Brief content of lectures on Discipline "Brief content of lecture Safety of GMO and organic products

Lecture 1. Introduction to the problem. conceptual apparatus of discipline and

Terminology used:"genetically modified organism (GMO)", "transgenic organism TGO)", "genetically modified source (GMI)", "transgene", "transgenesis", "genetic engineering", "molecular cloning", "recombinant DNA", "transduction", "transformation"

Lecture 2. Theme Transgenic crops- categorization

- Most GM commercially available today are categorized as the first class of transgenics, also called single trait transgenics. These crops typically contain common transgenic elements, such as the 35s promoter sequence of cauliflower mosaic virus, and nopaline synthase terminator (nos-T) from *Agrobacterium*
- The second class transgenics have stacked modified traits, and these varieties usually result from hybrid crosses of first-generation GM crop varieties.
- The third class of transgenics are so-called near-intragenics, these are GM crops where the transgene construction originates from the host with some minimal modifications.
- The IY class are more related to true intragenic or cisgenic technologies, where the transgene is comprised of only products and elements from the host, without modifications and the only difference with its conventional counterpart is the specific order and insertion loci of the transgenes.

Lecture 3 Benefits and risks associated with genetically modified food products

The genetic modifications aim at improving utilizable and technological traits, nutritional

enrichment of the obtained products, as well as providing potential for the synthesis of therapeutic substances using transgenic organisms. The introduction of genetically modified components for general use is linked to the obligation of their appropriate labelling, in line with European Union (UE) law.

The labelling imperative pertains to all trade goods which contain GM components and products produced with use of GMO, in which the contents of transgenic components exceeds 0.9%.

Detection of GM components becomes an inseparable element of legislative procedure and the introduction to the market of genetically modified food, ensuring, in parallel, appropriate labelling of products, subject to respective official control.

The procedure of certification genetically modified food is controlled by a number of legal acts and requirements, the fulfilling of which provides conditions for allowing GMO to enter trade turnover.

Not only the traits of the parental organism, source and expression products of genes used

for modification are evaluated, but also new, non-existing earlier properties of the transgenic organism.

The analysis includes effects of GMO on:

living bodies, the environment and biodiversity, with particular attention paid to the risks of using a GMO.

In European Union countries, genetically modified food is required to fulfil respective legal Acts, among them Directive 1829/2003/WE on genetically modified food and

fodder, and Directive 1830/2003/WE, related with the potential for monitoring and labelling genetically modified organisms, while in the individual Member States the appropriate legal and normative Acts.

It should be added that the procedure for obtaining consent for the legalization of GMO is complex and includes acceptance of consecutive supervising bodies,

Lecture 4 Benefits resulting from genetic modification of food products.

The increasing number of transgenic food products on the food market induces the belief that genetic modification of plants and animals provides profits.

The potential for improvement of agronomic, technological or utilitarian traits prompts food producers to an increasingly frequent use of achievements provided by genetic engineering.

The groundwork of every modification performed involves a complex procedure of altering genome structure which, in effect, is responsible for the expression and manifestation of the desired utilitarian trait

Lecture 5 Modification of chemical composition in transgenic food.

Among numerous modifications induced in plants, transformations resulting in altered chemical composition of food products deserve particular attention.

Enrichment of transgenic food in specific alimentary products results in such food frequently having a much higher utility value than traditional food products.

Moreover, it provides a concentrated source of nutraceutics, or substances carrying high therapeutic and pro-health value, representing a desirable element of a differentiated diet.

The group of nutraceutics contains, vitamins A, C, E, plant pigments, indispensable unsaturated fatty acids (IUFA), alimentary cellulose, and pre- and probiotics.

The achievements of genetic engineering include the significant example of Golden Rice, the genome of which was modified by the introduction of additional copies of genes conditioning the synthesis of provitamin A (Tab. 1).

Carotenoids, including, among other, â-carotene, vitamin A and its provitamin, represent a group of biologically active compounds responsible for normal sight and body resistance.

The project of enriching rice in food products involved the isolation and transfer of genes from *Erwinia uredovora* bacteria and jonquil flowers directly to rice grains. A change

in expression of individual alleles resulted in an increased activity of the enzyme of phytoene synthase, translated to an increased amount of synthesized â-carotene.

The success of the project was followed by subsequent modifications, achieving parallel augmentation of the level and bioavailability of iron.

In this way, Golden Rice proved to provide the product of choice for the reduction of malnutrition, due to its high nutritive value and low price.

Lec 6. Theme: Improvement in technological and utility trends.

The aim of plant cell genetic transformation involves not only modification of the chemical composition and nutritional value of transgenic products, but also alterations in functional traits, important in the technological and processing processes.

The highest interest is attracted by varieties in which the introduced change manifests certain practical importance. One of the first achievements in perfecting food on the molecular level involved the abovementioned FlavrSavr tomato, the genetic material of which was transformed with respect to *activity of the*

enzyme of polygalacturonase. A reaction of silencing gene expression, responsible for the phenomenon of ripening, resulted in the tomato manifesting a slowed-down metabolism at the stage when the process progressed rapidly and, due to the slowing, it gained longevity, permitting its long storage (Tab. 1).

Potato bulbs, because they are easily modified, became important objects of studies. Their transformation included not only their quantitative composition but, first of all, their technological parameters.

The most important alterations included decrease in the amount of reducing sugars,

paralleled by an increased content of cyclodextrins, change in the activity of polyphenol oxidase responsible for the phenomenon of potato darkening, and a reduced content of alkaloids which negatively affect the process of potato storage.

A potato was successfully cultivated in which the Bt gene, isolated from Bacillus thuringiensis bacteria, conditioning resistance to potato beetle, allowed an increase in the potato crop (Tab. 1). The same resistance gene was used for the transgenesis of maize. It is assumed that a toxin coded by

a bacterial chromosome, after transferring to plant tissues, allows the development of resistance to noxious insects which reduce crops, but exert no negative influence on the health of humans and animals consuming the plants. Due to such procedures, the maize became resistant to corn borer (*Pyrausta mirilabilis*), while its commercial variety (MON810) was admitted to cultivation worldwide, including Poland and

other countries of the European Union

Table 1. Advantageous technological and utilitarian features of genetically modified food.

FOOD BENEFITS FROM GENETIC MODIFICATIONS

Rice

Higher content of β-carotene

Higher iron bioavailability

Tomato	Higher content of dry matter
	Delayed ripening process
	Aroma intensification
	Virus resistance

Potato	Higher amylopectin content
	Cyclodextrin production
	Resistance to viruses and potato beetle
	Lower alkaloids content

Milk (cow, goat, sheep)	Increased tolerance for high temperature
	Modified casein content
	Lower lactose content
	Increased tolerance for high temperature

Transgenic fishes

(carp, salmon, trout)

Faster growth rate

Lecture 7 Safety Assessment of GM

The scientific evidence that must be provided in the safety assessment of GM crops can vary among different legal jurisdictions.

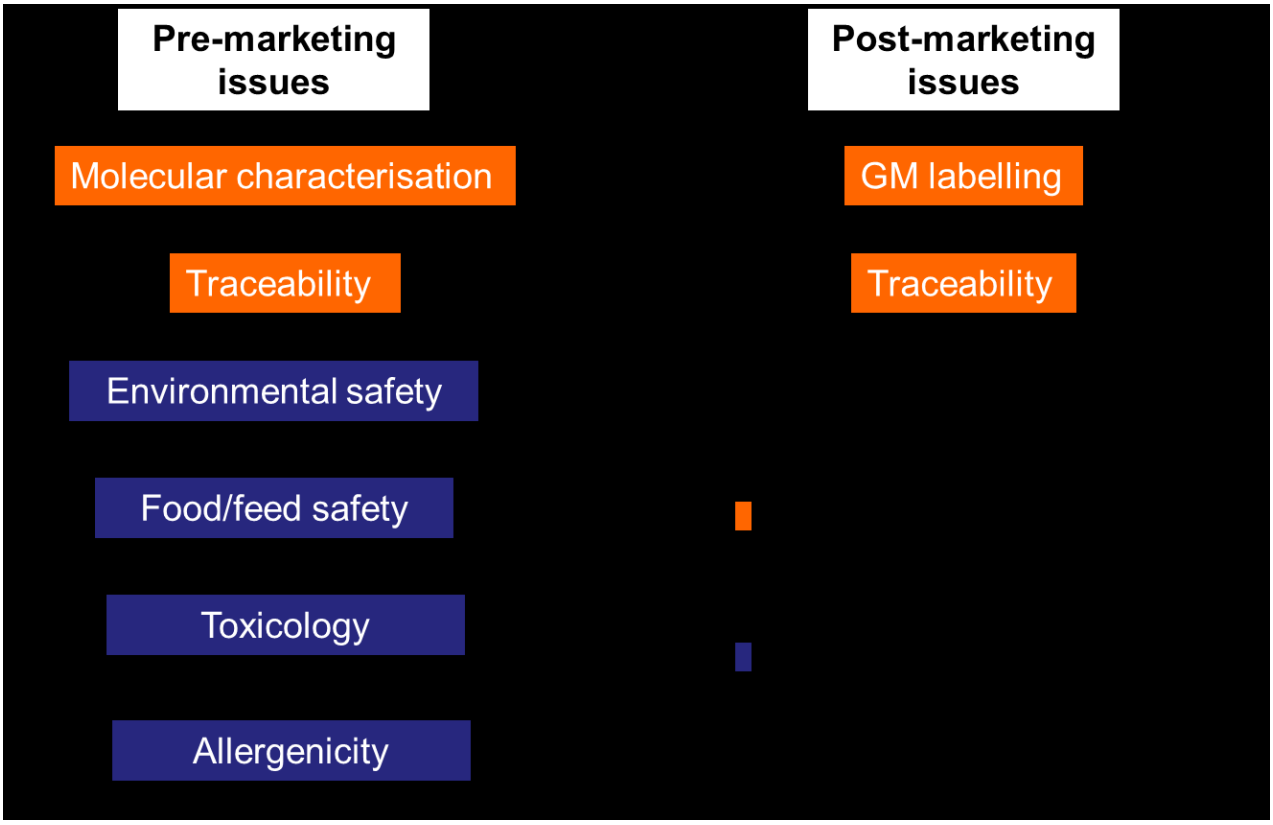
However, a detailed molecular characterization of the transgene insertion, development of tracking and tracing methodologies to ensure legality and traceability, and environmental studies to enable coexistence frameworks, are common studies in the safety assessment of GM crops studies, such as toxicological, allergenicity, nutritional, and horizontal transfer, have been performed following a case-by-case approach considering newly emerging scientific knowledge and technologies.

The use of GM crops as a feed can reduce concerns around human safety and underline other features such as feeding value and nutritional equivalence.

From an industrial point of view, the assessment required for the regulatory authorities could be divided into two groups; pre- and post-marketing issues. The former includes relatively standard technologies for all GM food and feed, such as molecular characterization and development of tracking and tracing tools for traceability purposes.

Pre-marketing issues also involves technologies under development that varies on a case-by-case basis, including environmental, food/feed, toxicological, and allergenicity safety studies.

Post-marketing issues are related with regulatory monitoring, which contemplate GM labeling and traceability



Lecture 8 The key concepts of the relevant risks of food and feed. Modification of chemical composition in transgenic food.

Among numerous modifications induced in plants transformations resulting in altered chemical composition

of food products deserve particular attention. Enrichment of transgenic food in specific alimentary products results in such food frequently having a much higher utility value than traditional food products.

Moreover, it provides a concentrated source of nutraceutics, or substances carrying high therapeutic and pro-health value, representing a desirable element of a differentiated diet. T

he group of nutraceutics contains, first of all, vitamins A, C, E, plant pigments, indispensable unsaturated fatty acids (IUFA), alimentary cellulose, and pre- and probiotics.

The achievements of genetic engineering include the significant example of Golden Rice, the genome of which was modified by the introduction of additional copies of genes conditioning the synthesis of provitamin A (Tab. 1).

Carotenoids, including, among other, â-carotene, vitamin A and its provitamin, represent a group of biologically active compounds responsible for normal sight and body resistance. The project of enriching rice in food products involved the isolation and transfer of genes from Erwinia uredovora bacteria and jonquil flowers directly to rice grains. A change in expression of individual alleles resulted in an increased activity of the enzyme of phytoene synthase, translated to an increased amount of synthesized â-carotene.

The success of the project was followed by subsequent modifications, achieving parallel augmentation of the level and bioavailability of iron. In this way, Golden Rice proved to provide the product of choice for the reduction of malnutrition, due to its high nutritive value and low price

Lecure 9. Theme Nutritional and medical risks

Thr type of component in genetically modified food involves products from the transgenesis of animal products.

The rationale for altering the structure of the genes includes attempts to improve utility traits of farm animals and attainment of the highest economical profits. Farm animal modifications encompass several branches of contemporary economy, including agriculture, the food industry, pharmacyand medicine.

The principal objects in studies on transgenesis processes include cattle and pigs, while the main directions of transformation involve optimization of their alimentary potential and parameters of breeding. Modification of genetic material aimed at enrichment of its fraction responsible for synthesis of growth hormone resulted in the production of animals manifesting a higher growth rate and greater increases in body weight.

At present, attempts are being made to obtain varieties of the animals with low feed demand,

compared to their rate of growth. Such attempts have been successful in the production of transgenic fish, such as carp, trout and salmo.

Extensive interest was devoted to improvement of the nutritive value of milk originating from genetically modified cows, goats and sheep (Tab. 1). Through the introduction or elimination of respective genes,

a milk was produced with augmented tolerance of high temperatures, containing an altered content of casein or a decreased content of lactose, representing one of causes of alimentary intolerance. An important aspect involved the humanization of bovine milk using human proteins and reduction of â-lactoglobulin content, the principal allergen of milk which induces allergic reactions.

Lecure 10 Theme Environmental and agricultural risks

The dissemination of genetically modified food in various branches of human activities promoted the introduction of detailed controls related to transgenesis products, particularly in the scope of evaluating the safety of their use, and specification of possible risks associated with theconsumption of such products.

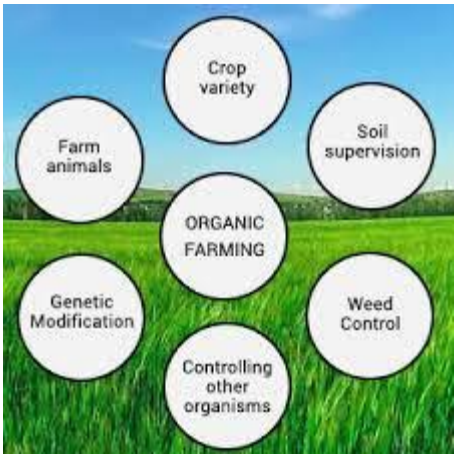
The anxiety of consumers is induced both by the effects of genetic modifications, including effects of molecular biology techniques which, in interfering with the process of natural recombination, disturb the ability for normal propagation. The problem of taking advantage of transgenic food reflects misgivings of both a biological nature, related to the complexity of the involved processes, and ethical principles linked to problems of theexistence of living organisms

Lecture 11. Organic foods: Are they safer? More nutritious?

Discover the difference between organic foods and their traditionally grown counterparts when it comes to nutrition, safety and price.

Once found only in health food stores, organic food is now a common feature at most grocery stores. And that's made a bit of a problem in the produce aisle.

For example, you can pick an apple grown with usual (conventional) methods. Or you can pick one that's organic. Both apples are firm, shiny and red. They both provide vitamins and fiber. And neither apple has fat, salt or cholesterol. Which should you choose? Get the facts before you shop.



What is organic farming?

The word "organic" means the way farmers grow and process farming (agricultural) products. These products include fruits, vegetables, grains, dairy products such as milk and cheese, and meat. Organic farming practices are designed to meet the following goals:

- Improve soil and water quality
- Cut pollution
- Provide safe, healthy places for farm animals (livestock) to live
- Enable natural farm animals' behavior
- Promote a self-sustaining cycle of resources on a farm

Materials or methods not allowed in organic farming include:

- Artificial (synthetic) fertilizers to add nutrients to the soil
- Sewage sludge as fertilizer
- Most synthetic pesticides for pest control
- Using radiation (irradiation) to preserve food or to get rid of disease or pests
- Using genetic technology to change the genetic makeup (genetic engineering) of crops, which can improve disease or pest resistance, or to improve crop harvests
- Antibiotics or growth hormones for farm animals (livestock)

Organic crop farming materials or practices may include:

- Plant waste left on fields (green manure), farm animals' manure or compost to improve soil quality
- Plant rotation to keep soil quality and to stop cycles of pests or disease
- Cover crops that prevent wearing away of soil (erosion) when sections of land aren't in use and to plow into soil for improving soil quality
- Mulch to control weeds
- Insects or insect traps to control pests
- Certain natural pesticides and a few synthetic pesticides approved for organic farming, used rarely and only as a last choice and coordinated with a USDA organic certifying agent

Organic farming practices for farm animals (livestock) include:

- Healthy living conditions and access to the outdoors
- Pasture feeding for at least 30% of farm animals' nutritional needs during grazing season
- Organic food for animals
- Shots to protect against disease (vaccinations)

Organic or not? Check the label

The U.S. Department of Agriculture (USDA) has set up an organic certification program that requires all organic food to meet strict government standards. These standards control how such food is grown, handled and processed.

Any product labeled as organic on the product description or packaging must be USDA certified. If it's certified, the producer may also use an official USDA Organic seal.

The USDA says producers who sell less than $5,000 a year in organic food don't need to be certified. These producers must follow the guidelines for organic food production. But they don't need to go through the certification process. They can label their products as organic. But they can't use the official USDA Organic seal.

Products certified 95 percent or more organic may display this USDA seal.
The USDA guidelines describe organic foods on product labels as:

- **100% organic.** This label is used on certified organic fruits, vegetables, eggs, meat or other foods that have one ingredient. It may also be used on food items with many ingredients if all the items are certified organic, except for salt and water. These may have a USDA seal.

- **Organic.** If a food with many ingredients is labeled organic, at least 95% of the ingredients are certified organic, except for salt and water. The items that aren't organic must be from a USDA list of approved additional ingredients. These also may have a USDA seal.
- **Made with organic.** If a product with many ingredients has at least 70% certified organic ingredients, it may have a "made with organic" ingredients label. For example, a breakfast cereal might be labeled "made with organic oats." The ingredient list must show what items are organic. These products can't carry a USDA seal.
- **Organic ingredients.** If a product has some organic ingredients but less than 70% of the ingredients are certified organic , the product can't be labeled as organic. It also can't carry a USDA seal. The ingredient list can show which ingredients are organic.

Does 'organic' mean the same thing as 'natural'?

No, "natural" and "organic" are different. Usually, "natural" on a food label means that the product has no artificial colors, flavors or preservatives. "Natural" on a label doesn't have to do with the methods or materials used to grow the food ingredients.

Also be careful not to mix up other common food labels with organic labels. For example, certified organic beef guidelines include pasture access during at least 120 days of grazing season and no growth hormones. But the labels "free-range" or "hormone-free" don't mean a farmer followed all guidelines for organic certification.

Lec 12 Theme Difference between organic foods and their traditionally grown counterparts

Lecture 13. Assessment of food safety in organic farming. Organic food: Is it safer or more nutritious?

Some data shows possible health benefits of organic foods when compared with foods grown using the usual (conventional) process. These studies have shown differences in the food. But there is limited information to prove how these differences can give potential overall health benefits.

Potential benefits include the following:

- **Nutrients.** Studies have shown small to moderate increases in some nutrients in organic produce. Organic produce may have more of certain antioxidants and types of flavonoids, which have antioxidant properties.
- **Omega-3 fatty acids.** The feeding requirements for organic farm animals (livestock) usually cause higher levels of omega-3 fatty acids. These include feeding cattle grass and alfalfa. Omega-3 fatty acids — a kind of fat — are more heart healthy than other fats. These higher omega-3 fatty acids are found in organic meats, dairy and eggs.
- **Toxic metal.** Cadmium is a toxic chemical naturally found in soils and absorbed by plants. Studies have shown much lower cadmium levels in organic grains, but not fruits and vegetables, when compared with crops grown using usual (conventional) methods. The lower cadmium levels in organic grains may be related to the ban on synthetic fertilizers in organic farming.
- **Pesticide residue.** Compared with produce grown using usual (conventional) methods, organically grown produce has lower levels of pesticide residue. The safety rules for the highest levels of residue allowed on conventional produce have changed. In many cases, the levels have been lowered. Organic produce may have residue because of pesticides approved for organic farming or because of airborne pesticides from conventional farms.
- **Bacteria.** Meats produced using usual (conventional) methods may have higher amounts of dangerous types of bacteria that may not be able to be treated with antibiotics. The overall risk of contamination of organic foods with bacteria is the same as conventional foods.

Are there downsides to buying organic?

One common concern with organic food is cost. Organic foods often cost more than similar foods grown using usual (conventional) methods. Higher prices are due, in part, to more costly ways of farming.

Food safety tips

Whether you go totally organic or choose to mix conventional and organic foods, keep these tips in mind:

- **Choose a variety of foods from a mix of sources.** You'll get a better variety of nutrients and lower your chance of exposure to a single pesticide.
- **Buy fruits and vegetables in season when you can.** To get the freshest produce, ask your grocer what is in season. Or buy food from your local farmers market.
- **Read food labels carefully.** Just because a product says it's organic or has organic ingredients doesn't mean it's a healthier choice. Some organic products may still be high in sugar, salt, fat or calories.
- **Wash and scrub fresh fruits and vegetables well under running water.** Washing helps remove dirt, germs and chemical traces from fruit and vegetable surfaces. But you can't remove all pesticide traces by washing. Throwing away the outer leaves of leafy vegetables can lessen contaminants. Peeling fruits and vegetables can remove contaminants but may also cut nutrients.

Lecture 13. Effects of regulation of organic plant production.

The regulations for organic plant production are comprehensive and detailed. An EU regulation released in 1991 (2092/91) contains parts which relate directly to the composition of organic plant products. The more important aspects of this regulation include: • a ban on genetic engineering and GMOs • lower nitrogen levels: maximum limits for manure application of 170 kg N ha-1yr-1 • a ban on synthetic pesticides • a ban on synthetic mineral fertilisers • a ban on growth promoters In the following the significance of these different aspects for food safety will be described. Ban on GMOs In organic farming it is forbidden to use genetic engineering and GMOs. Consequently, organic products may normally be assumed to be free of GMOs. However, organic products may become polluted by GMOs originating from conventional farming. This may occur through I) atmospheric spread and deposition, II) the use of polluted storage containers, and III) the feeding of conventional GMOcontaining feeds to animals. In Denmark, it is currently permitted to include respectively 20% and 10% conventional feed in pig and cattle diets. However, after 2005 Denmark will be subject to the EU regulation demanding 100% organic feed in organic agriculture. The ban on GMOs in organic food reflects the fact that their long-term effects on humans and nature are still unknown. For this reason the precautionary principle has been applied. Lower nitrogen levels In general, total applications of nitrogen (N) are lower in organic than in conventional farming systems. A comparison of different types of well-managed farming systems in Denmark showed that on average N inputs in organic farming (104-216 kg N ha-1 yr-1) were lower than in conventional farming systems (146-311 kg N ha-1 yr-1).

Lecture 14. *Effects of regulation on organic animal production.*

The regulation of organic animal production is comprehensive, and influences aspects of feeding, housing, demarcation, care, medical treatment and slaughter. An EU regulation on organic animal husbandry was released in 1999 (1804/99), different aspects of which are expected to directly affect the composition of organic

animal products. This regulation provides for: • 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 In the following the effects on food safety of extended access to out-door areas, the compulsory use of coarse fodder, and the restrictions on medicine use will be described. Extended access to out-door areas Infections (zoonoses) can be transmitted from animals to human beings through the consumption of food. In conventional agriculture attempts have been made to control zoonoses through the use of hygiene barriers. Knowledge about the influence of different production systems on the occurrence and distribution of microbes in food is still very limited. However, in comparison with conventional farming practice, the extended access to out-doors areas encouraged in organic production systems more greatly exposes animals to disease-promoting soil microbes (Table 6). Furthermore, the presence of rats, mice and birds increases the risk of animals being infected with Salmonella or Campylobacter bac- 7 teria, 55 especially in poultry production (Ole Heuer pers. Com.).56 Parasites also exist in nature and can cause infections (e.g. tapeworm), particularly in out-door pig production systems.26 However, in out-door organic animal production systems the density of livestock per hectare is relatively low. This may decrease the pressure of infection and help to neutralise the risk of zoonoses.26 Compulsory use of roughages Feed composition can reduce the incidence of zoonoses in organic as compared to conventional production systems (Table 6), the compulsory use of roughages in organic systems reducing the occurrence of harmful intestinal bacteria.26 A significantly higher content of conjugated linolic acid (CLA) has been observed in organic compared to conventional milk.58 This may reflect the higher content of grass in animal diets on organic farms (Table 6). A higher content of CLA in organic milk could have positive consequences for health, because CLA may help to control the onset of cancer and arteriosclerosis.26 Restricted use of medicine In accordance with EU directives, all EU countries monitor their animal products for the presence of residues of medicines. In the Danish controls of 1999 59 only limited amounts of these compounds were detected. Residues of medicine were found in 0.03% of pig meat and 0.09% of cattle meat, but nothing was found in the meat from poultry, venison, breeding fish, and milk and honey. In 1996, about 68% of the antibiotics used in conventional agriculture in Denmark were used as growth promoters (mainly to pigs), while only 31% was used directly for the treatment of different diseases.60 However, the use of antibiotics as growth promoters for pigs was prohibited in 1999. The restricted use of medicine in organic farming may be expected to produce a lower incidence of residues in organic animal products (Table 6), partly because of the double retention time imposed following medical treatment. However, no results are yet available from Danish controls on organic animal products.26 The restricted use of antibiotics could have a positive effect on health by reducing the risk for transfer of resistance genes from animal to human pathogens.

Lecture 15. Effects of processing on organic production.

The processing of organic food aims to maintain nutritional value and limit the number and quantity of additives and processing aids in food products.4 The regulations for organic processing in relation to food safety prohibit: • the use of more than 5% non-organic constituents, • irradiation, colouring agents, sweeteners, • synthetic additives, • the flavouring of animal products and artificial flavouring in vegetable food products, • GMOs, • artificial trans fatty acids These exclusions directly affect the composition and nutritional value of food products, and thereby the state of food safety. However potential impacts are still unknown.

8 AGRI-FOOD-SYSTEM SAFETY The safety / security of the agri-food system is an important but poorly understood aspect of food safety in general. It relates principally to the concepts of supply, distribution, transparency, proximity, information and consumer influence, and must ensure that production systems have no negative impacts on humans, other living organisms, the environment, climate etc. Effect of technological and structural development on organic production, processing and marketing There are no specific regulations for the technological and structural development of organic production, processing and marketing, although there exist several basic principles for the area.4 These include: • the production of food of high quality in sufficient quantities, • the fostering of local and regional production and supply chains, • support for the establishment of a comprehensive production, processing and distribution chain that is both socially and ecologically responsible There exist no specific regulations on the storage of organic products, and no national or EU regulations relating to the wrapping of these products. However, the Codex Alimentarius Commission advises the use of biodegradable and recyclable wrapping for organic products.63 Supply and distribution Adequate supplies of agricultural products result from ample primary production as well as efficient distribution chains. They are therefore linked to the structural development of agriculture, from production and processing to the marketing of products. The primary distribution routes for organic products are I) supermarkets chains, II) specialist retailers, and III) direct distribution outlets. The increase in sales by supermarkets has greatly affected the size of the market for organic produce in Europe.26 The question of supply of organic food products can be discussed at the local, regional, national and global levels. At the national level, the Bichel Committee 61 undertook an extensive analysis of the implications for the Danish Ministry of Food of a 100% transition to organic farming in Denmark. They concluded that a total transition to organic farming would produce a reduction of 1-3% in the gross national product and a decrease in private consumption of 1900-4700 DKK (2-5%) per year per inhabitant. Although this constitutes a considerable economic reduction, the analysis shows that it is possible to have 100% organic farming in Denmark, depending on consumer demand. At the global level, food supply can be discussed from two basically different perspectives of sustainability – resource sufficiency or functional integrity.84 Resource sufficiency emphasises the use of resources and the production and distribution of food, focusing first and foremost on the relationship between input and output in the systems under consideration. A sustainable development infers that agriculture can satisfy the requirements for food and textiles etc. for current and future generations, such that the most productive systems are also the most sustainable. This concept has been the dominating one in modern

conventional agriculture. From the perspective of resource sufficiency organic farming results in lower food safety than that achieved by conventional agriculture.