Food Safety in Grain Milling

Urs Dübendorfer
## Agenda

1. In general
2. The consumers view
3. Main risks for grain based food
4. Micotoxines, allergens and bacteria
5. Possible controls and processes for risk minimisation
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Challenges for the Miller.

- Lower wheat quality
- Increasing consumer sensitivity
- Increasing contaminants

Food safety non-negotiable

Price pressure

Commodity Prices

- Wheat
- Corn
- Crude Oil
- Rice

Price pressure
The risks within the value chain.
Possible places of contamination
What are the greatest dangers in the value chain of cereals?

- **Biological hazards**
  - insects, larvae and eggs
  - mycotoxins
  - microorganisms (bacteria, yeasts and mold)
  - genetically modified organisms (GMOs)

- **Chemical hazards**
  - residues of pesticides and fungicides
  - pollutants from machines (e.g. lubricants)
  - result of processing contaminants (e.g. acrylamide)
  - contaminants that migrate from packaging into food
  - allergens
  - additives and supplements
  - adulteration of food

- **Physical hazards**
  - foreign matter (sand, metal, glass, plastics, ...)

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**Codex Alimentarius**

Hazard Definition: A biological, chemical or physical agent in food, or property thereof, which may cause adverse health effects.

Definition of pollutant: Any biological or chemical agent, foreign matter or other substances not intentionally added to food which may compromise the safety or suitability of food.
Allergens and gluten

- It is estimated that 6-8% children and 2-3% adults are allergic to food.

- Celiac disease is the most common genetic disease in Europe (1:300). This is a gluten intolerance that affects intestinal health.

- Most common allergens are:
  - cow's milk
  - eggs
  - soy
  - wheat
  - fish and crustaceans
  - almonds and walnuts

- Containing gluten:
  - wheat
  - rye
  - barley
  - oats
Quality Management Tools

Management level
- Risk analysis
- Recommendations
- Inspections

Operational level
- ISO 22000
- HACCP
- Traceability
- BP (Best practice)

Industrial Level
- International organisations (FAO, EHEDG...)
- Government (FDA, EFSA, ...)
- Legislation

Conditions and needed measures to grant a production, storage and distribution of food which is guaranteed harmless, in good condition and fit for human consumption.
Food Safety is a systemic solution

Food Producer: learn and take all precautions as necessary to ensure food safety and quality

Hygienic design of equipment

Design of process

Validation of the process

Raw material

House keeping

Training and personal hygiene

Know your suppliers

Food processing plant

Quality control

Food

Know your customers

Quality control

Water
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What are the consumers concerns?

- Dioxine in animal feed
- GMO in Food (rice)
- E.Coli in cookie dough
- EHEC in vegetables
- Micotoxine in nuts
- Salmonella in pepper
- Melamine in milk powder
- Radiation in food

USA, march 2010
USA, march 2010
Europa 2011
Risk perceptions

Food-related risks - spontaneous

**Question:** What are all the things that come to mind when thinking about possible problems or risks associated with food?

- **Food poisoning:** 16%
- **Chemicals:** 14%
- **Obesity:** 13%
- **Illnesses:** 9%
- **GMOs:** 8%
- **Food additives:** 7%
- **No problems or risk:** 7%
Foodborne disease outbreaks reported per year, US 1973–2006

Source CDC
Controlable risks against non controlables
The consumers view about FOOD SAFETY

I want to eat this food and be sure that...

- ......it is not harming me!
- ...... that there is no contamination in.
- ...... that it is healthy and its nutritional properties are well balanced.
- ......it is “natural” and does not contain any useless additives.
- ......it was processed in a hygienical manner.
- ...... it was seriously checked.
- ......all the needful information are on the label.
- ......that I do know the provenience of it.
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Bear in mind

- Detect biological contamination in food is like finding a needle in the haystack
- To detect contamination an appropriate methodology for sampling must be applied
- Food safety is not created only by analyzing the final product
- To reduce the risk, it is essential to manage the entire food production chain

Peanut company lied on salmonella testing, FDA finds

Some batches were not retested for the bacteria before shipping, the agency says -- though Peanut Corp. of America said it did.

February 07, 2009 | Thomas H. Maugh II and Mary Engel

Peanut Corp. of America, the company that produced the contaminated peanut butter now being widely recalled, lied to Food and Drug Administration investigators about shipping batches of the food known to be tainted with salmonella bacteria, the agency said Friday.

The company had previously told the FDA that some lots of peanut butter had initially tested positive for the bacterium, then were retested and found to be negative before they were shipped. But further investigation showed that the company actually shipped some of the lots before the second tests were completed. Other lots were shipped without testing and, in some cases, no second test was performed even after the first one came back positive.
The reactivity of water in food is measured by the water activity.

Water activity is the amount of reactive water available for biochemical reactions.

The sorption isotherm of water vapor for wheat at T = 25 °C shows the water activity [-] as a function of relative humidity of air (%).

- Enzymatic reaction occurs above water activity 0.8.
- Mold growth occurs between water activity 0.6 and 0.8.
- Bacteria growth occurs above water activity 0.93.
- Minimum water activity for Salmonella growth is 0.93.

Relative humidity of air (%): 20, 40, 60, 80, 100

Water activity [-]: 0.2, 0.4, 0.6, 0.8, 1.0

Moisture [%] w.m.: 5, 10, 15, 20, 25, 30
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What are Mycotoxines?

- Mycotoxins are toxic substances produced by mold.

- Molds are multicellular and filamentous microorganisms. The main molds that produce toxins are of the genus Aspergillus, Penicillium and Fusarium.

- Cereal grains can be infected during cultivation or after harvest.

- Temperature and high humidity favor the growth of mold.

- FAO estimates that 25% of the global food harvest is affected by mycotoxins.

- Aflatoxin B1 is one of the most potent toxins in nature.
There are many types of mycotoxins that contaminate our food

Deoxynivalenol
Zearalenone
Ochratoxin A

Ochratoxin A

Aflatoxin M₁

Patulin

HT2 and T2 in oats
Ochratoxin A in dried fruit and cereals
Aflatoxins in nuts

Fumonisins

Mycotoxins are toxic to humans and animals!
Mycotoxines alerts within the CE

- cereal products
- cocoa, coffee and tea
- feed for food-producing animals
- fruit and vegetables
- herbs and spices
- milk and milk products
- nuts, nut products and seeds
- other food products / mixed
- pet food

Comparison between 2007 and 2008.
Aflatoxine

Peanuts and corn with fungi

Apergillus flavus

Aflatoxine B1

Acute toxicity
In 1960 some 100,000 British small turkeys died in a few months, a seemingly new disease called "Turkey X disease". A careful examination showed that they were all associated with portions of peanut flour from Brazil.

Chronic Toxicity
Aflatoxin B1 shows up on the list of human carcinogens. Several epidemiological studies have shown a causal relationship between aflatoxins in foods and liver cancer.
Fusariosis is a major wheat disease causing damage to the productivity

Infected kernels

Gibberella zeae

Fusarium graminearum

Micotoxine DON
Desoxinivalenol (vomitoxine)

Ocurre on wheat and maize. Harmfull to humans and animals

Del Ponte et al., Fitopatol. bras., 29, 2004
The properties of mycotoxines

- Mold growth (and mycotoxin formation) is sensitive to variations in temperature and humidity.

- Mycotoxins are very unevenly distributed in agricultural products.

- Contaminated grains also gets hard on the inside. Grain shows changes in color, appearance and density.

- Mild to moderate contamination especially in the outer layer of the grain. Kernels show changes in color and appearance.

- Mycotoxins are quite thermostable and difficult to inactivate by heat treatment.
Risk containment measures for mycotoxins

- The best prevention is rapid drying of grain after harvest at moderate temperatures (<60 °C) to grant storage @ water content below 14% wb

- Control of temperature and humidity during storage. Optimal conditions: T <25 °C, water content ≤ 14.0% (relative humidity <65% at 25 °C).

- Decontamination / separation:
  Detection and separation of contaminated kernels; according density, color and appearance.
  Elimination of the outer layer of the grain. At least outer pericarp, 0.4 -1.0% of the wheat.

- Monitoring the concentration of mycotoxins in raw material at the intake. Due to the inhomogeneous distribution of mycotoxins it is essential to have an appropriate sampling procedure.
Relative change of concentration of DON in durum wheat processing

The cleaning and grinding of wheat (bran separation) substantially reduce the concentration of DON.

Initial concentration in durum wheat: 300 - 1310 mg / kg

DON reduction in the production and cooking of spaghetti is very limited.

The cleaning and grinding of wheat contribute to the reduction of DON.

The highest DON contamination was found in wheat bran and products separated by aspiration.

EC DON limits
- Wheat
- Finished product / Flour
- Baby Food

Wolf, Mycotoxin Research 21, 2005
Microorganisms: Bacteria

Bacteria are part of our life and our ecosystem

- there are more bacterias in the human gut than cells in the human body
- probiotic microorganisms (alive) are favorable to health when absorbed in adequate amounts
- Lactobacillus bacteria are applied in food fermentation
- microorganisms decompose organic matter and are responsible for food spoilage
- pathogenic bacteria are the leading cause of foodborne illness
- Salmonella, E. coli, listeria, staphylococcus, etc., are often to the source of foodborne disease

5 μm

5 μm
Typical reduction of endogenous bacteria upon cereal processing

Some pathogenic microorganism like *Salmonella* are more heat resistant than endogenous grain bacteria. Efficacy and reproducibility of *Salmonella* reduction upon processing need to be tested (validated) using appropriate test designs and non-pathogenic surrogate microorganisms.
Wheat is inhabited by bacteria

- Microorganism concentration is high at the surface and decreases toward the interior of the grain.
- Endogenous bacteria are not pathogenic on cereals, but pathogenic bacteria may be present ...

* APC: total mesophilic aerobic bacteria

Laca et al., J. Food Eng. 72, 2006
Salmonella multiplies in the presence of water (water activity > 0.93) and may represent a hazard in dry food

Example:

Salmonelosis case in the U.S. in 2009 caused by breakfast cereals

March 2009: The Minnesota State Health Department has launched an investigation to determine if the latest salmonella poisoning outbreak is linked to the cereals manufactured by Malt-O-Meal.

On April 5, 2009 Malt-O-Meal made a voluntary recall of unsweetened puffed wheat and puffed rice cereals after a routine testing has shown that they had been contaminated cereals.
Pathogenic forms of E. coli can cause foodborne illness

June 2009

Nestlé announced the recall of refrigerated cookie dough.

According to FDA there were 66 cases of illness in 28 U.S. states since March 2009.

Bacteria can multiply rapidly in food containing water (fresh dough) when the cooling is insufficient.

**Multiplication is exponential!**
The Codex Alimentarius does not establish specific limits for bacteria in wheat flour

<table>
<thead>
<tr>
<th>3.1.1 Quality factors – general</th>
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<tbody>
<tr>
<td>Wheat flour and any added ingredients shall be safe and suitable for human consumption.</td>
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| 3.1.2 |
| Wheat flour shall be free from abnormal flavours, odours, and living insects. |

| 3.1.3 |
| Wheat flour shall be free from filth (impurities of animal origin, including dead insects) in amounts which may represent a hazard to human health. |

It is the responsibility of the food processor to analyze hazards and establish control measures as necessary.
Containment measures to reduce hazards of allergens and gluten

- Avoid cross contamination
- Guarantee traceability
- Proper and correct labeling

Products made out of **Wheat, Oats, Rye, Barley or Malt** contain gluten!

Gluten: maximum limit for gluten-free products is 20 mg of gluten per kg (20 ppm)

Allergens: there is no limit to allergens
The EHEC crisis has shown...

...the impact if the medias within communication

...the consumer uncertainty

...the hasty reactions of the authorities

...the difficult search for scientific answers

...the economic damage

El Pais, 31st May 2011
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Product safety.  
Clues and where to take influence.

- Monitoring and control of RM and FP
- Defined and standardised processes
- Sanitation optimised production environment
- Up to date equipment
- Continuos online observation
- Preventive maintenance and Housekeeping
- Information and Training of employee
Recommendations for flour mill building design.

**Building**
- Minimize windows to reduce emissions and immissions
  - Noise
  - Dust
  - Insects
  - Rodents
- Window insect screens
- Spring loaded doors
- No level window sills

**Air make-up**
- Control humidity and temperature of process air
  - Avoid condensation
- Slight overpressure in mill building

**Cleanability**
- Epoxy flooring
- Round corner finish
- Grated cable trays – preferably vertical orientation
Implementation of high sanitation design concepts.

Easy access for cleaning
Example MDDR Roller Mill

Use of stainless steel
Example MPAK Sifter

Smooth profiles
Example Novapur Sieves

Closed design
Example MQRG Purifier
Fusarium Affected Grains

Hard Red Winter – Fusarium & pink mould

Soft Red Wheat – Fusarium & pink mould

Soft Red Wheat – Fusarium

Soft Red Wheat – Healthy Grains
Optical Signature Comparison

![Graph showing optical response of good grains and fusarium contaminated grains. The graph includes two curves, one for good grains and one for fusarium, with corresponding images of wheat grains.]
Defect Removal Segregated

Good Grains: Soft Red Wheat

Reject: Fusarium, Unhulled

Reject: Fusarium, Unhulled and Brokens
Contamination tests were carried out on specific elements of the rejected product.
This confirmed that the majority of contamination lies in the fusarium affected grains, but that the broken grains also have a higher contamination than the input product.
Samples

First Accept: <1ppm

Final Reject: >20ppm
Light peeling process to remove surface contaminants.

Application
- Peeling process to remove surface contamination

Features
- Gentle removal of surface contamination such as sand, bacteria and pesticides
- Contaminants are removed by friction between kernels and rotor and screen jacket, as well as kernel to kernel
**Why mechanically sterilize flour?**

- Improvement of shelf life of wheat flour
- Ministry of Health started to communicate in September 2010 that BPO (Benzoyl peroxide) will be outlawed as a flour additive
- Chinese government emphasizes the production of hygienic and safe food with the implementation of the new Safe Food Legislation in June 2009
- Large international flour consumers operating in China start to demand that Chinese flour mills treat their flour with an impact machine before shipping
- Use of MJZG is standard practice in the flour milling industry both in Europe and USA
Food Safety / Sanitised Food

- Reduction of total plate/germ count
- Minimised impact on flour properties
- Flour suitable for:
  - Fresh (refrigerated / frozen) Doughs
  - Yeast-risen Doughs
  - Cookie Doughs
  - Soup Flours
  - Carrier Flour for Premixes
  - Infant Food
Thermal and Hydro-Thermal Process

Flour Hygienisation

- Base Flour
- Dosing
- Energising
- Retention
- Cooling
- $\text{H}_2\text{O}$ Compensation
- Hygenised Flour

Flour Inactivation

- Base Flour
- Dosing
- Energising
- Conditioning
- Retention
- Cooling
- $\text{H}_2\text{O}$ Compensation
- Inactivated Flour
Process Layout – Hygienisation

- Surge bin
- Dosing scale
- Heat exchanger
- Retention bin
- Pneumatic and aspiration filters
- Start up bin
- Finished product