

SESSION 7

MEAT SAFETY



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Keywords: residues, contaminants, analytical evaluation, risk assessment**Abstract**

By **Meat** in this paper all edible parts of a slaughtered animal are understood preserved by chilling or freezing without any addition. **Meat Products** are physically treated meats (e.g. heated) to which other ingredients may be added. **Man-made Residues** are potential health hazards given to animals by direct human activity e.g. application of hormones. **Residues by Handling** occur during processing e.g. smoking or nitrite curing. **Environmental Contaminants** are all other potentially hazardous and unwanted substances who appear in meat via feed, drinking water or air.

Most residues are detected in meat only in minute concentrations. Many analytical data are quite often below detection or quantification limits and must be quantified in order to evaluate the risk. A way to achieve reliable results is presented. The paper deals with pharmaceuticals, nitrosamines, mycotoxins, agricultural pesticides, organochlorine compounds (dioxines, PCB etc), heavy metals and radionuclides. It is shown that in general meat is rather lightly contaminated by residues and environmental contaminants. There will be no health hazards by eating meat if regulations and recommendations are observed and good agricultural practice (GAP) and good manufacturing practice (GMP) are applied. In many instances by eating meat in average quantities there is a lower uptake of unwanted substances than with plant food.

1) Introduction

Hazardous concentrations of environmental contaminants like pesticides, organochlorine compounds, radioisotopes and heavy metals in meat and meat products are since many years of considerable concern for consumers and governments alike. It started with heavy metals in the sixties especially with high concentrations of inorganic lead which were found in many animal tissues. Also cadmium and mercury were detected in some special tissues and species and caused concern in the public due to their persistence.

Before and more so with the ban of DDT and other organochlorine pesticides in the seventies and eighties the widespread and persistent prevalence in fatty tissues of slaughter animals and accumulation in adipose tissues of human beings came into the focus of the public interest, especially when its appearance in higher concentrations in human milk was detected.

After the disaster of the atomic reactor in Chernobyl in 1986 radioactivity was spread widely over Eastern, Central and Northern Europe. The deposition of dust particles loaded with radioactivity especially Cs137 with its half life of 30 years causes still considerable contaminations of wild animals and venison in some limited areas of Europe.

Environmental contaminants found in meat are not directly dependent in their concentrations by human activity. Indirectly, however, human behaviour influences the environmental contaminants. Lead in gasoline as lead-tetraethyl intoxicated our environment; likewise did the use of methyl-mercury as staining in grain or the release of cadmium by industrial exhaustion. These treatments were not intended to contaminate food. Regulations caused considerable reductions of toxic substances in our environment and in consequence also in feedstuffs and animal tissues. Only the persistence of organochlorine compounds after decades of the ban is still a matter of concern.

A new dimension in the consumer's awareness of unwanted substances created the detection of the cancerogenic diethylstilbestrol (DES) in the seventies in baby food containing veal. Since this time an uninterrupted sequence of the illegal use of hormone cocktails, hormonelike substances (e.g. clenbuterol) applied to calves and found in meat lead in many countries of Europe to substantial reductions in veal and beef and to a reduced increase in pork consumption. Only poultry intake has increased consistently probably due to the in many minds of consumers existing but in this respect by no means justified differentiation between red meats and poultry.

In recent years additionally the widespread use of prophylactic applied antibiotics in animal feeds caused concern about residues and the possible development of antibiotic resistance in microorganisms. The problem was enhanced by the public opposition of the medical profession to the preventive application who themselves use (or overuse) many antibiotics in treatment of human diseases.

The awareness was brought to the public knowledge by scientists, journalists and politicians. It initiated governmental and business reactions. Man-made residues by application of pharmaceutically active substances are now worldwide regulated. They should cause no health hazards to human beings if they are applied according to the rules. Nevertheless the public is concerned about the abuse or mismanagement of these compounds. The different legal requirements in various countries and parts of the world add in a global trade to the suspicion and distrust of the public.

This paper will attempt to describe the current situation and clarify a number of points of concern.

2) Definitions

As can be concluded by the introduction there should be made a differentiation between residues and contaminants.

RESIDUES are unwanted substances in a food caused by the direct action of human beings during pre- and postharvest (slaughter) activities or processes. These activities are e.g. the application of pharmaceuticals to live animals. The improper heating of nitrite cured

meat products leading to the formation of nitrosamines, the smoking of meat products resulting in the deposition of polycyclic aromatic hydrocarbons (PAH) or the feeding of poorly stored grain contaminated with mycotoxins are processes which cause residues in meat and meat products by handling. The contamination by direct application of pharmaceuticals can be controlled by observing legal requirements, the contamination by processes can be avoided or minimized by proper technologies and handling implemented in Good Agricultural Practice (GAP) and Good Manufacturing Practice (GMP).

CONTAMINANTS are unwanted substances in food which are brought into animals by feed, drinking water or air without knowledge or the direct activity of a farmer. Polycyclic aromatic hydrocarbons (PAH) produced by furnaces or vehicle exhaust and deposited on feedstuffs are contaminants and not residues which the PAH are by smoking of meat products.

3) Principles about the evaluation of analytical data

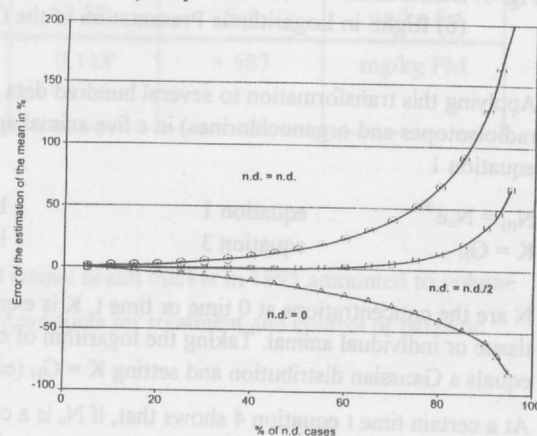
Many residues and contaminants are found in food, also in meat in very minute quantities. Legislative measures have reduced in the recent years the concentrations in the tissues even further. Despite of the permanent improvement of the analytical techniques the analytical chemists observe more and more frequently results which are below the range of the level of detection or of quantification (determination). Often more than half of the observations in a reported set of data are at or below the limits of detection (n.d.) or below the limits of quantification (n.q.). These data must be, however, quantified often in some way in order to derive legal limits (MRL), daily intakes or toxicity values. For this reason values n.d. and n.q. are quantified. They may be set

- as zero, ($n.d. = 0$),
- as the half value of the detection limit ($n.d. = \text{value of } n.d./2$) or
- all n.d. values obtain the value of n.d. ($n.d. = n.d.$)

n.q. values may be quantified in a similar manner.

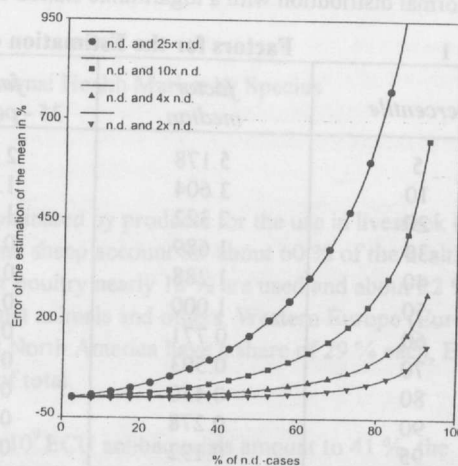
Fig. 1 shows how the three different „quantification methods“ of n.d. values in dependence of its percentage in a set of data lead to misinterpretations.

Fig. 1 Percentage of the Errors Made when Estimating the Mean in Dependency of the Percentage of Non-detectable Observations (n.d.); Demonstrated for 3 Methods: $\langle n.d. = 0$; $\langle n.d. = n.d./2$; $\langle n.d. = n.d.$



The problem gets even worse if results of two laboratories with two different analytical limits of detection (n.d.) are put together for quantitative evaluation. Fig. 2 shows that with a variation in detection limits between two laboratories by a factor of 2 to 25 the error of estimation increases heavily if more than 20 resp. 70 % of the data are n.d. values.

Fig. 2 Errors of Estimation of the Mean Using n.d. data Equal to n.d./2 Values. Two Different Laboratories are Assumed to Have Different Limits of Detection by the Factors of 2, 4, 10 and 25



Under the conditions of practice variations of even factor 50 in detection limits are observed (Weigert et al. 1991). This latter report evaluated the contamination of pig fat with the PCB congener 28 using 1039 samples of analyses with n.d. values (91 %) of 1145 samples altogether and quantified them. n.d. values were set „equal to n.d./2“ with about two dozen different n.d. values of about 40 laboratories varying by the factor of 50. The report calculated $17 \mu\text{g PCB-28/kg pork fat}$. We measured the same contaminant in pork fat with a detection limit of $1 \mu\text{g/kg fat}$. 30 % of our samples were n.d. values (Scheuer 1992). We found using the above mentioned three ways of evaluation between $0.5 \mu\text{g}$ and $1.8 \mu\text{g PCB-28/kg pork fat}$. Using our higher value only ca. 1/10 of value by Weigert et al. (1991) was calculated; with the lower one 1/30 of $17 \mu\text{g PCB 28/kg pork fat}$ was obtained.

Due to this unsatisfying discrepancy we developed an evaluation method for contaminants and residues present in low concentrations in food (Hecht and Honikel 1995). From evaluations of many data sets of contaminants we knew that the distribution of concentrations was not following a linear Gaussian (normal) bell shape (fig. 3a). One always observes a steep increase at low and a slow decrease to higher concentrations. By transforming the concentrations into logarithmic values, the distribution of fig. 3b is found with a always rather good fit to an ideal Gaussian distribution of the values in one data set.

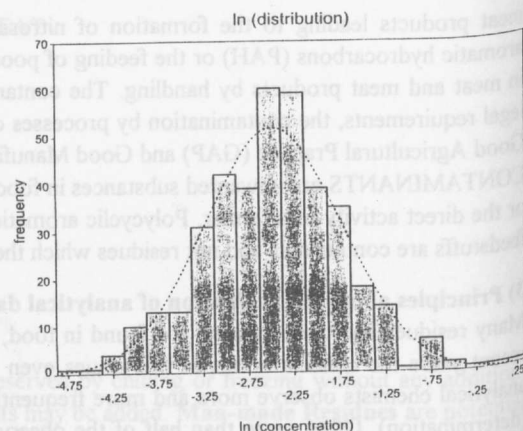
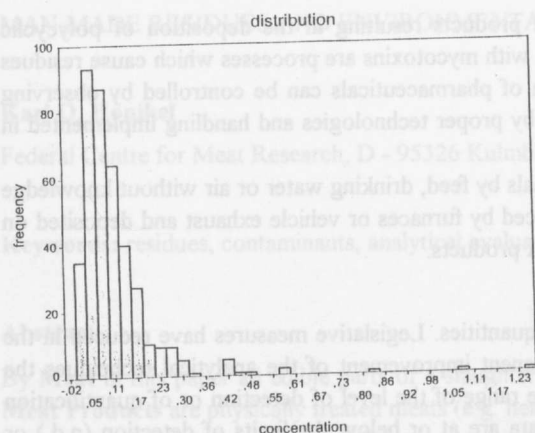


Fig. 3. Distribution of Cadmium concentration (mg Cd/kg FM) in Liver of Roe Deer in (a) Left: Linear Presentation; (b) Right: in Logarithmic Presentation of the Concentration

Applying this transformation to several hundred data sets of residues and contaminants we observed that all substances (heavy metals, radioisotopes and organochlorines) in a live animal apparently are following in absorption and excretion rates in the tissues the equation 1

$$N_{(t)} = N_0 e^{-Kt}$$

$$K = G_N$$

equation 1
equation 3

$$\ln N_t = \ln N_0 - K \cdot t$$

$$\ln N_t = \ln N_0 - G_N t$$

equation 2
equation 4

N are the concentrations at 0 time or time t , K is expressing the velocity of the process which may be different for each substance, tissue or individual animal. Taking the logarithm of equation 1 one obtains equation 2. Assuming as shown in many datasets that K equals a Gaussian distribution and setting $K = G_N$ (equation 3), then equation 2 gets the form of equation 4.

At a certain time t equation 4 shows that, if N_0 is a constant value, the logarithm of the actual concentration of the pollutant ($\ln N_t$) is following a normal (Gaussian) distribution in a set of data. Evaluating hundreds of data sets we found that many of them did show a log normal distribution with a logarithmic standard deviation (σ) of about 1.

Table 1 Factors for the Estimation of Percentiles^{a)}

percentile	factor median	factor 25 - percentile	factor 75 - percentile
5	5.178	2.642	10.159
10	3.604	1.839	7.071
20	2.322	1.185	4.556
30	1.689	0.862	3.314
40	1.288	0.657	2.527
50	1.000	0.510	1.962
60	0.771	0.396	1.524
70	0.593	0.303	1.163
80	0.430	0.219	0.844
90	0.278	0.142	0.545
95	0.192	0.098	0.377
98	0.126	0.064	0.247
99	0.097	0.049	0.190

^{a)} Use of the table: If one has quantified data up to the 60 percentile 60 of 100 samples) and one wants to calculate the 25 percentile, then „25 percentil value = 0.396 x 60 percentil value“. If the median should be calculated from the value of the 90 percentil, then „median value = 90 percentil value x 0.278“.

Assuming that the above said applies to all non-essential contaminants and residues having a logarithmic standard deviation of 1 then it is possible to estimate the distribution of values below detection (n.d.) or below quantification (n.q.) limits. The full calculations are reported in Hecht and Honikel (1995). The calculated factors are described in table 1 to estimate the median of a data set with quite a considerable number of n.d. values. The table gives very satisfying results if up to 80 % of n.d. values are present in a data set and the number of data are around 100 and above. Table 2 shows the quality of these calculations. With a high number of N the deviations of calculated and measured values are below 10 %.

Many national and international evaluations of concentrations of residues and contaminants in food, of daily intakes and of toxicological significance are carried out from data with many values of n.d. or n.q. The relevance of the results calculated from these data should be dealt with caution.

Table 2 Measuring and Calculating the Median with the Factors of Table 1 from a Number of Data Sets (Hecht and Honikel 1995)

	Pollutant	Matrix	N	calculated median	measured median	% deviation	unit
unbiased	HCB	red pepper	44	0.30	0.21	+ 60	µg/kg DM
	PCB 153	carrots	17	0.54	0.39	+ 38	µg/kg DM
	Cs-137	muscle, red deer	19	122	150	- 19	Bq/kg FM
	Cs-137	muscle, roe deer	150	637	600	+ 6	Bq/kg FM
	Cs-137	muscle, wild boar	97	4512	4350	+ 4	Bq/kg FM
	Pb	leaves of birch	220	1.07	1.0	+ 7	mg/kg DM
	Cd	muscle, red deer	403	5.06	5.28	- 4	µg/kg FM
	PBC-153	fat of pigs	98	3.55	3.52	+ 1	µg/kg fat
biased	Pb, biased by bullet splinters	muscle, roe deer	845	0.663	0.113	+ 587	mg/kg FM

4) Man-made residues

4a) World market for Pharmaceuticals

According to the European Federation of Animal Health (Fedesa 1997) the world animal health market in 1995 amounted to volume of 11×10^9 ECU^a). 44 % equal to 4.5×10^9 ECU were pharmaceuticals. Especially products for treatment and control of parasitic infections have done most to boost the pharmaceutical market in the last years.

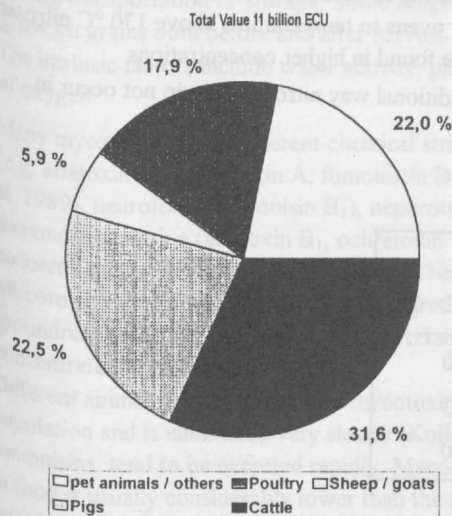


Fig. 4 World Animal Health Market by Species

The market is dominated by products for the use in livestock (fig. 4). Cattle, pigs and sheep account for about 60 % of the health product sales; for poultry nearly 18 % are used and about 22 % go for treatment of pet animals and others. Western Europe (European Community) and North America have a share of 29 % each, East Asia buys 19 % of total.

In Europe the pharmaceuticals account for 48 % of sales. Of the total value of 1.5×10^9 ECU antibacterials amount to 41 %, the antiparasitics amount to 32 %. Feed additives account in Europe for a share of 37 %. While the whole market is growing, the sales of antibacterials (antibiotics) drop. But there are variations between countries. With 3.3×10^9 ECU in 1995, animal health sales in Europe amount to about 5 % (!) of the human pharmaceutical market value only. In Germany with a total sale of about 380×10^6 ECU in 1995 the hormones had a market share of 5 %, antiparasitics amounted to 19 %, antibiotics to 30 % and biologicals (mainly vaccines) to 25 %.

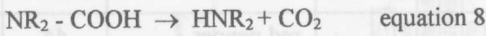
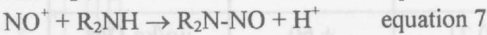
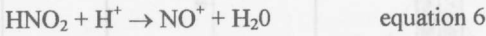
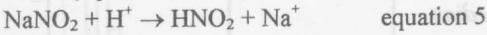
4b) Veterinary drugs

Veterinary drugs may be administered in animal feeds. Of all the pharmaceuticals the use of hormones and antibiotics as feed additives or growth promotors are the most heavily discussed topics in Europe and many countries around the world. If the concentrations in foods of animal origin exceed the established Maximum Residue Limits (MRLs), there may be a potential risk to human health. MRLs, however will not be exceeded if concentrations are applied according to recommendations and Good Agricultural Practice (GAP) and Good Veterinary Practice (GVP) are observed. Controls worldwide by surveys confirm this (Hapke 1996). Only products licensed for administration to food production animals should be used and the withholding time should be observed before milk or eggs are used for food or animals are sent for slaughter.

5) Residues by handling

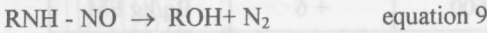
5a) Nitrosamines

Stable nitrosamines are formed by a sequence of reactions in light acidic environment in the presence of secondary amines (R₂NH) and nitrite (equations 5 to 7).



In fresh meat there are neither nitrite (table 3) nor amines in sufficient concentrations available. During ageing and heating of meat and storage of raw meat products, amines increase by decarboxilation of free amino acids (equation 8).

With primary amines, produced by most amino acids, the decarboxilation product of α-amino acids does not form stable nitrosamines and the following reactions occurs resulting in alcohol and nitrogen (equation 9):



Secondary amines can only be formed by the amino acids tryptophan, proline, hydroxiprolin, histidine and arginine and some other rare amino acids (equation 8).

Table 3 Concentrations of Nitrate and Nitrite in Germany (according to Weigert et al. 1986)

food group	nitrate mg/kg		nitrite mg/kg	
	median	variation	median	variation
milk and dairy products	12.0	0.5 - 166	0.2	0.2 - 1.3
meat	4.75	1.0 - 495	0.2	0.1 - 16.5
meat products	29.0	0.1 - 1384	3.0	0.1 - 48.7
cereals and bakery products	10.0	0.3 - 194	0.4	0.3 - 1.0
vegetables	29.3	0.05 - 6798	0.04	0.04 - 15.6
water	10.6	0 - 46.8	< 1	—

In many foods, especially plant foods nitrate is present naturally. In processed foods (dairy-, meat products) nitrate may be added (table 3). In aged raw or heated meat there is still no nitrite present. In cured meat products, however, nitrite is either added or formed from nitrate by microbial activity (table 3). In cooked meat products of Bologna or liver sausages type the pH-value is about pH 5.9 and higher. At this pH nitrosamines cannot be formed in detectable quantities. So only in aged, fermented raw meat products with a pH below 5.5 nitrosamines may be formed. During heating of such products especially frying in pans, grills or ovens to temperatures above 130 °C nitrosamines are found in higher concentrations.

Studies by Kühne (1995) show (table 4) that in raw unheated hams manufactured in a traditional way nitrosamines do not occur in higher quantities.

Table 4 Nitrosamine Concentration in Raw Hams (N = 48) (Kühne 1995)

	Nitrosamine (µg/kg)			
	0 - 0.5	0.5 - 1	1 - 2	> 2
N - Nitroso-dimethylamine (NDMA)	27	14	7	0
N-Nitrosopiperidine (NPIP)	40	2	3	3
N-Nitrosopyrrolidin (NPYR)	48	0	0	0

Nitrosamines in meat and meat products are therefore of no concern if the products are properly manufactured and if cured meat products are not heated above 130°C. The calculated uptake of nitrosamines by food was reported to be approaching 1 µMol/day. This is a small quantity in comparison to the endogeneous production in the stomach and intestinal tract up to 100 µMol/day (Shephard 1995). For calculating the latter value the total uptake of nitrate + nitrite must be taken into account. Whereas the comparatively small nitrite intake is mainly coming from meat products (table 3) the nitrate intake is coming mainly from vegetable sources (Bundesrat 1994). The nitrate uptake is manifold higher than that of nitrite (table 3). This again shows that the nitrite in meat products are contributing only to a small part to the nitrosamine problem.

5b) Polycyclic aromatic hydrocarbons (PAH)

PAH can be environmental contaminants if they are deposited with dust particles on plants. PAH are produced by many combustion processes especially with the lack of sufficient oxygen and at temperatures above 600°C. One of the PAH sources in our environment are car exhausts. PAH are occurring as environmental contaminants only in plant or marine food as they are usually metabolized in farmed livestock.

Smoking of food, however, may contaminate the products with PAH. Meat products in Central, Eastern and Northern Europe are smoked to a considerable part. In Germany 75 - 80 % of all meat products have undergone some kind of a smoking process. Smoking is done today mainly for sensorical reasons and in raw meat products to prevent the growth of moulds.

Do to the widespread use of smoking already in 1972 the MRL for benzo-a-pyrene (BaP), as a guide substance for PAH was set in Germany for meat products to 1 µgBaP/kg product. Meat products were the only food group for this limit, as in plants and marine products as said above PAH occur as environmental contaminants in variable and often higher concentrations. Fresh meat is free of PAH.

Due to the legal requirements for meat products smoking techniques were developed and as can be seen by a survey from 1990 - 93 only 25 (ca. 3 %) of 735 samples of meat products (table 5) were above 1 µgBaP/kg.

Table 5 : Benzo-a-pyrene Content in Smoked Meat Products 1990 to 1993 (Westphal et al. 1994)

meat products	n	min-max (µg/kg)	mean (µg/kg)	median (µg/kg)	n > 1 µg/kg
Bologna type	170	< 0.03 - 2.80	0.39	0.21	16
liver sausage type	149	< 0.03 - 0.79	0.19	0.16	0
raw sausages	262	< 0.03 - 1.18	0.22	0.16	6
raw and cooked hams	154	< 0.03 - 5.43	0.22	0.14	3
total	735	< 0.03 - 5.43	0.25	0.17	25

Most of the meat products were produced with freshly produced smoke. Liquid smoke which is used more and more often during the last decade has reduced the BaP concentration even further.

5c) Mycotoxins

Mycotoxins are secondary metabolites produced by fungi of various genera growing on agricultural products before or after harvest or during transportation or storage. Some fungi typically infest grains before harvest, others can invade grain after harvest, some can grow on grains both before and after harvest. Many factors influence fungal growth and mycotoxin production on a given substrate. The intrinsic factors include water activity, pH and redox potential. Extrinsic factors are relative humidity, temperature and availability of oxygen.

Many mycotoxins, with different chemical structures and biological activities, have been identified. Mycotoxins may be carcinogenic (e.g. aflatoxin B₁, ochratoxin A, fumonisin B₁; Fukal and Sova 1988), oestrogenic (zearalenone and α and β zearalenols, Sawinsky et al. 1989), neurotoxic (fumonisin B₁), nephrotoxic (ochratoxins, citrinin, oosporeine), dermonecrotic (trichothecenes) or immunosuppressive (aflatoxin B₁, ochratoxin A and T-2 toxin; Honstead et al. 1992). Much of the published information on toxicity concerns studies in experimental animals. These may not reflect their effects in humans and other animals.

Mycotoxins are found regularly in feed ingredients such as maize, sorghum grain, barley, wheat, rice meal, cottonseed meal, groundnuts and other legumes. Most are relatively stable compounds and are not destroyed by processing of feed and may even be concentrated in screenings.

Different animal species metabolise mycotoxins in different ways. For example in pigs, ochratoxin A can undergo entero-hepatic circulation and is eliminated very slowly (Koller 1992) while it is rapidly excreted by poultry species. The polar mycotoxins, such as fumonisins, tend to be excreted rapidly. Mycotoxins, or their metabolites, can be detected in meat, milk and eggs. Their concentration in food is usually considerably lower than the levels present in the feed consumed by the animals and unlikely to cause acute intoxications in humans. However, residues of carcinogenic mycotoxins, such as aflatoxin B₁ and M₁, and ochratoxin A, when present in animal products pose a threat to human health. In most instances the principal source of mycotoxins for humans is contaminated cereals and legumes rather than animal products. There is limited information available worldwide regarding the occurrence of mycotoxin residues in animal products intended for human consumption. The levels of mycotoxins detected are usually below the maximum levels accepted in most countries (Van Egmond 1989).

6) Environmental Contaminants

6.1) Control of hazards by environmental contaminants

Throughout Europe the contamination of foods with contaminants is controlled on a regular basis. Each country gets assigned a number of analyses which are announced by a governmental publication. For 1999 in Germany (Gemeinsames Ministerialblatt 1998) it was announced that 4798 samples of food must be analysed. 54 state laboratories in all 16 states of Germany participate. The year by year changing foods and pollutants are called with their requested limits of quantification. For 1999 in the meat area turkey meat, turkey liver and salami type sausages must be analysed for many chlorinated pollutants like DDT, DDE, PCB congeners, toxaphen

congeners, and metals like lead, cadmium, mercury, copper and zink. The data are collected for 4 years and evaluated in the Nutrition Report - Ernährungsbericht. The last one appeared in 1996.

6.2) Agricultural chemicals

The invention of artificial fertilizers and the use of herbicides, pesticides and fungicides permitted mankind to keep up their food production with population growth. Presently the use of genetically modified organisms (GM0) opens even wider scopes and may permit to reduce to amounts of fertilizers and pesticides in the future. In the early years of application pesticides were used heavily. As they were regarded as helpful a surplus use was regarded as even better. Only after intoxications or long range effects e.g. with DDT were observed, the use became more careful. Nowadays most of the pesticides used are rather fast metabolized either extracellular or in organisms. The ones which persist in nature or organisms are used carefully.

The potential hazards in foods include excessive residue levels of herbicides, pesticides, and fungicides and contaminants such as the polychlorinated biphenyls (PCBs) and heavy metals including mercury, lead, or cadmium. Cereals and treated seeds are the most likely source of latter contaminants. The most significant hazards in animal foods to human health are those chemicals which accumulate in animal tissues which are excreted in milk or become incorporated in eggs at levels in excess of established limits such as the MRLs for foods. It is therefore essential that the levels of agricultural chemicals in feed are sufficiently low that their concentration in food is consistently below the established MRLs.

In animal products most of the non chlorinated pesticides are metabolized fast or not taken up by feed. Studies in Italy (table 6) and other countries show that animal foods contain no pesticides above MRL. Most of these compounds are not found in meat (Hapke 1996). Chlorinated pesticides like Lindan or the metabolic product of DDT, the p,p-DDE can be found in small quantities. The concentrations are small and far below the MRL.

6.3) Dioxine contamination of meat

In 1996 200 samples of meat and meat products were collected in the different regions of Germany. The collected cuts were neck of pork, entrecote of beef and hindleg of chicken with skin. The samples were collected in artisanal butcher shops in order to obtain meat from the region. With meat products samples of liver sausage (cooked sausage), Lyoner sausage (emulsion type sausage), raw sausage (salami type) and Frühstücksspeck (bacon) were collected.

The results showed log-normal distributions for all congeners as demonstrated in chapter 3 for environmental contaminants. This form of distribution is also valid for total international toxicity equivalents (iTEQ). Fresh meat exhibited clear differences between the species. In beef the 2,3,4,7,8-PeCDF (F114) is the most important congener. In pork additionally the 2,3,7,8-TCDD (D48) and the hepta and octa chlorinated dibenzo-p-dioxines are the decisive congeners. Chicken is situated between beef and pork. Meat products with pork as their main ingredient show values in the range of fresh pork. Calculating the iTEQ (Natoscale), beef has a higher iTEQ than chicken, pork and meat products (table 7)

Table 6 Monitoring of Pesticide^{a)} Residues in Food Commodities in Italy, Years 1992 - 1994 (Losi et al. 1998)

		Number of samples MRL			above MRL %
		total	below	above	
Fruit	grapes	66	61	5	7.2
	kiwi	66	60	6	9.1
Vegetables		467	459	8	1.8
Mushrooms		3	2	1	33.4
Cereals	wheat	106	106	0	0
	maize	9	8	1	11.2
Animal	milk	416	416	0	0
Products	meat	1823	1823	0	0
	egg	11	11	0	0

^{a)} substances like carbendazim, methidation, procymidone, chlorpyrifos, iprodione, profram, chlorprofam, p,p-DDE and others.

Table 7 Contamination of Meat with Dioxines

species and product	N	Median total iTEQ (ng/kg fat)
pork	46	0.073
chicken	17	0.215
beef	32	0.458
liver sausage	12	0.213
lyoner sausage	40	0.127
raw sausage	20	0.153
bacon	12	0.080

The intended change of toxicity equivalence factors (TEF) by WHO will not change the results dramatically.

There exists quite a variation of contamination within Germany. In southern Germany the iTEQ of fresh meat are about 1/5 of the values of the western part. With meat products this variation is much smaller.

Calculating the intake of the consumer by meat and meat products we found a **daily intake of 4.32 pg iTEQ**. Assuming a 70 kg weighing person, each person takes in **0.062 pg iTEQ per kg body weight and day**.

Taking into consideration the intended acceptable German value of 1 pg iTEQ per kg body weight and day only 6.2 % of this value are taken in by meat and meat products. Comparing meat and meat products with other foods of Germany which were measured in their dioxine content we calculated that 0.46 pg iTEQ dioxines and furanes/kg body weight and day are eaten by the German consumer. Meat and meat products account for 13.5 % of the total intake. Milk and milk products and fish will contribute about 30 - 40 % each to the total intake.

6.4) Polychlorinated Biphenyls, toxaphens and chlorinated paraffins

Dioxines occur in our environment and consequently also in meat in pg or ng/kg fat. Polychlorinated Biphenyls (PCB) contrary to dioxines PCB have been produced on an industrial scale estimated up to more than 1 million tons until 1984 when the production ceased worldwide. PCB were used as inflammable oils of excellent physical characteristics in hydraulic systems, in printer's ink or paints and as electric insulator in many everyday machinery and equipment. Due to this widespread use PCB were contaminating the environment. PCB are fat soluble and accumulate in adipose tissue of animals and man. Primary source is the soil and dirt particles on feedstuff and plant food. Further contamination occurred via paints in barn and silage chambers. They are persistent and are very slowly metabolized.

In human milk with the mobilization of the fat depots of the mother's body also PCB are set free and occur in the milk in unwanted high concentrations. In animal food, milk, eggs and meat(fat) contain PCB. There exist 209 congeners. They are numbered PCB1 to PCB 209 according to their degree of chlorination. Higher numbers mean a higher degree of chlorination. The PCB with low degree of chlorination (low PCB number) are comparatively fast metabolized in animal and human tissues. In table 8 monitoring results in Germany are presented. As the PCB concentration is related either to fresh matter (in table 8 with egg and cod) or to the fat in the food (all meat fats and milk in table 8), the results are often not easy to compare. The low values of chicken egg (about 12 % fat) must be multiplied by about a factor of 8 to be comparable to beef-, pork fat and milk. Cod is a very lean fish (< 1 % fat) having a very high concentration of PCB, if related to its fat content. Both wild living animals, fish and roe deer, as observed in many other cases of environmental contaminants (see radionuclides), are higher contaminated than food from the farm.

Toxaphen (Camphechlor) is a mixture of chlorinated camphenes with about 65 - 70 % chlorine in the molecule. From 1948 up to about 1980 (OECD countries) or 1989 (Commecon countries) several hundred thousand tons were produced. Toxaphen was used as rodenticide and insecticide in farming and animal production. Even if it was used on farmland the main contamination is observed in salt-water fish. The concentration in meat animal are much smaller.

Another group of organochlorine compound are chlorinated paraffins. They are still in use for similar purposes as PCB. They have been introduced in the 1920 and used still as they are regarded as only lightly toxic. But they are also persistent. No satisfactory analytical method exists to measure their concentrations in foods.

Table 8: PCB Congener Concentrations (µg/kg Fat resp. in Cod and Egg µg/kg Fresh Matter) in Various Foods

tissue	PCB 28	PCB 52	PCB 101	PCB 138	PCB 153	PCB 180	References
beef fat	-	-	-	5	9	5	Hapke (1996)
pork fat	-	-	-	1.5	6.3	4.1	Scheuer (1992)
chicken fat	0.5	0.5	0.5	3.3	5.5	2.5	Ueberschär (1993)
chicken egg	0.2	0.2	0.2	1.2	1.9	0.7	Ueberschär (1993)
roe deer fat	-	-	-	14.0	20.9	11.0	Hecht (1993)
cow's milk	7.5	7.5	5.0	6.0	9.5	5.0	Weigert et al. (1993)
cod	< n. d.	0.3	0.5	0.6	0.7	0.2	Karl, Kellermann (1993)

6.5) Heavy metals

Under heavy metals all transition metallic elements are understood. Many of them are essential elements in low quantities. Therefore mechanisms exist to bind or store ions of these elements in different tissues. Liver and kidney are organs which are used as food and which accumulate heavy metals. Pollution of pasture and other farm land with heavy metals may occur either following aerial spread

from smelting plants and other types of industrial process or the spreading of human and animal waste (sewage sludge, manure and slurry) on to land (e.g. Strauch, 1987). In both circumstances the metals may be ingested by animals grazing the pasture or consuming conserved forages and these metals may subsequently pass to the human population via meat or other products of animal origin. The uptake of heavy metals by plants is a complex matter and is influenced, inter alia, by the soil type (Miller et al. 1995

Table 9: Median Cadmium and Lead Contents of Meat of Different Species (µg/kg Fresh Matter) 1982 and 1993 in Germany (Hecht 1997)

element	cadmium		lead	
	BAFF ^{a)} '82	WHO ^{b)} '93	BAFF ^{a)} '82	WHO ^{b)} '93
meat				
beef	6.12	0.76	141	3.6
veal	2.84	1.95	92	4.3
pork	4.40	0.55	25	4.9
turkey	4.48	0.78	47	2.1
wheat grain	-	74	-	17
rye grain	-	18	-	29

^{a)} BAFF = German Federal Centre for Meat Research

^{b)} WHO = WHO study in Germany carried out by BAFF

All other heavy metals, including mercury are of only local or short term importance. In meat itself in most of the cases the concentrations are below detection limit, in liver and kidney the reduction in the las decades becomes obvious.

6.6) Radionuclides

The accidental emission of radioactive material from nuclear power stations is a recognized problem. It has implications for humans, animals and their food and feed. The Chernobyl accident was the most serious of its kind. Many areas of Northern, Eastern and Central Europe were contaminated. 13 years after the accident, the contamination beyond the environment of Chernobyl is limited to some small areas. In Germany we collected data since 1986 and identified the still contaminated regions. Within this region we have tremendous differences within a distance of a few kilometers, between forests and agriculturally used areas, between the seasons and between animal and plant species.

The isotope which is still present is (Cesium) Cs-137 with a half life of 30 years. Cs is chemically close to potassium (K). It remains with a minimal wash out effect within the environment of original deposition. In general farmed food products of plant and animal origin are nearly uncontaminated as the alkaline fertilizers bind Cs in the soil. In forests with a lower pH (< pH 5) the Cs is only partially bound and taken up by plants from the soil. Wild animals living and feeding in forests are contaminated. This varies with seasons. There are also variations between the years.

7.) Conclusions

Non-made residues can be easily kept below hazardous concentration by observing recommendations for the application of drugs, applying GAP and GVP. Technological processes can be controlled as well. GMP must be used. Environmental contaminants have been reduced in the last decades. Meat is in most cases only lightly contaminated especially meat from farms. In general meat and meat products are no health hazards when produced with the recommended codes of practice.

8.) References

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With the introduction of the atomic absorption spectroscopy in the sixties the contamination of foodstuffs with heavy metals could be detected. The unexpected worldwide pollution of food with heavy metals lead to regulations. Measures like lead-free gasoline or filtering the exhaust of industrial plants lead to reductions since the seventies which is shown for lead and cadmium in various meat species in table 9. In principal lead has been reduced in Germany from 1982 - 1993 by a factor of 5 to 20, the cadmium contamination by a factor of 2. The concentrations of lead in meat is the same or smaller than nonmeat food. By the intake of meat only about 5 - 6 % of the total lead contamination is consumed.

Cadmium concentrations in meat are usually lower than in non-meat food. This is due to the uptake of cadmium by roots whereas lead is not absorbed in this way. Lead is spread on leaves by dust or soil particles. The uptake of cadmium by meat due to its low concentrations amounts to only 1 % of the total already low intake.

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