (P<0.05).
Hajslová et al., 2005	Potatoes	In a 4-year study, differences were seen whithin single crop years; however, pooled results showed that year-to-year, variety and geografical variations were equal or more important factors.

 Source: Tobin et al. 2013. Int. J. Food Sci. & Tech. 48, 157-162

Sensory evaluation of milk

Sensory panelists clearly differentiate organic cow milk from conventional milk by:

- Overall flavor
- Liking
- Mouthfeel

Consumers clearly show preference to conventional milk. It is primarily due to specific cow's milk odor which consumers are not accustomed to.

Source: Bopanna N. 2007, MSc Theses

Sensory evaluation of meat

Sensory description of organic meat perceived by light and heavy users:

- **Taste:** Satisfying taste, rich, strong taste, tastier, the taste as I remember it from earlier days, the real taste / unpleasant strong animal taste, sweeter, taste too much like animal, stronger in taste, very delicious, artificial aromas missing
- **Appearance:** Nicer / deeper red, natural color since it lacked nitrate, less pink, fresh and red, Bordeaux color, does not get a grey sheen as quickly as conventional meat
- **Texture:** More tender and less tough, firmer and tougher (especially for chicken) when frying, meat does not shrink as much and less water comes out, retains volume during cooking and loses less liquid, tender, soft as butter, well-seasoned, better consistency, stays firm, tender and moist, juicy but not watery, compact texture, tender, more tender, firm in consistency, more tender, less water
- **Odor:** Fat smelling, right and pleasant smell

Source:Stolz *et al*. 2010. http://orgprints.org/20233/1/deliverable_4_2_consumer_research.pdf

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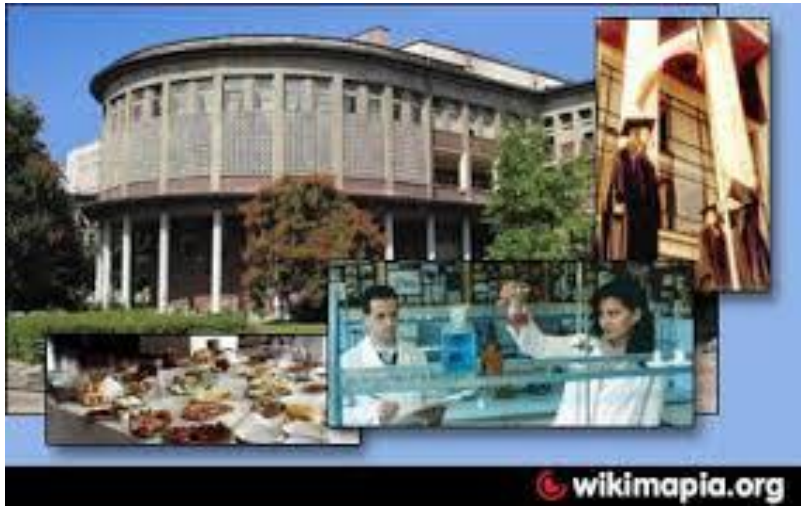

Thank you!

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