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BfEL

TRACEABILITY FROM A EUROPEAN PERSPECTIVE

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Situation up to the end of 2004

- **Food and feed business operators had to conform to traceability directives demanded by their customers along the entire chain**

- **Large European retailers (Aldi, Lidl, Real, Metro, Marks and Spencer, etc.) were very rigorous with respect to their traceability criteria**

EUROPEAN LEGISLATION ON TRACEABILITY

Situation as from 1 January 2005

- EU regulations mandate that all food and feed business operators
- be legally bound to have traceability systems
- even when their customers do not require it

- Questions arising:
- Are there sufficient traceability procedures in place?
- Are problems solved hidden in the detail?
- Can smaller companies comply with traceability requirements of large retail companies?

The General Food Law

- Regulation (EC) 178 (2002) of the European Parliament and the Council published on 28 January 2002:
- Outlines the general principles and requirements of food law
- Establishes the European Food Safety Authority (EFSA)
- Provides procedures in matter of food safety, i.e. among other things the implementation of traceability systems in the food and feed supply chains in Europe
- Article 18 of the regulation referring to traceability of food and feed is effective since 1 January 2005

Article 18 of Regulation (EC) 178 (2002)

1. The traceability of food, feed, food-producing animals, and any other substance intended to be, or expected to be, incorporated into a food or feed shall be established at all stages of production, processing and distribution.

Article 18 of Regulation (EC) 178 (2002)

2. Food and feed business operators shall be able to identify any person from whom they have been supplied with a food, a feed, a food-producing animal, or any substance intended to be, or expected to be, incorporated into a food or feed.

To this end, such operators shall have in place systems and procedures which allow for this information to be made available to the competent authorities on demand.

Article 18 of Regulation (EC) 178 (2002)

3. Food and feed business operators shall have in place systems and procedures to identify the other businesses to which their products have been supplied. This information shall be made available to the competent authorities on demand.

Article 18 of Regulation (EC) 178 (2002)

4. **Food or feed which is placed on the market or is likely to be placed on the market in the Community shall be adequately labelled or identified to facilitate its traceability, through relevant documentation or information in accordance with the relevant requirements of more specific provisions.**

Article 18 of Regulation (EC) 178 (2002)

5. Provisions for the purpose of applying the requirements of this Article in respect of specific sectors may be adopted in accordance with the procedure laid down in Article 58, paragraph 2, referring to *Committee* and *Mediations Procedures.*

Articles 19 and 20 of Regulation (EC) 178 (2002)

If food and feed business operators consider, or have the reason to believe that a food/feed which they have imported, produced, processed, manufactured or distributed is not in compliance with the food/feed safety requirement, they will immediately initiate procedures to withdraw the food/feed in question from the market where the food/feed has left the immediate control of that initial food/feed business operator and inform the competent authorities thereof.

Conclusions for food processors

- **Previously:**
- **To identify the source of an ingredient was sufficient**

- **Now:**
- **Food products have to meet the requirements of food law**
- **Source of each ingredient has to be traceable**
- **Suppliers are obliged to provide full traceability**

Traceability

- **<u>Tracking:</u> Provision of Information Downstream**

Primary production
↓
Processing
↓
Distribution/Retailing
↓
Consumer

- **<u>Tracing:</u> Provision of Information Upstream**

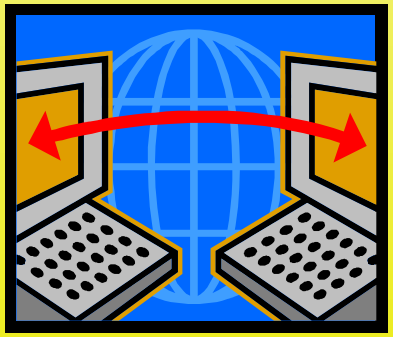
Consumer
↓
Distribution/Retailing
↓
Processing
↓
Primary production

Traceability along the full supply chain

- **Combination of:**

- **Suitable methodologies for the analyses of food and feed materials (finger-print techniques)**

- **Information Technology Systems**



Traceability along the full supply chain

- **Traceability**
- **applies to everything that contributes to food safety (packaging, closures, seals, jars, etc.)**
- **covers everything that happens to the products before, during and after the manufacturing, packaging, and distribution involving ingredients, processes, test and test results, environment (temperature, time, humidity), resources used (people, machines, knives), transport methods, timescales, etc.**

Implications for food processors

- More data will have to be recorded on different levels
- Data have to be kept for extended periods of time
- Gathered data have to be linked for traceability and to be highly accurate
- Data have to be collected and stored quickly
- Data collecting may not afford production costs
- Processors cannot rely on paper records, systems that are not linked together or manual data entry
- Processors must have thoroughly tested proven, infallible systems
- Who will do this and how will this be done?
- Storage and accessibility of data has to be taken into consideration!
- Data error could result in a whole consignment of products being recalled or lead to a factory shutdown
- Data collecting has to be achieved at lowest cost level
- Automated data logging is the only possible option
- Integrated traceability data through production, storage, selling and quality control are needed

TRACEABILITY IN MEAT AND MEAT PRODUCTS

Traceability in meat and meat products

- **Various technologies are available:**
- **Some can be used to make definite inferences regarding the foodstuff`s origin or history**
- **Others can only be used to confirm the presence of specific components**

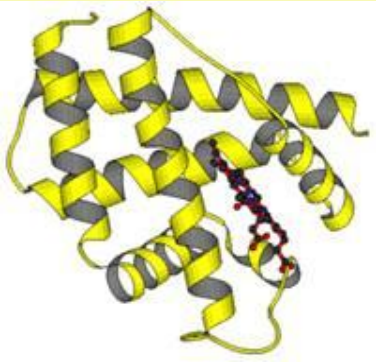
Traceability in meat and meat products

- Information on
- animal species
- age
- composition
- origin
- authenticity
- production system
- feed

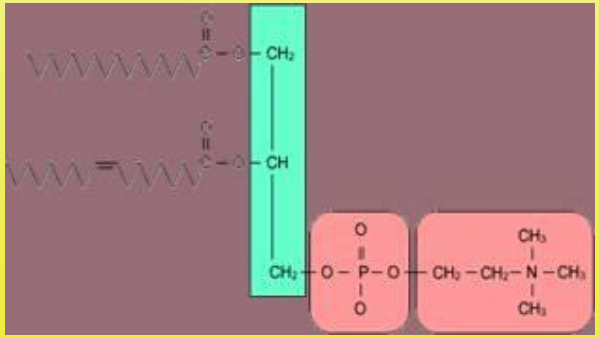
Identification of animal species in meat and meat products

- **Analytical targets:**

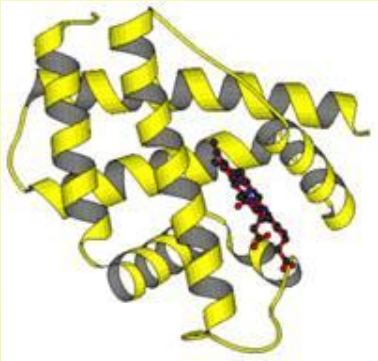
Proteins



Lipids



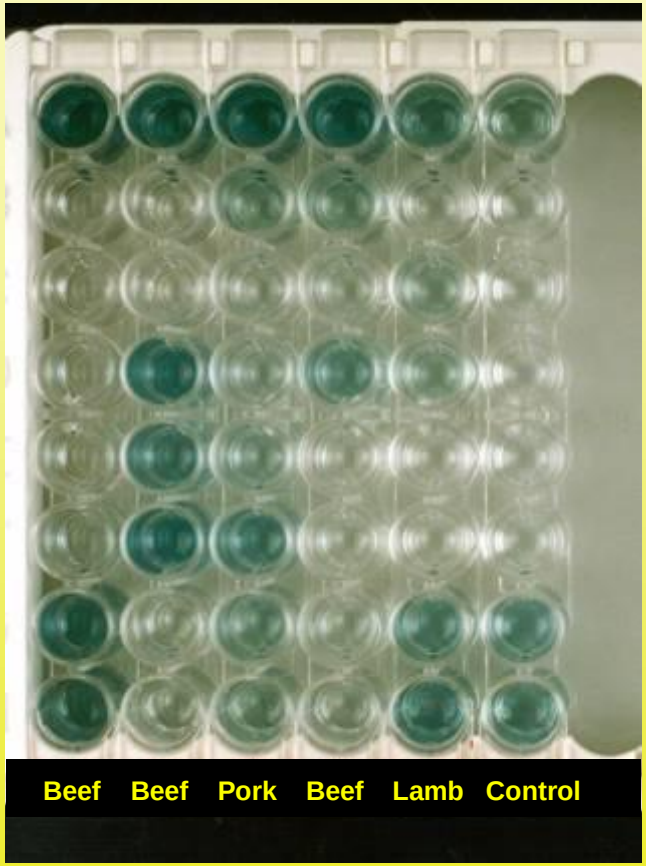
DNA



Protein based methods

- Immunological techniques:
- Western-Blotting
- ELISA (Enzyme Linked Immuno Sorbent Assay)
- Specific interaction between antigen (immunogen) and antibody (immunoglobulin)
- Coupled enzymatic reaction leads to a colour change of a specific chromogen

ELISA



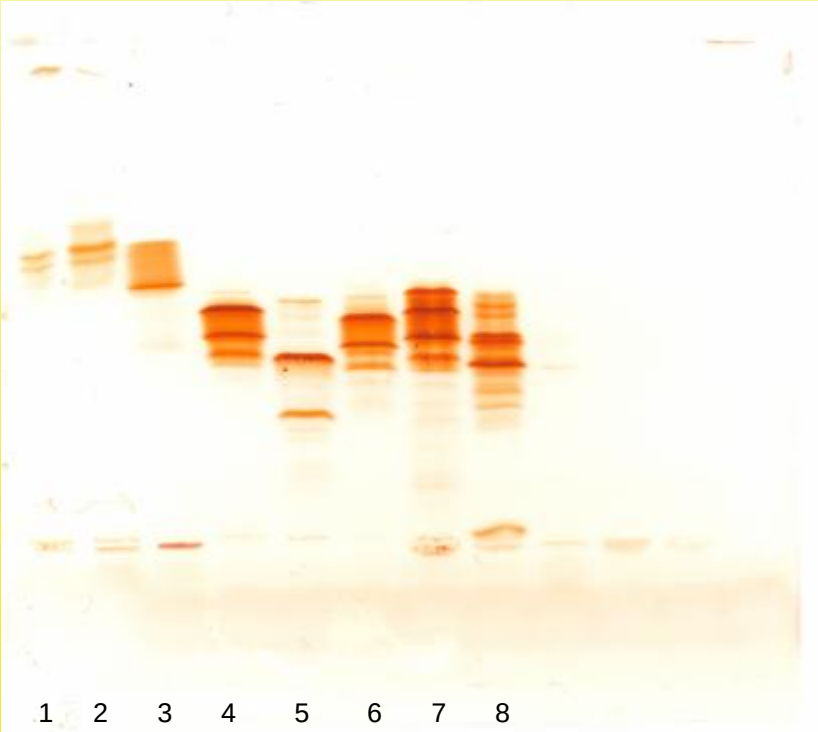
§ **Limit of detection:**

- **Pork 1 % - Beef 2 %**
- **Poultry 2 % - Lamb 5 %**
- **Quantitative analysis of animal species in products not possible**
- **False positive results, if content of gelatine in meat products > 2,5 %**

Protein based methods

- IEF (Iso-Electric-Focussing) technique
- Separation of proteins according to their isoelectric point in a pH-gradient applying an electric field
- Identification of animal species by means of myoglobin possible

1 Chicken
2 Turkey
3 Ostrich
4 Beef
5 Pork
6 Lamb
7 LGC 44
8 LGC 45



IEF

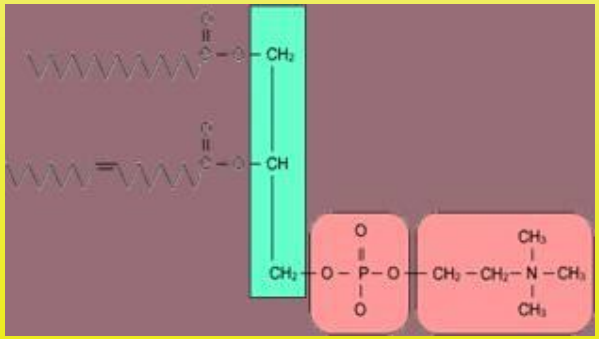
- Limit of detection depends on the staining method:
- Pure myoglobin 5 %
- Pseudoperoxidase method 1 %
- Silver staining < 1 %
- Myoglobin reference material is necessary
- In dependency upon temperature (> 100 °C) and duration of heat treatment myoglobin denaturates and can not be applied for IEF!
- Quantitative analysis of animal species in products is not possible

Protein based methods

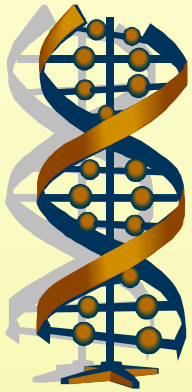
- Proteomics are another tool to differentiate species, breeds and varieties by their specific protein pattern
- Method requires experienced analysts
- Quantification is not possible

Lipid based methods

- Percentage of the composition between saturated, monounsaturated and polyunsaturated fatty acids provides information on animal species
- Analytical tools:
- Gaschromatographie (GC)
- GC coupled with mass spectrometry (MS) - GC-MS
- Limits:
- Large variations within the different animal species
- Influence of feed composition
- Less reliable results

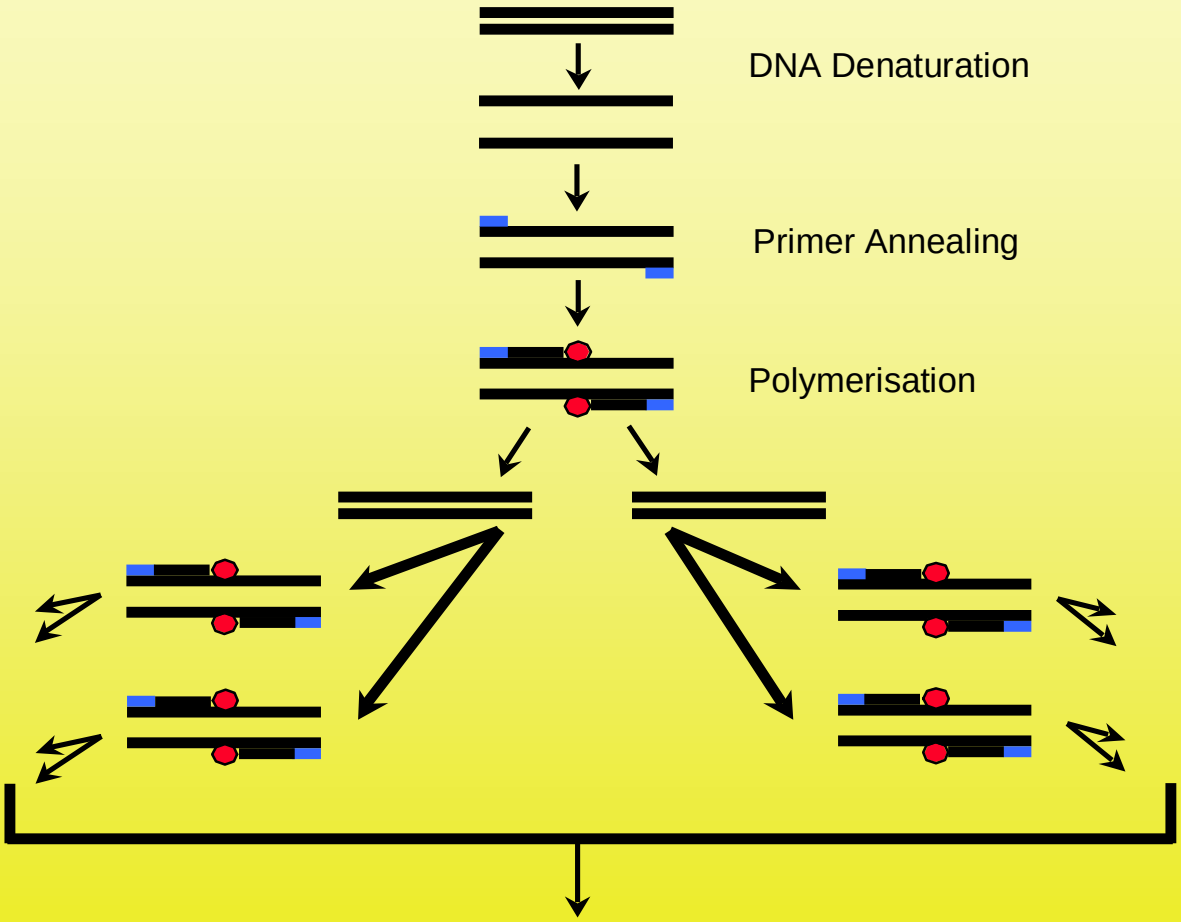


DNA based methods



- Southern blotting (DNA hybridisation assay)
- Various Polymerase Chain Reaction (PCR) techniques:
- Random Amplified Polymorphic DNA (RAPD-PCR)
- Restriction Fragment Length Polymorphism (PCR-RFLP)
- Single Strand Conformation Pattern (SSCP-PCR)
- DNA amplification in combination with DNA sequencing
- PCR applying animal species specific primer pairs
- Real time PCR applying different fluorescence markers (probes, intercalation dyes)

Polymerase Chain Reaction



$$N = K \times (1 + E)^n$$

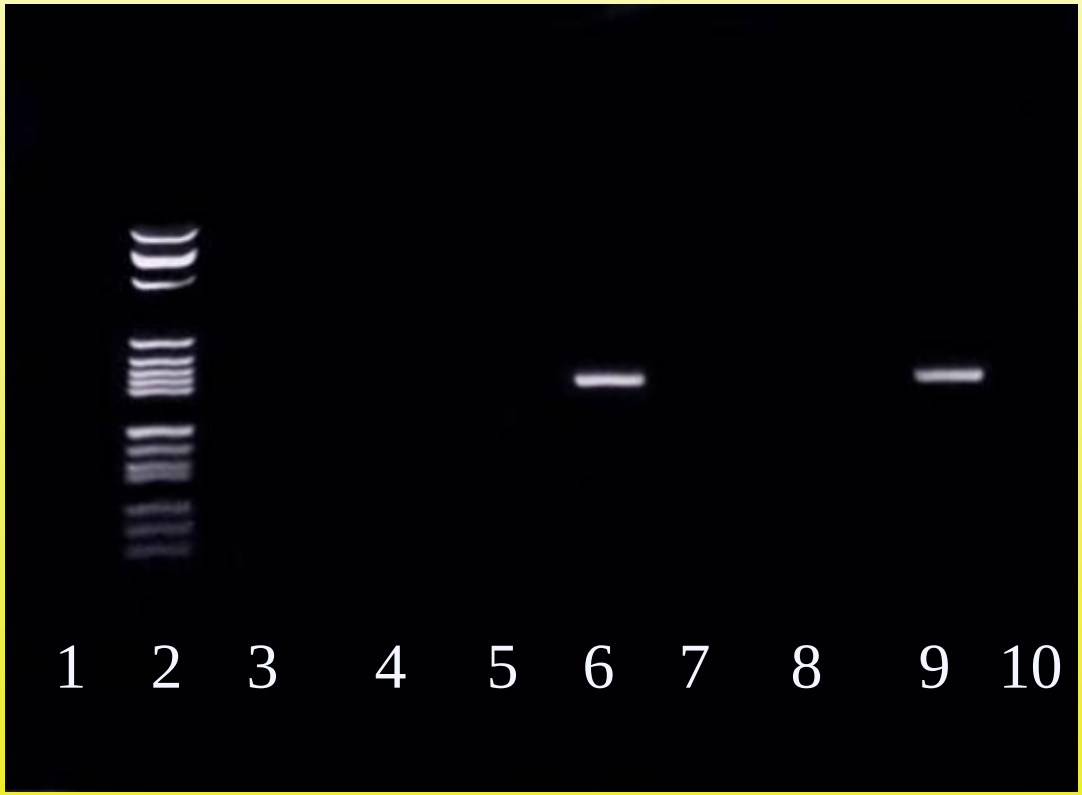
n = number of cycles

Polymerase Chain Reaction

- **PCR applying animal species specific primer pairs:**
- **Isolation of DNA from meat/meat product**
- **Amplification of an animal species specific DNA fragment (< 200 bp)**
- **Detection of the DNA fragments by means of gelelectrophoresis or sequencing**

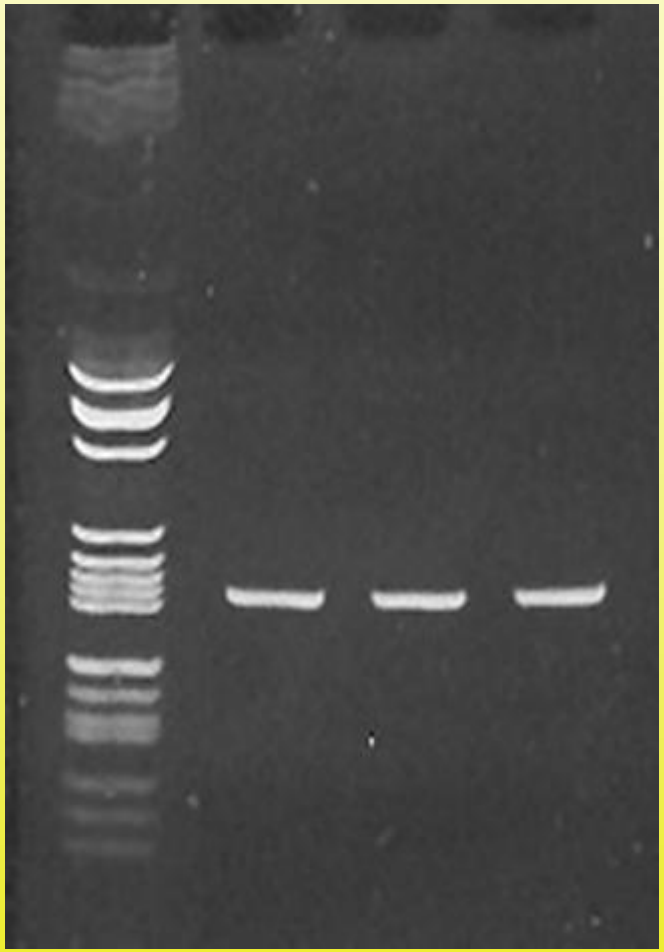
Qualitative system for the detection of goat

PCR product: 161 basepairs (β-casein)



1 Pig
2 Marker
3 Cattle
4 Horse
5 Sheep
6 Goat
7 Chicken
8 Turkey
9 Goat
10 Duck

Specificity



Burenziege

Weiße Deutsche Edelziege

Bunte Deutsche Edelziege

Limits of PCR

- PCR is 10 – 1000 times more sensitive than ELISA:
- Small contaminants of animal tissue will be detected
- Limit of detection depends upon PCR protocol:
- Number of cycles
- Applied cycle temperatures (DNA melting, annealing, polymerisation)
- Type of DNA polymerase (Taq)
- Length of DNA fragments to be amplified

Authenticity, geographical origin, and detection of fraud

- **To ensure authenticity, geographical origin and to detect fraud the following methods can be applied:**
- **Electrophoretic, chromatographic and molecular biological methods**

  in combination with
- **Other chemical and physical procedures (NMR, MS, IR)**

Protected legislative scopes

- **Protected Designation of Origin – PDO**

Foodstuff, which is produced, processed, and prepared in a given geographical area using recognised methodology (e.g. Jamon de Teruel, Parma ham, Tyrolian bacon, etc.)

- **Protected Geographical Indication - PGI**

  Geographical link, which must cover at least one of the stages of production, processing or preparation or the relevant product benefits from a good reputation (e.g. Schwarzwälder Schinken, Nürnberger Bratwürste, Thüringer Rostbratwürste)

- **Certificate of Specific Character - CSC**

Foodstuff, which pocesses specific characteristics, which distinguishes it clearly from similar products in the same category (Salami Milanese, Münchner Weißwurst, Nürnberger Stadtwurst)

NMR and MS based methods

- Determination of characteristic ratios of stable isotopes (^{2}H, ^{13}C, ^{15}N, ^{18}O, ^{34}S and ^{87}Sr) by:
- Isotope-Ratio-Mass-Spectrometry - IRMS
- Site-specific Natural Isotope Fractionation NMR – SNIF-NMR
- Determination of characteristic trace element pattern by:
- Inductively-Coupled-Plasma Mass Spectrometry – ICP-MS
- Analysis of organic contaminants from environment and feed (Dioxin, PCBs, etc.) by:
- GC-MS and HPLC-MS

Possibilities and limits of NMR and MS based methods

- Good indicators of environmental conditions ($^{18}O/^{16}O$; $^{2}H/^{1}H$)
- $^{2}H/^{1}H$ ratio can be accurately quantified by SNIF-NMR
- Physical and biological influences have to be taken into consideration:
- Environmental conditions (air, water, rainfall)
- Metabolism of plants and animals
- Ratio of stable isotopes in meat and meat products is influenced by:
- Imported feed ($^{18}O/^{16}O$; $^{2}H/^{1}H$)
- Origin of animal material ($^{18}O/^{16}O$; $^{2}H/^{1}H$)
- Metabolism of specific components ($^{13}C/^{12}C$)

Ø **Multielement-isotope analysis is recommended!**

Other spectroscopical methods

- **Fast physical methods (expenditure of time: some seconds to a few minutes)**
- **Near-Infrared-Spectroscopy (NIR): 0,78 < λ < 3,0 µm (wave number v*: 12820 – 3333 cm^{-1})**
- **Middle-Infrared-Spectroscopy (MIR): 3,0 < λ < 30 µm (wave number v*: 3333 – 333 cm^{-1})**
- **Low resolution ^{1}H Nuclear Magnetic Resonance Spectroscopy (LR ^{1}H-NMR); frequency v: 5 - 30 MHz**

Possibilities and limits of fast physical methods

- **NIR:**
- **Determination of fat, protein, water, minerals and vitamins**
- **Differentiation of beef with respect to feeding systems used in production**
- **MIR:**
- **Differentiation of pure beef and beef containing potential adulterants (up to 20 % heart, tripe, kidney, and liver, etc.)**
- **<u>Not possible:</u>**
- **Determination of carbohydrates**
- **LR ^{1}H NMR for analysis of meat and meat products just in test stage**

Traceability of production process and storage

- Analytical targets: protein, DNA, lipids, carbohydrates
- Applicable technologies:
- Immunological methods (ELISA, Western Blotting)
- Enzymatic methods
- DNA based methods (PCR, real time PCR, Southern Blotting)
- Electrophoretic procedures (PAGE, IEF, CE)
- Chromatographic methods (HPLC, HPLC-MS, GC, MS, GC-MS, GC-GC-MS)
- Spectroscopy (IR, UV/VIS, NMR, ESR)
- Computertomography, electron microscopy
- Multivariate data analysis

Traceability of production process and storage

- Use of endogenous or exogenous „tracer substances“ (proteins, lipids, metabolites, catabolites, etc.) to:
- Quantify the degree of batch mixing associated with a given blend of raw materials
- Gather information on heat treatment, storage conditions, storage duration, irradiation, etc.

Ø e.g.: Endogenous „tracers“ in „Hungarian style salami“ (fermented product) like lipid catabolites, lactic acid or volatile substances, emerging during ripening

Traceability of production process and storage

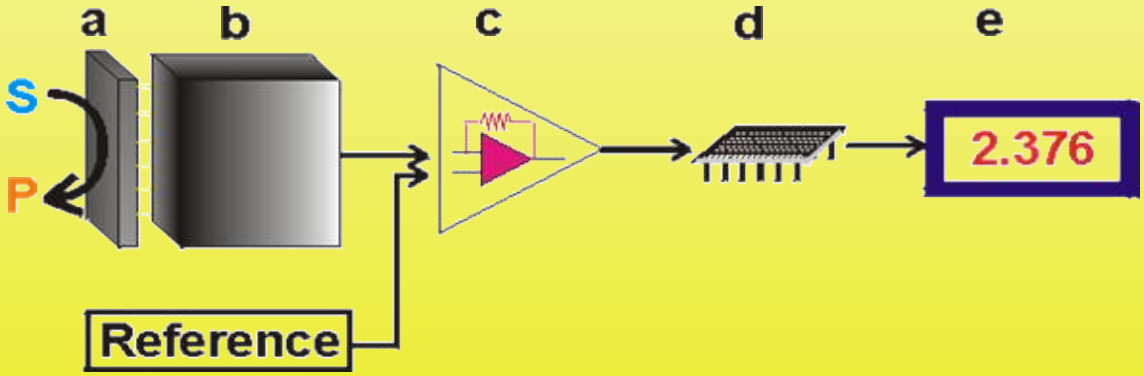
- Development of holistic analytical procedures applying a combination of methods like GC-MS, LC-MS and NMR to gather data on:
- Metabolite profiles
- Protein pattern
- Analysis of collected data by means of multivariate statistical system
- Computer modelling to characterize foodstuffs (degree of processing, freshness, allergen contamination, etc.)

Traceability of production process and storage

- Biosensors for online analysis:
- Easy to handle, rapid, sensitive, transportable
- Basically two components:

  Sensor (biomolecular component: antigen, antibody, enzyme, substrate)

  Signal transducer (detects and transduces physico-chemical changes of the biomolecules in the sensor unit



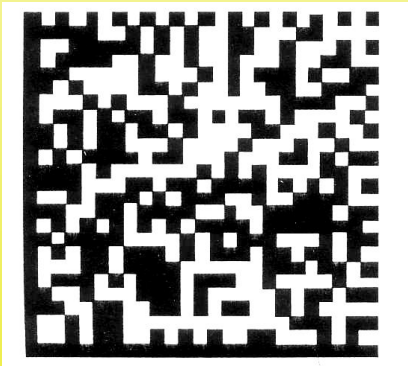
e.g.: Microbiological and virological investigations in the meat area (enterotoxins, typing of foot and mouth disease viruses)

„Tracking“ technologies

- Electronic data management (Automatic Identification and Data Capture – AIDC) important for improving operational efficiency and accuracy of information handling
- Possibilities:
- EAN (European Article Numbering Association) Codes

Linear

2-Dimensional Codes



Matrix

„Tracking“ technologies

- EAN-Codes (EAN-UCC) require a clean environment and have to be kept undamaged
- Read success rate of 2-Dimensional and Matrix Codes < 90 %

- Radio Frequency IDentification (RFID)
- Instead of Barcodes
- Reusable „tags“
- Read success rate of RFID > 98 %
- RFID not very wide spread
- In comparison to Barcodes very expensive

Computer modelling and risk assessment

- Computer modelling as a tool to:
- Estimate the contamination and transmission pathways for pathogens and food contaminants
- Assess the reliability and accuracy of decision trees, composed of a suite of test pathways
- Risk assessment modelling to:
- Manage food chain risks
- Make policy decisions regarding the safety of the food chain from food-to-farm

Conclusions

- Regulation (EG) 178 (2002) of the European Parliament and the Council of 28 January 2002:
- Stipulates that the delivery of safe food and animal feed belongs to specific food and feed producers
- Specifies that foodstuffs, animal feed and feed ingredients must be traceable
- Includes clear procedures for developing food law and dealing with emergencies
- Gives the European Commission new powers to make emergency measures when national authorities are unable to contain an emerging food risk
- Establishes the „Standing Committee on the Food Chain and Animal Health“ with important roles in decision-making on food safety issues

Conclusions

- **In the area of meat and meat products exists a need for fast and reliable systems to enable traceability along the full chain to provide safe and high quality food for the consumer**
- **Traceability is not only a request of the legislation, it has to be the very own interest of food business operators in terms of product liability to find practicable ways to implement the new regulation**
- **Within the 5th and 6th framework program the European Commission has funded various research and development projects dealing with traceability along the food chain**

Thank you for your attention!