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ORGANIC FOOD: HIGH QUALITY OR HAZARD? - PLENARY LECTURE

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Organic farming is based on harmony with the environment and promotes biodiversity and biological cycles. Products obtained from organic arable farms exhibit lower levels of pesticides along with a higher content of vitamin C, minerals, sugars and flavonoids, but probably also mycotoxins. Organic production methods seem to have a positive effect on meat, milk and egg quality, although the prohibition of antibiotic use may cause an increase in the frequency of bacterial and parasitic infections in consumers. Importantly, contamination of conventional food with chemicals and that produced from organic crops with fungal toxins may modulate immune system function.

ORGANIC FOOD – WHAT DOES IT MEAN?

Organic farming is an integrated system of agriculture based on ecological principles. It promotes biodiversity, biological cycles and natural soil cultivation. In the European Union, organic agriculture is defined in the "COUNCIL REGULATION (EEC) No 2092/91 of 24 June 1991 on organic production of agricultural products and indications referring thereto on agricultural products and foodstuffs". Organic crops are cultivated under controlled conditions according to the guidelines specified in the aforementioned regulation [Rosati & Aumaitre, 2004].

Subcultural movements devoted to organic agriculture have began with the development of production methods by individual farmers or by a few private research institutions. Despite the increasing interest in organic food production, the number of research and review articles describing the positive and negative effects of organic and conventional foodstuffs on human and animal health is still very small. At the end of 2001, Lund & Algers found only 22 peer-reviewed papers that broached this subject, and these mainly dealt with parasitology and the health of dairy cattle [Lund & Algers, 2003].

Methods of organic production are based on harmony with the environment. Regulations for organic crop cultivation prohibit the use of synthetic pesticides, mineral fertilizers, growth promoters and genetic engineering or Genetically Modified Organisms (GMOs). There are also limits for manure applications used to improve nitrogen levels in the soil [Rembiałkowska, 2004]. On the other hand, a recent investigation in Saudi Arabia has suggested that the increased use of chemical fertilizer improve protein content of flour from wheat grown on sandy soil. This could, however, have resulted from the poor quality of the soil [Salah, 2006].

Organic meat, poultry and eggs must come from animals reared on regularly inspected accredited farms that do not receive antibiotics and have free access to the outdoors, fresh air and sunlight [Borell *et al.,* 2004].

QUALITY OF ORGANIC FOOD

Studies evaluating the relative contamination of crops clearly show lower levels of pesticides, their metabolites and other harmful chemicals in organically-grown plants compared with those produced by conventional means, *e.g.* on average organic crops have a 49% lower content of nitrates and nitrites [Rembiałkowka, 2004]. The presence of chemical contaminants in food is likely to have an influence on their concentration in the bodies of consumers, both human and animal. In a novel study on organic diets, the urinary concentration of organophosphorous pesticides was measured in a group of elementary school-age children. It was found that the concentrations of specific metabolites of malathion and chlorpyrifos decreased dramatically after consumption of an organic diet for five days [Lu *et al.,* 2006].

Phytochemicals and mycotoxins present in plants represent other food contaminants that are potentially risky to health. However, a recent study has shown that the increase in the level of phenolic agents in samples of organically-grown lettuce and collard was not significant [Young *et al.,* 2005]. The available data concerning levels of toxic contaminants in organic *versus* conventionally-grown crops are ambiguous. Mycotoxins are compounds produced by fungi, mainly *Aspergillus*, *Penicillium* and *Fusarium* species that are present on plants. It has been suggested that organic crops may be more susceptible to infection by fungi because of the prohibi-

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tion of anti-fungal agent use. One recent study found no differences in the fungal contamination of foods derived from organic and conventionally-grown crops [Kouba, 2003], but another reported that mycotoxins, such as fumonisins and deoxynivalenols, were more frequently detected in organic foods [Cirillo *et al.,* 2003].

The quality of plant foodstuffs is also measured by the nutritional value. There are data suggesting that the quality of grain, assessed by essential amino acid content, is better in cereals produced organically, regardless of the lower total protein levels. Fruit and vegetables from organic farms were found to contain higher levels of vitamin C and minerals [Rembiałkowska, 2004]. Olsson *et al*. [2006] demonstrated a higher ratio of ascorbate to dehydroascorbate in organically-cultivated strawberries. An increased content of flavonoids – compounds with potent anti-carcinogenic properties – was also reported in organic crops. Differences in the urinary excretion of major flavonoids have been observed in people eating fruit and vegetables grown under different agricultural conditions [Grinder-Pedersen *et al.,* 2003]. Extracts from organically-cultivated strawberries produced a greater antiproliferative effect on both HT29 colon cancer cells and MCF-7 breast cancer cells, than those from fruits grown conventionally. This might indicate a higher content of secondary metabolites with anticarcinogenic properties in organically grown strawberries [Olsson *et al.,* 2006].

The sensory quality of food from organic and conventional agriculture has also been compared, with the former consistently scoring higher for taste and smell. This may be due to the higher concentration of sugars and dry matter found in organically-grown fruit and vegetables [Rembiałkowska, 2004].

The nutritional value and contaminant content have also been investigated in animal products: mostly in milk and meat. One experiment evaluating the effect of excluding synthetic amino acids (that are prohibited in organic farming) from animal feed, showed a reduction in pig growth performance but an increase in intramuscular fat content, an important determinant of meat quality [Sundrum *et al.,* 2000]. There is also evidence that organically-produced chicken meat is of higher quality compared with that produced under the conventional system; organic chicken carcasses had a higher breast and drumstick percentage and lower levels of abdominal fat [Castellini *et al.,* 2002]. Little or no difference in the investigated nutritional parameters was seen when organic milk and milk from conventional farms were compared. However, significant differences were found in urea and somatic cell count, both of which were lower in organic milk, thus increasing its quality [Toledo *et al.,* 2002]. The organic way of production also seems to have a positive effect on egg quality. As early as in 1989, Plochberger, studying genetically identical but differently housed hens, showed that eggs from organic farms were heavier and had more yolk [Plochberger, 1989].

Farmyard manure and other animal wastes used in organic agriculture may be a source of bacterial and parasite infections of animals. Moreover, prohibition of the prophylactic use of antibiotics and other medicines may cause an increase in the incidence of these infections. Despite that, a recent study reported that organic dairy farms showed no increase in the incidence of such diseases as clinical mastitis, and bulk tank somatic cell counts were not raised compared with conventional farms [Sato *et al.,* 2005]. However, earlier reports presented by the EU in 2001 showed that there were higher levels of *Salmonella* contamination in eggs, poultry and pork meat produced organically [Kouba, 2003]. Several studies have indicated that animals allowed to move freely outdoors (pigs, sows and laying hens) have more prevalent helminth and ascaris infections than those subject to greater confinement on conventional farms [Permin *et al.,* 1999; Thamsborg *et al.,* 1999].

A recent comparative study on the incidence of wild-type and fluoroquinolone-resistant *Campylobacter* infections in chickens suggested that antibiotic-free production had no effect on the level of meat contamination. It is notable that these results also suggest that fluoroquinolone resistance may persist in conventional production where antibiotics are allowed [Price *et al.,* 2005].

IS ORGANIC FOOD HEALTHIER FOR US?

Until there are epidemiological studies on the long-term effects of an organic diet on human health, it is difficult to answer this question. Our knowledge of the physiological effects of both organic and conventional food contamination is still poor and further investigation is urgently required. Experiments *in vitro* suggest that contamination of food from conventional farms may cause immunosuppression. For instance, in rats fed organic feed, the proliferative response of lymphocytes cultured with fetal calf serum (FCS) and the levels of acute-phase proteins did not differ from those of animals fed conventionally. However, in protein-energy-malnourished rats the proliferative response of lymphocytes cultured with autologous serum was elevated in animals fed organic feed compared to those on a conventional diet. Rather than showing the impact of organic *versus* conventionally-produced food on immunity, these results may simply demonstrate the influence of protein or energy malnutrition on immune system functions [Finamore *et al.,* 2004]. It has been suggested that immune responses in farm animals on either conventional or organic diets are comparable, whereas organic housing can increase stress resistance at slaughter compared to conventional housing [Millet *et al.,* 2005]. Some studies have shown that farmers exposed to pesticides may be at increased risk of reproductive impairments [Ratcliffe *et al.,* 1987].

Most studies on the toxicity of pesticides have focused on enzyme alterations, pathological and mutagenic effects and potential carcinogenic properties, while only a few have concerned the potential immunomodulatory effects. The immune system is regulated in an intricate manner and free radicals play an important role in its function [Koner *et al.,* 1997]. Pesticides can reportedly perturb the homeostasis between pro- and anti-oxidant forces in the cell and this oxidative stress may be responsible for immune suppression by these toxic substances. Exposure of mouse thymocytes to pesticides *in vitro* caused apoptotic and necrotic cell death, indicating the potent immunotoxicity of pesticides or their metabolites [Banerjee, 1999; Olgun *et al.,* 2004].

The health implications of ingesting mycotoxins have been well characterized: ranging from acute mortality, to

slowed growth and reduced reproductive efficiency. Consumption of lesser amounts of fungal toxins may result in improved immunity. Several studies have detailed the effects of mycotoxins on the immune response in domestic and laboratory animals, but their impact on the local intestinal immune response has not been examined [Bouhet *et al.,* 2005].

Experience in the European market has shown that consumers prefer to choose and buy organic foods because they consider these products to be healthier and safer, and believe that organic farming is better for the environment and animal welfare [Beharrell *et al.,* 1991].

CONCLUSIONS

There is currently no evidence that the nutritional value and healthiness are features characterizing organic rather than conventional foods. More importantly, while organic foods do not contain antibiotics or pesticides, they are, however, a potential source of mycotoxins and bacterial or parasitic contaminants. Despite these concerns, organic farming is a way to protect the environment that will be profitable in the future and it deserves to be the subject of well controlled experimental research.

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REFERENCES

1. Banerjee B.D., The influence of various factors on immune toxicity assessment of pesticide chemicals. Toxicol. Lett., 1999, 107, 21-31.
2. Beharrell B., MacFie J.H., Consumer attitudes to organic foods. Brit. Food J., 1991, 93, 25-30.
3. Borell E., Sørensen J.T., Organic livestock production in Europe: aims, rules and trends with special emphasis on animal health and welfare. Livestock Prod. Sci., 2004, 90, 3-9.
4. Bouhet S., Oswald I.P., The effects of mycotoxins, fungal food contaminants, on the intestinal epithelial cell-derived innate immune response. Vet. Immun. Immunopath., 2005, 108, 199-209.
5. Castellini C., Mugnai C., Bosco A., Effect of organic production system on broiler carcass and meat quality. Meat Sci., 2002, 60, 219-225.
6. Cirillo T., Ritieni A., Visone M., Cocchieri R.A., Evaluation of conventional and organic italian foodstuffs for deoxynivalenol and fumonisins B_1 and B_2. J. Agric. Food Chem., 2003, 51, 8128-8131.
7. Finamore A., Britti M.S., Roselli M., Bellovino D., Gaetani S., Mengheri E., Novel approach for food safety evaluation. Results of a pilot experiment to evaluate organic and conventional foods. J. Agric. Food Chem., 2004, 52, 7425-7431.
8. Grinder-Pedersen L., Rasmussen S.E., Bugel S., Jørgensen L.V., Dragsted LO, Gundersen V., Sandstrom B., Effect of diets based on foods from conventional *versus* organic production on intake and excretion of flavonoids and markers of antioxidative defense in humans. J. Agric. Food Chem., 2003, 51, 5671-5676.
9. Kouba M., Quality of organic animal products. Livestock Prod. Sci., 2003, 80, 33-40.
10. Koner, B.C., Banerjee, B.D., Ray, A., Effect of *in vivo* generation of oxygen free radicals on immune responsiveness in rabbits. Immunol. Lett., 1997, 59, 127–131.
11. Lu C., Toepel K., Irish R., Fenske R.A., Barr D.B., Bravo R., Organic diets significantly lower children's dietary exposure to organophosphorus pesticides. Environ. Health Persp., 2006, 114, 260-263.
12. Lund V., Algers B., Research on animal health and welfare in organic farming – a literature review. Livestock Prod. Sci., 2003, 80, 55-68.
13. Millet S., Cox E., Buyse J., Goddeeris B.M., Janssens G.P.J., Immunocompetence of fattening pigs fed organic *versus* conventional diets in organic *versus* conventional housing. Vet. J., 2005, 169, 293-299.
14. Olgun S., Gogal R.M. Jr., Adeshina F., Choudhury H., Misra H.P., Pesticide mixtures potentiate the toxicity in murine thymocytes. Toxicology, 2004, 196, 181-195.
15. Olsson M.E., Andersson C.S., Oredsson S., Berglund R.H., Gustavsson K-E., Antioxidant levels and inhibition of cancer cell proliferation *in vitro* by extracts from organically cultivated strawberries. J. Agric. Food Chem., 2006, 54, 1248-1255.
16. Permin A., Bisgaard M., Frandsen F., Pearman M., Kold J., Nansen P., Prevalence of gastrointestinal helminths in different poultry production systems. Br. Poult. Sci., 1999, 40, 439-443.
17. Plochberger K., Feeding experiments. A criterion for quality estimation of biologically and conventionally produced foods. Agric. Ecosyst. Environ., 1989, 27, 419-428.
18. Price L.B., Johnson E., Vailes R., Silbergeld E., Fluoroquinolone-resistant Campylobacter isolates from conventional and antibiotic-free chicken products. Environ. Health Persp., 2005, 113, 557-560.
19. Ratcliffe J.M., Schrader S.M., Steenland K., Clapp D.E., Turner T., Hornung R.W., Semen quality in papaya workers with long term exposure to ethylene dibromide. Br. J. Ind. Med., 1987, 44, 317-326.
20. Rembialkowska E., The impact of organic agriculture on food quality. Agricultura, 2004, 3, 19-26.
21. Rosati A., Aumaitre A., Organic dairy farming in Europe. Livestock Prod. Sci., 2004, 90, 41-51.
22. Salah M.Al-Eid., Effect of nitrogen and manure fertilizer on grain quality, baking and rheological properties of wheat grown in sandy soil. J. Sci. Food Agric., 2006, 86, 205–211.
23. Sato K., Bartlett P.C., Erskine R.J., Kaneene J.B., A comparison of production and management between Wisconsin organic and conventional dairy herds. Livestock Prod. Sci., 2005, 93, 105-115.
24. Sundrum A., Bütfering L., Henning M., Hoppenbrock K.H., Effects of on-farm diets for organic pig production on performance and carcass quality. J. Anim. Sci., 2000, 78, 1199-1205.
25. Thamsborg S.M., Roepstorff A., Larsen M., Integrated and biological control of parasites in organic and conventional production systems. Vet. Parasitol., 1999, 84, 169-186.

26. Toledo P., Andren A., Bjorck L., Composition of raw milk from sustainable production systems. Int. Dairy J., 2002, 12, 75-80.

27. Young J.E., Zhao X., Carey E.E., Welti R., Yang S-S., Wang W., Phytochemical phenolics in organically grown vegetables. Mol. Nutr. Food Res., 2005, 49, 1136-1142.

ŻYWNOŚĆ EKOLOGICZNA: WYSOKA JAKOŚĆ CZY ZAGROŻENIE? - WYKŁAD PLENARNY

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Produkcja ekologiczna bazuje na współpracy ze środowiskiem naturalnym i promuje różnorodność biologiczną i dostosowanie do naturalnych cykli przyrodniczych. W produktach pochodzenia ekologicznego stwierdza się mniejszą zawartość pestycydów i ich pochodnych, więcej witaminy C, związków mineralnych, cukrów, flawonoidów, ale także toksyn grzybiczych. Sposób produkcji wydaje się mieć wpływ na jakość mięsa, mleka i jaj, może jednak skutkować zanieczyszczeniami bakteriologicznymi i pasożytniczymi zwierząt. Zakaz stosowania antybiotyków w produkcji ekologicznej może ponadto wpływać na częstość pojawiania się tych infekcji. Zanieczyszczenia, zarówno pożywienia pochodzenia konwencjonalnego, jak i ekologicznego, wydają się także modulować funkcjonowanie układu odpornościowego, co wymaga jednak podjęcia badań eksperymentalnych.