Authenticate: Workshop proceedings

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**Authenticate: Workshop proceedings**

<table>
<thead>
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<th>Title</th>
<th>Growing societal demand for food authenticity, safety and broader food security is creating both new opportunities and increased challenges for Nordic food suppliers, manufacturers and retailers. The mislabelling of food products came to great prominence during the 2013 “horse meat scandal” in Europe, when a range of supposedly beef products were found to contain horse meat. What makes this discovery surprising is that it took place despite the clear set of European Union (EU) regulations relating to food traceability and labelling, which require a complex system of checks to ensure that food remains authentic and traceable. Research have shown that the seafood sector is particularly vulnerable when it comes to fraud, partly due to the fact that seafood is the world’s most international traded food commodity and because seafood has extreme biological diversity and variable characteristics that can create or hamper competitive advantage in marketing of products. Among the issues relevant for this discussion are species substitution, false claims of origin, social responsibility, sustainability, food safety and fair trade. A handful of Nordic institutes and companies came together few years ago to initiate networking among stakeholders in the Nordic seafood industry, with the aim of discussing the challenges and opportunities related to food integrity for the sector. As results a series of workshops were organised in Iceland, Norway and Denmark; and the outcome of these workshops were then discussed at a final workshop held in Faroe Islands on Nov. 14th 2017. This report contains the proceedings from that workshop.</th>
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<tr>
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<td>02-18</td>
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<td>Verknr. / Project no.</td>
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<td>Nordic Council of Ministers - Working Group for Fisheries (127-2014)</td>
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<tr>
<td>Summary in English:</td>
<td>Food Integrity, Food fraud, species substitution, seafood, false claims</td>
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1 Matís ohf. Iceland. 2Norima, Norway. 3AZTI technalia, Spain. 4Havforskningsinstituttet, Norway. 5DTU aqua, Denmark.
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Introduction

Food authenticity and in particular mislabelling of food products came to great prominence during the 2013 “horse meat scandal” in Europe, when a range of supposedly beef products were found to contain horse meat. What makes this discovery surprising is that it took place despite the clear set of European Union (EU) regulations relating to food traceability and labelling, which require a complex system of checks to ensure that food remains authentic and traceable. It was primarily through the use of DNA based methodologies for identifying species that this fraud was detected.

Growing societal demand for food authenticity, safety and broader food security is creating both new opportunities and increased challenges for Nordic seafood suppliers, manufacturers and retailers. Research have shown that the seafood sector is particularly vulnerable when it comes to fraud, partly due to the fact that seafood is the world’s most international traded food commodity and because seafood has extreme biological diversity and variable characteristics that can create or hamper competitive advantage in marketing of products. Among other issues that the seafood sector has to deal with in regard to food fraud are:

- Species substitution is among the highest of all food commodities, as published research has identified an average substitution rate of around 30%, and much higher for certain high value species. Many of the species supplied from the Nordic countries have favourable characteristics, which make them a target for substitution.
- False claims of origin, where the Nordic sector is particularly vulnerable. Seafood from the Nordic countries is in many cases having competitive advantage because of its clean and natural image, sustainable sourcing practices, good management etc.
- False claims of social responsibility, where fish processed by for example slave labour is being sold in competition with Nordic products.
- False documents where IUU catches are being sold in competition with Nordic products.
- Unsafe products that have not been produced in accordance with Nordic or EU standards are being sold in competition with Nordic products.

These are only few examples of the severity of the problem and how it may affect the Nordic seafood sector.

A handful of Nordic institutes and companies came together few years ago to initiate networking among stakeholders in the Nordic seafood industry, with the aim of discussing the challenges and opportunities related to food integrity for the sector. The Authenticate project was formulated from that discussion. The Authenticate project identified the following five key objectives as discussion points in the beginning: 1) issues and methods for monitoring of feed composition (e.g. in aquaculture); 2) possible issues and methods for detection of specific microbial pathogens (e.g. common to seafood borne diseases that contribute significantly to reduced consumer confidence in safety and lead to increased costs for public health); 3) identification of optimum technical platforms for testing through the development of validated, (SOP based) genomic authenticity assays; 4) Exploration and evaluation of economic, legal and regulatory barriers that may influence the development and deployment of new and novel technologies in the marine food system; 5) promotion of the role of genomics in traceability and speciation within the industry.
To ensure the intended progress and results of the project, a total of six milestones were identified; which were:

1. An official Kick-off meeting; which took place during ICES WG meeting in Italy 4-8 May 2015.
3. H2020-SFS-14b-2015 application (Authent-Net) – Which was submitted and funded. The project partners include Matís and Nofima and the total H2020 contribution to the project is 500,000 EUR. The project will among other things facilitate ERA-NET projects that the Nordic countries will have a chance of taking part in.
4. Facilitating workshops in Iceland, Norway and Denmark where national stakeholders would be brought together to discuss the issue of food fraud in the seafood sector. The first workshop was held in Iceland on March 16th 2016. The meeting got considerable attention amongst stakeholders and the media. Over thirty stakeholders attended the meeting, which was a great success. The presentations and further discussions are available on the Matís webpage. The second workshop was facilitated by IMR in Bergen on October 26th 2016. The workshop was primarily attended by professionals in the field of genetics and served as such an interesting role in bringing together leading Norwegian experts in that field. The third and final workshop was organised by DTU and held at DanFish 2017. The workshop was attended by researchers, managers and the fishing industry. Some really good discussions were initiated.
5. Organise a final meeting in Faroe Islands where the input from the national workshops would be discussed along with a selection of relevant presentations. The meeting took place at Havstovan in Torshavn on November 14th 2017. The meeting was attended by around 20 people, but the event was also broadcasted on Facebook where it got 180 views. Discussion on the meeting, along with the presentations can be seen on the Matís webpage.
6. Final reporting.

In general, the project has delivered what was intended. It has brought together stakeholders in the field of food authenticity in the Nordic countries, raced awareness of the issue of food fraud in the Nordic seafood sector, facilitated networking, contributed to work on standardisation of methods for detecting fraud, and contributed to the writing of a successful H2020 proposal.

This report contains the proceedings of the final workshop, which was held in the Faroe Islands on November 14th 2017. This report does also serve as the final report of the Authenticate project.
Workshop proceedings

The workshop was broken into ten presentations and connected discussions, focusing on the different priorities that had been identified at the national workshops in Iceland, Norway and Denmark. The agenda for the workshop is shown below:
Following is a discussion on each of these presentations, along with the presentations themselves.
Welcome and introduction

Jónas R. Viðarsson from Matís opened the workshop, introduced the Authenticate project and the issue of food authenticity in general. He presented some of the research that have been done on food fraud in the seafood industry, which highlight what a severe problem it is for the entire industry. The issue is particularly important for the Nordic seafood industry, since Nordic seafood has many favourable characteristics that provide competitive advantage. Food integrity presents therefore both challenges and opportunities for the Nordic seafood sector.
Food fraud / Food Integrity

Food fraud and various sorts of “cheating” have been an intrinsic part of the food industry as long as we can remember.

With globalization and expanding food value chains the fraud has become increasingly lucrative. Food fraud has therefore become a part of organized crime in some instances.

Food fraud is in most cases low risk vs. high return for the “criminals”.

The horse meat scandal in 2013 was a turning point. Regulations, traceability and awareness has improved........and penalties have become stricter.
Food fraud is common in all food systems

Sweden’s National Food Agency has issued a warning after as much as 20 tonnes of meat labelled as beef turned out to be coloured pork.

Operation Opson V (March 2016)

More than 10,000 tonnes and one million litres of hazardous fake food and drink have been seized in operations across 57 countries in an INTERPOL-Europol coordinated initiative to protect public health and safety.

Operation Opson VI (April 2017)

EUR 230 million worth of fake food and beverages seized in global Opson operation targeting food fraud

Portugal - More than 300,000 tins of fish seized in a factory.

Press Release

Operation Opson VI, the fifth Europol-INTERPOL operation targeting counterfeited fish and beverages, as well as the organised crime networks behind this trade, has resulted in the seizure of 900 tonnes and EUR 30 million worth of counterfeit and stolen fish products and ready meals from every day products such as alcohol, mineral water, seasoning cubes, animals and soups. In total, goods such as...
Most fraudulent food items

1. Olive oil
2. Milk / dairy
3. Honey
4. Saffron
5. Orange juice
6. Coffee
7. Apple juice
8. Tea
9. Fish
10. Spices, balsamic vinegar, caviar, vines and spirits etc...

Seafood mislabeling – Species substitution

Species substitution are the most common fraud in the seafood industry:
Report from Oceana published in 2013 about mislabeling in the USA
- 1,200 samples from 674 outlets in 21 states of USA
- 33% mislabeling
- Red snapper 87% mislabeling
- White tuna 59% mislabeling
- Cod 32% mislabeling
- Salmon 7% mislabeling

Seafood mislabeling – Species substitution

Oceana report from 2015 focusing solely on salmon showed
- The situation was much worse than the 2013 report indicated.
- 43% mislabeling.
- Most common to sell farmed Atlantic salmon as wild Chinook, King and Sockeye
- Mislabeling much more common in restaurants than in grocery stores
Seafood mislabeling – Species substitution

Oceana report about seafood mislabeling in Brussels

“Oceana carried out DNA testing on 280 fish samples collected from major restaurants and EU institutions’ canteens in Brussels – facilities used by EU civil servants and politicians. The testing focused on commonly served fish species under the denomination of cod (Gadus spp.), common sole (Solea solea) and bluefin tuna (Thunnus thynnus), and aimed at verifying the exact species sold and its origin in comparison to EU and Belgian law. Samples were analysed by the Laboratory of Biodiversity and Evolutionary Genomics from the Katholieke Universiteit of Leuven. The results show an overall 31.8% of clear cases of mislabelling based on information gathered from either the menu or from restaurant staff. More than 77% of samples focused on popular restaurants from the EU districts and the city centre, with a particular focus on specialized fish restaurants. 31% of samples came from within the EU institution’s own canteens (EU Commission and European Parliament), while the remaining covered sushi restaurants.”

Seafood mislabeling – Species substitution

Oceana report about seafood mislabeling in Brussels

EU has invested a lot of funds and efforts in addressing food fraud. Oceana did therefore look specially at mislabelling of seafood in EU canteens in Brussels.

The results were shocking. …… 38% mislabeling

Seafood mislabeling – Species substitution

The UK Food Safety Authority published a report in 2011 revealing that 7% cod sold in Britain was not really cod. This was followed with a similar research in Ireland that showed 28% mislabelling.

- Takeaway sector with highest portion of mislabelling
- Pangasius og Alaskan Pollock most commonly substituted for cod
- 90% of the mislabeling is breaded & battered products or smoked products
Seafood mislabeling – Species substitution

Mislabeling also common in the scandinavian countries

2014 Danish fishmongers cod red handed
MARINE conservation organization, Oceana has revealed high levels of seafood fraud amongst fishmongers in Denmark. Alongside the Danish newspaper Søndagsavisen and the TV program Go Aften Denmark, Oceana conducted a study revealing that 18% of cod sold in fishmongers is not actually cod, but haddock or saithe. In total, 120 samples were collected from fishmongers, supermarkets and restaurants in the wider Copenhagen region in order to undergo DNA analysis.

MSC putting emphasis on tackling species substitution

Mislabelling motivations

MSC putting emphasis on tackling species substitution

The latest DNA testing results

99.6% of the 256 MSC labelled products we tested were correctly labelled.

30% of seafood is mislabelled globally, on average.

The testing sampled 256 unique products and 12 species of fish, sourced from retailers across 16 countries.
**Regulations have been made stricter**

- Traceability, documentation and labeling laws are now much stricter than before (EU and US leading the way).
  - EC 1224/2009 (Traceability): ‘all lots of fisheries and aquaculture products shall be traceable at all stages of production, processing and distribution, from catching or harvesting to retail stage’.

**Regulations have been made stricter**

*And enforcement has improved*

UK 2015
A businessman from Cumbria was sentenced to six months in prison and a fine of more than USD 75,000 for his involvement in a scandal originated in a seabass sale fraud. Substituted Atlantic seabass with Japanese seabass.

UK 2012
Cumbrian Seafoods lost reputation and incurred heavy losses in 2012 following a scandal where they were caught selling scrimp with BAP ecolabelling, which was not coming from BAP certified

Europol – Operation Opson

**Other fraud than species substitution**

- IUU – Illegal Unreported and Unregulated (pirate) catches have to be sold somewhere...and one way is to falsify documentation.
- Favourable characteristics are important. Mislabelling of origin, ethical claims, fishing method
- Certifications of all sorts
- Fresh vs. frozen
- Food miles – CO2
- Additives – For example using Citric acid or phosphates
- Food Safety i.e. that the fish is processed in sanitary circumstances
- Short-weighting
- Over glazing
How do producers react?

Retail chains and processors have increasingly set up own laboratories or outsourced such service.

- DNA
- NIR - Near-infrared spectroscopy
- MNR - Nuclear magnetic resonance spectroscopy
- Stable Isotope Analysis
- WNC – Water Holding Capacity
- Additives

Research projects on seafood integrity

Labelfish finished last year. Thousands of DNA testing were done. Mislabeling dependent on geographical area, food sectors and how fragmented the value chains are.

http://labelfish.eu/

Research projects on seafood integrity

Food integrity Network
Publications

https://secure.fera.defra.gov.uk/foodintegrity/index.cfm
Research projects on seafood integrity

Authent-Net

http://www.authent-net.eu/

FARNHub
http://www.authent-net.eu/AN_FARNH.html

CEN-Workshop Agreement – European standard on key terms and concepts
Published mid 2018
Food Integrity – Overall challenges and standards
Patrick Sørdahl from Nofima discussed how complex and variable fraud in the seafood sector can be. There are numerous claims and favourable characteristics that can presented on the product packaging or on the documents accompanying the products, and validation of such claims can be difficult. There are analytical methods available to detect some of these, but others cannot be validated so easily. Example of claims that is difficult to validate through analytical methods are for example claims on sustainability, fair trade, legal/illegal landings, social responsibility etc. A combination of analytical methods and “paper trail” traceability is therefore often needed to validate authenticity of seafood products.

**Food fraud – A global issue**

- When the claimed characteristics of a product does not match the actual characteristics of said product
  - Farmed salmon sold as wild caught
  - Cheaper fish passed of as a more expensive variety
  - Processed products containing less fish than claimed
  - IUU-fish sold as “sustainably caught”

**Approaches to verification**

- Analytically verifiable claims
  - Species
  - Fresh/frozen
  - Additives/chemicals
  - Farmed/wild caught

- Non-analytically verifiable claims
  - Weight
  - Origin
  - Sustainably caught
  - Vessel/producer

Has no chemical or physical properties relating to fraud
Non-analytical verification methods

- Using public registrations in the food sector to identify sources of discrepancy
- Case study: Norwegian fisheries
- In cooperation with «FoodIntegrity»
  - www.foodintegrity.eu

Discrepancies in the Norwegian fisheries sector

- Various studies indicate different levels of misreporting
  - Survey by Nofima in 2013 indicates 5% misreporting (Svorken & Hermansen 2013)
- Registered imports and landings do not match consumption and exports – why?

What causes a discrepancy?

- Intentional actions
  - Misreporting
  - Mislabeling
  - Substitution
  - Adulteration
  - Counterfeiting
  - Etc...
- Unintentional
  - Product conversion factors
  - Storage conditions
  - Time delay in reporting
  - Mismatch between registrations
  - Poor quality control
  - Production process error
  - Human error
Discrepancies in the Norwegian fisheries sector

- Map and identify mandatory registrations relating to product properties
- Establish the relation between registrations
- Identify sources of discrepancies

### Mapping of registrations

| Authority
| Fisheries directorate | Food safety authority | Value date |
|---|---|---|---|
| Type of information | Transport | Transport | Quality inspections |
| Date | Date received | Date received | Date received |
| Issuing authority | Issuing authority | Issuing authority | Issuing authority |
| Product type | Product type | Product type | Product type |
| Product | Product | Product | Product |
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| Product | Product | Product | Product |
## Mapping of registrations

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<th>Food safety authority</th>
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</tbody>
</table>

## THE VALUE CHAIN FOR WILD CAUGHT FISH

- **Fishing**
  - Landing
  - Production
  - Transport

- **SCA (Sustainability Chain Agreement)**
  - **QUANTUM**
    - Electronic recording
    - Phytosanitary certificate
  - **Transport report**
  - **Product declaration**
  - **Cash certificate**

- **Customer**
  - Norwegian Directorate of Fisheries
  - Norwegian Food Safety Authority
  - Test Customer
Non-analytical verification methods

- Used in combination with various other methods
  - Document study
  - Interviews with value chain actors
  - Material-flow analysis

- Strengths
  - Can detect fraud that has no analytical component
  - Can highlight nodes in the value chain susceptible to fraud
  - Can give indications of the scope

- Weaknesses
  - Requires considerable contextual knowledge
  - Vulnerable to data access
  - Preferably requires micro-level data

In conclusion

- Fraud comes in all shapes and sizes – must use a combination of various approaches to identify fraud

- Is a more holistic system needed?

- New technologies might provide new avenues for preventing food fraud
  - Blockchain?

Thank you for your attention

www.nofima.no
Food integrity and animal feed
Jónas R. Viðarsson from Matís discussed issues related to food integrity and animal feed; particularly aquaculture feed. There are to a point different issues that come up when discussing authenticity and animal feed, than when discussing food for human consumption. The main importance for aquaculture feed is that it fulfills nutritional requirements, ensures health and animal welfare, contains low volumes of anti-nutritional elements and is affordable in prices. Most of the aquaculture feed used in the Nordic countries is produced in Europe and the suppliers (feed producers) have, as far as we know, been very responsible in their raw material sourcing.
Food Integrity and animal feed

Majority of aquaculture feed used in the Nordic countries is produced in Europe.

Approximately 70% of the production cost in salmon farming is feed.

Big emphasis on R&D by aquaculture feed producers.

The feed producers take on responsibility for sustainable, ethical, responsible sourcing.

The Nordic aquaculture industry generally not willing to take chances in sourcing feed from producers in other continents.

Aquaculture feed – What is important?

1. The feed needs to fulfill nutritional requirements – different depending on species and life-stages.

2. The feed has to ensure health and animal welfare issues

3. The feed has to include low volumes of anti-nutritional elements

4. The feed has to be affordable/inexpensive

Nutrition

The feed needs to fulfill nutritional requirements – different depending on species and life-stages.

Nutritional elements:
- Protein (amino acids), fat, carbohydrates, phosphorus, Calcium, natrium and potassium

Trace elements:
- Vitamins, minerals and other amino acids

Energy:
- Feed has to be high in energy

Ratio of nutritional elements:
- Dependent on species, life-stages, age and size

Low amounts of anti-nutritional elements
- For example trypsin inhibitors, lipase, antibody catalyzed, lectin, saponin and other elements that can have negative effects on digestibility and growth.
Nutrition - ingredients

What are the most common ingredients

Protein sources:
- Animal - other fish proteins, seeds, beans (Soya), nuts, by-products from olive- and grain/cereal production.

Fat sources:
- Fish oil, plant oil, fat from other animals

Carbohydrate sources
- Cereals of different types

Mineral sources:
- From animal/other fish

Vitamin sources:
- Various ingredients

Labelling laws on feed and feed ingredients

Nutritional values:
- Water/solid materials
- Protein
- Fat
- Minerals/ash
- Carbohydrates NFE (Nitrogen-free extract)

Ingredients composition:
- The order of ingredients by volume

Example of a salmon feed formula

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<td>0.200</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>519</td>
<td>MONOCA-PHOSPHATE</td>
<td>2.111</td>
<td></td>
<td></td>
</tr>
<tr>
<td>600001</td>
<td>FM MEAL710/81 Polarl</td>
<td>14.000</td>
<td>14.00</td>
<td></td>
</tr>
<tr>
<td>2509</td>
<td>FISH OIL Polar mix q1 14</td>
<td>10.660</td>
<td>10.66</td>
<td></td>
</tr>
</tbody>
</table>
R&D on optimising feed is important

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>m/a</th>
<th>m/a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amino acids</td>
<td>44,000</td>
<td>60,000</td>
</tr>
<tr>
<td>Fish meal</td>
<td>3,800</td>
<td>3,800</td>
</tr>
<tr>
<td>Overhead</td>
<td>10,562</td>
<td>10,000</td>
</tr>
<tr>
<td>硫酸</td>
<td>150,000</td>
<td>150,000</td>
</tr>
<tr>
<td>Fish oil</td>
<td>50,000</td>
<td>50,000</td>
</tr>
<tr>
<td>etc.</td>
<td>50,000</td>
<td>50,000</td>
</tr>
</tbody>
</table>

Need for official monitoring / traceability

Ingredients
- Governmental monitoring – Food and veterinary authorities in most countries
- Feed producer – information from suppliers and internal monitoring/own measurements
- Feed buyer – information from producer and certifications e.g. ASC
- Consumer – Certifications from producer or third party

Ready made feed
- Governmental monitoring / regulatory - Food and veterinary authorities in most countries
- Certifications – such as ASC
- Feed buyers – information from producer and certifications e.g. ASC
- Consumer – Certifications from producer or third party

The most common measures

Most common: Water, protein, fat, minerals (ash), Carbohydrates
Often: Vitamins and minerals (what vitamins and minerals)
DNA / Isotopes: what is exactly in the feed

Testing for:
- Amino acid gives limited information on protein sources
- Fatty acids gives more detailed information on the sourcing of the fat
- DNA and RNA provides as detailed information as possible
Other considerations

Organic producers

Sustainability of the feed

Ethical considerations

Cannibalism – e.g. not to use salmon rest raw materials to produce salmon feed

Food miles / CO2

*Organic certification – but otherwise mostly trusted to the feed producers*
Rapid methods to detect undesirable microbes in fish

Guðbjörg Ólafsdóttir from Matís discussed advances in detecting undesirable microbes in fish using rapid methods. Real-time PCR technology can now be used to detect microbes in fish in just a few hours (4-24 hours) which used to take 3-7 days using conventional methods. This allows suppliers to detect problems before the products are put on market.

Introduction

Microbial communities in food and food production establishments have highly versatile structure based on various extrinsic factors.

Food type, temperature, salinity, pH, water content, packaging conditions, storage conditions etc.

Molecular methods have been developing rapidly in recent years both for specific detection of single species and screening methods that allow species composition of a given sample.
Monitoring of spoilage bacteria in the supply chain

What are the advantages?
Whatever storage time or conditions have been applied, the number of spoilage bacteria does not lie.

Gives an independent observation of product quality and estimate of freshness.

Could be a valuable addition to quality management at production sites and an unbiased quality control for buyers of fresh food.

First steps in the supply chain

- Large corporations
  - With their own supply chains
  - Large vessels – processing (onboard/in land) – transportation – secondary processing abroad – distribution
  - Catch can be few days old when landed
  - Streamlined production and quality of raw material

- Small corporations
  - Small vessels
  - Catch is sold through fish markets
  - Catch landed same day
  - Diverse handling of fish and therefore on quality of raw material

- How is the quality monitored?

Temperature of landed catch

July 2010

July 2011
What controls microbial quality?

- Temperature in the whole process
- Time of bleeding
- Time of gutting
- Handling
- Time of storage
- Processing methods
- Processing conditions
- Storage conditions

Is it possible to use a single microbial parameter as a reference for quality control?

No

Bacteria on fresh cod

Intestine: 10-100,000,000/g
Skin: 100-100,000/cm²
Flesh: No bacteria

Microbial indicators: Specific Spoilage Organisms (SSO)

![Graph showing changes in specific spoilage organisms and sensory rejection over days of storage.](image)
Fish in the supplied chain

Relevant microbial parameters to estimate spoilage

Until now, no single method is available for the rapid detection or quantification of these bacteria. Cultivating the most important bacteria can give a good estimate on product quality during processing, transportation or storage. The time frame however is too large to be able to use it for processing management purposes.

<table>
<thead>
<tr>
<th>Species</th>
<th>Method</th>
<th># days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pseudomonas</td>
<td>Cultivation on CFC agar at 22°C</td>
<td>3</td>
</tr>
<tr>
<td>Photobacterium</td>
<td>Malthusa conductance method</td>
<td>2</td>
</tr>
<tr>
<td>Shewanella</td>
<td>Cultivation iron agar at 17°C</td>
<td>5</td>
</tr>
</tbody>
</table>

New Methods to study fish microbiota

rt-PCR methods: rapid tests developed for estimation of P. phosphoreum and Pseudomonads

Cell count by flow cytometry: FACS (Aria II)

Community analysis (molecular level):
- 16S RNA gene sequence analysis
- Next Generation Sequencing (NGS)

Sensory evaluation
- Smell, taste, texture, appearance, colour
Analysis procedures

Real-time PCR technology

Analysis procedure and time (no preenrichment)
- 25g food sample diluted in 225ml buffer 35 min
- DNA extraction 40 min
- PCR analysis 120 min
- Results analysis 15 min
Total 4 hours

Required instrumentation:
- Stomacher
- Real-time PCR cycler
- DNA extraction robot

Real-time PCR technology

Small part of the DNA molecule from the bacteria is amplified using DNA polymerase

During amplification fluorescent substances in the reaction emit light and is detected by the instrument

The more bacteria present in a sample – the sooner the light is detected
The situation in retail – week days in same store

**Haddock at retailer**

![Haddock Graph]

**Cod at retailer**

![Cod Graph]

**Conclusions**

- Large variation in number of spoilage bacteria can be expected to be present in fresh fish.
- Direct monitoring of spoilage potential is rare. Data on number of spoilage bacteria in fish upon landing and processing is not available.
- Methods have been developed for rapid quantification.
- Can provide pressure to the industry to handle the material in the best way.
- Higher overall quality, increased shelf life and higher value.
- Can be of use in shelf life prediction where bacterial load is needed.
The role of genomics in detection of food fraud

Guðbjörg Ólafsdóttir from Matís discussed how genomics are used to detect food fraud and in particular species substitution in the seafood sector. DNA based methods are the most reliable approaches available to detect fraud of this kind and there have been significant advances in the field in the last few years. The methods are becoming easier to use, take shorter time and are less expensive than they used to be. Rapid methods and portable devices have also been developed that make DNA authentication more applicable for the seafood sector; and can potentially within not too long time be adopted as a tool within the production line of seafood processing plants.
Introduction

Neytendur gera kröfu um stöðugt framboð
Keðjan frá veidum og eldi er flókin

Seafood Fraud

Seafood is one of the most common foods subjected to fraud/mislabelling:
1. Orange juice
2. Honey
3. Truffle oil
4. Blueberry’s
5. Milk
6. Fish
7. Saffron
8. Olive oil
9. Pomegranate juice
10. Coffee

Source: consumers.nl

The problem: Species substitution

One out of three fish served in Brussels is not what consumers pay for

Bluefin tuna, sole and cod are substituted by species up to 40% cheaper

DNA testing found that one-third (33 percent) of the 1,215 samples analyzed nationwide were mislabeled, according to U.S. Food and Drug Administration (FDA) guidelines.
"Low mislabeling rates indicate marked improvements in European seafood market operations" - Martini et al. 2015

Mislabeling rate of 4.9% which can be further broken down into the following country-specific mislabeling rates:

- France – 2.7%
- UK – 3.25%
- Ireland – 3.9%
- Germany – 6.21%
- Portugal – 6.7%
- Spain – 8.9%

New Scientific Methods to Detect Fraud

Molecular techniques and Documentation procedures have improved.
Internationally funded research in this area, includes:

- Labelfish
- Authent-Net
- DiscardLess
- DNAqua-Net

Matis use DNA profiles for species, stock and individual ID

Stock and individual identification, traceability, parentage analysis, QTLs, etc.:

- Herring
- Mackerel
- Codfish / Wolffish
- Turbot
- Halibut
- Cat
- Redfish
- Plaice
- Norwegian Lektor
- Arctic char
- Brown trout
- Minke whale
- Fin whale
- Blue whale
- Blue mussel
- Scallops

Species identification:

- Fish species (3 gen)
- Shell, etc.
- Algae

Parental and breeding:

- Horse
- Sheep
- Dog
- Chicken

For:

- Monitoring, Control and Surveillance (MCS)
- Illegal, Unreported and Unregulated (IUU) fishing
DNA-based Tools for Seafood Identification

Species identification
DNA sequencing
- DNA sequencing can be used to identify the species against all known sequences in a database (DNA barcoding)

Real time PCR (qPCR)
- Species-specific PCR method

Population and population origin identification
Based on analysis of microsatellite or SNPs (single-nucleotide polymorphism) markers

Which method and molecular marker to use?
Population vs species identification
Available information on spawning locations
Existing genomic sequence data

Mitochondria

DNA barcoding
Real-time PCR (qPCR)

Stock assignment

Sebastes mentella (dijíkarfi)
Sebastes marinus, Norvegicus (gulfarfi)

Metagenomics

DiscardLess

EU að vinna í því að banna brottkast
Mattí er að þróa aðferðafæði til að greina fisktegundir og hlutföll í mélta
Notum MinION rægreina
Genetic structure of Atlantic salmon in Icelandic rivers and the assignment of marine caught salmon

K. OLAFSSON, C. PAMPOULIE, S. HORLEIFSDOTTIR, S. GUDJONSSON, S. M. EINARSSON, J. GIBBEY, G. O. HRAGGVIDSSON

Identifying Salmon Stocks in North Atlantic

3 Main Regions:
North
South
Iceland

Data credit: John Gilbeey and the Salsea genetics team

Genetic Profiling of Individual Rivers is Possible

Genetic distance (Dd) phenogram (neighbour joining algorithm)
Tracing salmon by-catch in ocean to origin

Thank you
From Sea to Plate? Fish mislabelling in European restaurants

Miguel Angel Pardo from AZTI Tecnalia in Spain presented a work that he has been leading where mislabelling of seafood in the European HoReCa (Hotels, Restaurants and Catering) sector has been researched. A total of 283 samples were collected in 180 outlets across Europe, in 23 countries. The average mislabelling rate showed to be 31%; canteens had the highest rate of substitution of all outlets and the more expensive species, such as tuna, had the highest substitution rate. 72% of mislabelled fish wars substituted with less expensive fish species, suggesting economic motivation.

Recent Findings Indicate that Seafood is One of the Most Mislabelled Foodstuff of Food Sector

- More than 1700 species of fish are traded internationally (1200 in the EU)
- Seafood is a valuable commodity
- Most often seafood is processed and then traded
- Long and complex food supply chain
- There is not internationally/national agreed upon commercial name
- Different consumption level among species
- Illegal unreported and unregulated (IUU) fishing
There is real need to **assure fish authenticity and reduce misdescription incidents**

**WP6**

Reduce product misdescription in the seafood sector

---

**The worldwide average of misdescription reported is 30% (2010-2015)**

- A comprehensive literature search of 50 peer-reviewed
- The number of data reported is **4150**
- Only 10% from restaurants

**The average of misdescription reported is 3-10%**

- Specific surveys in retail sector
- The number of analyzed samples is **1500**

---

**2015-2017**

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of establishments</th>
<th>Number of samples</th>
<th>City</th>
<th>Fish species</th>
<th>Reference</th>
<th>Misdescription (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>unknown</td>
<td>106</td>
<td>Paris</td>
<td>fish</td>
<td>Bénard-Capelle, 2016</td>
<td>8</td>
</tr>
<tr>
<td>Italy</td>
<td>23</td>
<td>185</td>
<td>-</td>
<td>sauri</td>
<td>Amiani, 2017</td>
<td>3.4</td>
</tr>
<tr>
<td>EU</td>
<td>unknown</td>
<td>471</td>
<td>-</td>
<td>white fish</td>
<td>EC, 2015*</td>
<td>8</td>
</tr>
<tr>
<td>UK</td>
<td>31</td>
<td>115</td>
<td>3 cities</td>
<td>sauri</td>
<td>Vandamme, 2016</td>
<td>10</td>
</tr>
<tr>
<td>Belgium</td>
<td>150</td>
<td>280</td>
<td>Brussels</td>
<td>fish</td>
<td>Christiansen, 2017</td>
<td>31</td>
</tr>
<tr>
<td>Germany</td>
<td>24</td>
<td>47</td>
<td>5 cities</td>
<td>sole</td>
<td>Kappel, 2015</td>
<td>50</td>
</tr>
<tr>
<td>Spain</td>
<td>unknown</td>
<td>130</td>
<td>3 cities</td>
<td>tuna</td>
<td>Gortze, 2017</td>
<td>83</td>
</tr>
</tbody>
</table>

- Great variability 3-83%
- Focused on a limited number of species
- Local sampling plans/limited number of cities
- Limited or unknown number of restaurants

**SPECIFIC SURVEY IN EU RESTAURANTS SHOULD BE UNDERTAKEN**

---

*Central peer coordinated at European Union level to assess the prevalence on the market of white fish mislabelled with regard to its declared species. 2015.*
WHAT IS THE PROBABILITY THAT CONSUMERS BUYING FISH IN EUROPEAN RESTAURANTS, CATERINGS, CANTEENS ETC... WILL NOT GET THE FISH THEY THINK THEY ARE OFFERING?

HOW? TAKING AS MUCH SAMPLES AS POSSIBLE

Volunteers collectors

- Scientific work undertaken by members of the general public
- Under direction and according to specific protocols
- The cost effectiveness of citizen science data can outweigh data quality issues such as:
  - Risk of introducing bias into the data
  - Members may lie about data
- So, any mislabelling case must be carefully checked
Sampling (2015-2016)

<table>
<thead>
<tr>
<th>Country</th>
<th>Fish consumption (kg/capita/year)</th>
<th>Number of establishments</th>
<th>Number of samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iceland</td>
<td>90</td>
<td>21</td>
<td>51</td>
</tr>
<tr>
<td>Portugal</td>
<td>56,8</td>
<td>17</td>
<td>23</td>
</tr>
<tr>
<td>Spain</td>
<td>42,4</td>
<td>22</td>
<td>17</td>
</tr>
<tr>
<td>Finland + Baltic States</td>
<td>40</td>
<td>9</td>
<td>19</td>
</tr>
<tr>
<td>France</td>
<td>34,6</td>
<td>17</td>
<td>23</td>
</tr>
<tr>
<td>Sweden</td>
<td>35</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Italy</td>
<td>25,4</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Belgium</td>
<td>25,1</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Netherlands</td>
<td>23,6</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Denmark</td>
<td>23</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Greece + Cyprus</td>
<td>19,6</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>UK + Ireland</td>
<td>19</td>
<td>22</td>
<td>24</td>
</tr>
<tr>
<td>Switzerland</td>
<td>15</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Germany</td>
<td>14,2</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Slovenia</td>
<td>12</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Norway</td>
<td>12</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>5,5</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>Romania</td>
<td>6,1</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>283</strong></td>
</tr>
</tbody>
</table>

23 EU countries

The DNA testing process:

1. **Sampling:** Take a tiny sample from each product.
2. **DNA extraction:** Using a process called polymerase chain reaction (PCR), the portion of DNA that contains the ‘barcode’ for each species is isolated.
3. **Barcode identification:** The code is identified and cross-referenced with the product label.
4. **Reference codes:** The reference code that matches the barcode is selected. The species is identified and cross-referenced with the product label.
Genetic Analysis

• Interpretable sequences were obtained in 282/283 samples
• Molecular identification was successfully addressed at species level in 97% of samples
• Eight rockfish samples were identified at genus level
• All tuna samples (n=50) were identified at species level

Mislabelling Determination

To conclude a misdescription incident we have compared the commercial name included in the menu with the scientific name for each fish species, in accordance with:

The National List of Commercial Names of different Member States

AND/OR

The FishBase Information System (www.fishbase.org)

Reg. (EU) 1379/2013 Article 37:
For the purposes of Article 35(1), Member States shall draw up and publish a list of the commercial designations accepted in their territory, together with their scientific names
Applicable Legislation

The EU fishery and aquaculture products’ market is regulated by Reg. (EU) 1379/2013, which introduced specific requirements for a common organization of the market and established traceability and labelling rules integrating the mandatory provisions of Reg. (EU) 1169/2011 on food labelling.

Reg. (EU) 1379/2013: Mandatory information: “the commercial designation and scientific name”

CHAPTER IV CONSUMER INFORMATION Article 35 (1) referred to in points (a), (b), (c) and (d) of Annex I

Exclusion of prepared and processed products (except raw fish and cooked crustaceans)

Restaurant owners are not obliged to put the mandatory information on their menus

But, legislation establishes that all the information provided to the final consumer (including “mass caterers”) have to fulfill the transparency requirements as regards the description of the ingredients used.

not mandatory but would be desirable

Results

WHAT IS THE PROBABILITY THAT CONSUMERS BUYING FISH IN EUROPEAN RESTAURANTS, CATERINGS, CANTEENS ETC... WILL NOT GET THE FISH THEY THINK THEY ARE OFFERING?

31% [25-38%]
Confidence level of 95% (α = 0.05; Wilson’s method) (n=180)
Margin of error of 7%

Disclaimer: The information expressed in this presentation reflects the authors’ views, the European Commission is not liable for the information contained therein.

The higher % of fish mislabeling was detected in caterings, canteens and take away restaurants

Restaurant (low)
Restaurant (medium)
Restaurant (high)
Take away
Hotels
Catering, Canteens

Mislabeling rates according to the origin of sample. All the confidence intervals (α = 0.05) were calculated using Wilson’s method and represented like error bars. Analysis of variance were calculated by Statgraphics.
The rate of mislabelling did not differ significantly between fish groups. 72% [63-81] of mislabeled fish were substituted with cheaper fish species suggesting economic motivation.

80 commercial fish species

% Misdescription

Misdescription rates according to the origin of sample. All confidence intervals (α = 0.05) were calculated using Wilson's method and represented the error bars. Analysis of variances were calculated by SPSS.

Great variability

Specific national surveys should be addressed

<table>
<thead>
<tr>
<th>Country</th>
<th>N</th>
<th>Nm</th>
<th>%</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spain</td>
<td>22</td>
<td>11</td>
<td>50</td>
<td>(31-69)</td>
</tr>
<tr>
<td>Iceland</td>
<td>21</td>
<td>10</td>
<td>48</td>
<td>(29-68)</td>
</tr>
<tr>
<td>Finland &amp; Baltic States</td>
<td>9</td>
<td>4</td>
<td>44</td>
<td>(19-75)</td>
</tr>
<tr>
<td>Germany</td>
<td>7</td>
<td>3</td>
<td>43</td>
<td>(16-75)</td>
</tr>
<tr>
<td>Portugal</td>
<td>17</td>
<td>4</td>
<td>25</td>
<td>(12-64)</td>
</tr>
<tr>
<td>Belgium</td>
<td>6</td>
<td>2</td>
<td>33</td>
<td>(10-70)</td>
</tr>
<tr>
<td>Norway</td>
<td>6</td>
<td>2</td>
<td>33</td>
<td>(10-70)</td>
</tr>
<tr>
<td>France</td>
<td>22</td>
<td>5</td>
<td>23</td>
<td>(13-53)</td>
</tr>
<tr>
<td>Romania</td>
<td>7</td>
<td>2</td>
<td>29</td>
<td>(8-54)</td>
</tr>
<tr>
<td>Italy</td>
<td>12</td>
<td>3</td>
<td>25</td>
<td>(14-76)</td>
</tr>
<tr>
<td>Netherlands</td>
<td>4</td>
<td>3</td>
<td>25</td>
<td>(0-79)</td>
</tr>
<tr>
<td>UK &amp; Ireland</td>
<td>22</td>
<td>4</td>
<td>18</td>
<td>(7-39)</td>
</tr>
<tr>
<td>Denmark</td>
<td>6</td>
<td>1</td>
<td>17</td>
<td>(1-34)</td>
</tr>
<tr>
<td>Greece &amp; Cyprus</td>
<td>7</td>
<td>1</td>
<td>14</td>
<td>(3-31)</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>8</td>
<td>1</td>
<td>13</td>
<td>(2-47)</td>
</tr>
<tr>
<td>Sweden</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Switzerland</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Slovenia</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>180</td>
<td>56</td>
<td>31</td>
<td>(25-38)</td>
</tr>
</tbody>
</table>

Misdescription rates according to the origin of sample. All confidence intervals (α = 0.05) were calculated using Wilson's method and represented the error bars. Analysis of variances were calculated by SPSS.

Spanish Survey

313 samples; 204 restaurants

48% [41-54%]

Confidence level of 95% (α = 0.05; Wilson’s method) (n=204)
Bluefin tuna
*(Thunnus thynnus)*

Mislabeled: 58% (36-77)
(n=19)

Tunas
*(T. obesus / T. albacares)*

Significantly lower rates
that similar studies

Yellowfin tuna
*(Thunnus albacares)*

Mislabeled: 43% (18-75)
(n=7)

Bigeye tuna
*(T. obesus)*
Swordfish (Xiphias gladius)

Mislabeling 14% [11-37] (n=7)

Stripped marlin (Kajikia audax)

Dusky grouper “Mero” (Epinephelus marginatus)

Mislabeling 100% [77-100] (n=13)

Atlantic wreckfish (Polyprion americanus)

Nile perch (Lates niloticus)

Saithe (Pollachius virens)

Panga (Pangasius hypophthalmus)

Common sole (Solea solea)

Mislabeling 60% [23-88] (n=5)

Yellowfin sole (Limanda aspera)

Argentine hake (Merluccius hubbsi)
The case of Cod

We have collected 51 samples under different denominations

- **Baccala**  
  (Gadus morhua)

- **Bacalao**  
  (Gadus morhua)

- **Cod**  
  (G. morhua, G. macrocephalus/ogac)

- **Cabillaud**  
  (Gadus morhua, G. macrocephalus, G. ogac, Arctogadus glacialis, Boreogadus saida, Eleoginus navaga, E. gracilis)
The case of Cod

Mislabeled
27% [17-41]
(n=51)

Blue shark
(Pseudosciaena porcus)

Butterfish
(Pampus spp., Pepsora spp.,
Stromateus spp.)

Mislabeled
50% [38-66]
(n=5)

Escalier
(Lepidopsetta flavobrunneum)

Indigestible wax esters can cause mild keratosis, a condition characterized by excretion of an orange/brown oil.

The most omnipresent species

Panga
(Pangasius hypophthalmus)

Pepperellis (2016); Wang (2016);
Koppel (2015); Helmer (2014)

Isothermal Amplification (RPA®: Recombinase Polymerase Amplification)

Cotton swab

Lateral flow detection

5-10 minutes
RPA: Recombinase Polymerase Amplification

- Detection in 15-20 min:
  - No initial denaturation step at 95°C
  - BsU polymerase requires short incubation time
- BsU polymerase maintains activity in inhbit environments
- Operates at lower temperatures (37-42°C)
- Two primers
- Can be multiplexed
- Extra functionality
  - RPA-ELISA, RPA-LFD (Lateral Flow Device)
  - Fluorescent probes for Real Time PCR
- Sensitivity (1 copy)
- Point of care applications (pathogens detection kits)

RPA employs 3 core enzymes:
- Recombinase (T4 uvsX-primer)
- Single strand DNA binding protein
- Strand displacing BsU polymerase

The 3 core RPA enzymes can be supplemented by other enzymes to provide extra functionality:
- Exonuclease III allows the use of an exo probe for real time
- Endonuclease IV means that a rpo probe can be used for lateral flow strip detection
SUMMARY

- This is the European largest fish survey focusing entirely on the restaurants
- 1 out of 3 establishments [31% (± 7%)] served mislabeled fish in the menu
- The higher % of fish mislabeling was detected in caterings, canteens and takeaways
- Remarkable differences between countries
- Specific national surveys should be addressed
- 72% (± 9%) of mislabeled fish samples were substituted with cheaper fish species suggesting economic motivation
- Lack of care in the manipulation of fish in the sector
- Aquaculture species (low optimal consumption) substituting wild-caught species (high optimal consumption)
- Some sustainability and food safety issues have been identified
- Legislation should be improved to include mandatory information (commercial designation and scientific name) in processed products (at restaurants etc...)

Technicians from AZTI (Kabi, Nagore, Mari and Amalia) and MATIS labs
Collectors of samples (FOODINTEGRITY and LABELFISH)

Disclaimer: The information expressed in this presentation reflects the authors’ views; the European Commission is not liable for the information contained therein.
The Authenticate workshop in Iceland

Jónas R. Viðarsson from Matís presented the main take-home messages from the Authenticate workshop that was held in Reykjavík on March 16th 2016. The workshop was attended by 44 stakeholders from different sectors of the Icelandic seafood industry. Lively discussions took place at the event and considerable media coverage was received following the workshop. Those attending the workshop agreed on the importance of raising the issue of food integrity for the Icelandic seafood sector. The biggest attention was given to preliminary results coming from a research that Matís was conducting, showing the 23% of samples collected at restaurants in Reykjavík proved to be mislabelled. This highlighted that mislabelling is also taking place in Iceland.
Attendance – 44 persons

Sýni: 3 persons
TM Insurance: 2 person
Marco Partners: 1 persons
Sjálværufélag / publications: 1 person

HB Grandi: 3 persons
Ogurvik: 2 persons
Einhamar: 1 person
Iceland Pelagic: 1 person

Ministry of fisheries: 3 pers.
Directorate of fisheries: 3 per
Food & veterinary: 2 pers.
Promote Iceland: 1 pers.

Ministry of fisheries: 3 pers.
Directorate of fisheries: 3 per
Food & veterinary: 2 pers.
Promote Iceland: 1 pers.

Ministry of fisheries: 3 pers.
Directorate of fisheries: 3 per
Food & veterinary: 2 pers.
Promote Iceland: 1 pers.

Ministry of fisheries: 3 pers.
Directorate of fisheries: 3 per
Food & veterinary: 2 pers.
Promote Iceland: 1 pers.
Attendance – 44 persons

Attendance – 44 persons

Attendance – 44 persons
What about Iceland?

In 2016 Matis took 56 samples from 22 HoReCa outlets. 13 samples (23%) turned out to be mislabelled

1. Tusk sold as monkfish
2. Yellowfin tuna sold as Bluefin
3. Bigeye sold as Bluefin
4. Ling sold as cod
5. Ling sold as cod
6. Ling sold as cod
7. Bigeye tuna sold as yellowfin
8. Bigeye tuna sold as yellowfin
9. Bigeye tuna sold as yellowfin
10. Wolfish sold as tusk
11. Haddock sold as cod
12. Wolfish sold as spotted wolfish
13. Spotted wolfish sold as wolfish

Discussions: take-home messages

- Not entirely clear who is responsible for monitoring food fraud / integrity
  MAST (Food & Vet.), the health authorities (municipal level), directorate of fisheries, customs.....

- Integrity of products exported from Iceland vs. products sold in Iceland
  People seem to think that products produced in Iceland are okay and therefore little need for monitoring.

- Our products need to be protected against competing products
  Pangasius, double frozen, refreshed/chilled, Icelandic bacalao (boxes), label of origin

- What about additives?
  Phosphates, citric acid

Discussions: take-home messages

- What about regulations?
  EU, National, Traceability legislations, labelling laws etc.....

- We should look at this as an opportunity for Nordic seafood
  We have the opportunity to be the suppliers of seafood of the highest (verifiable) integrity
  We should cooperate
  Need for success stories (collaboration between research and industry)

- Available methods for detection and verification should be easily available for industry
  What, how and where can stakeholders get verification?
  FoodIntegrity project and Authent-Net project

- R&D needs to be careful about publicising information on food fraud?
  Meet pesc (IS), Wild boar (NO), FoodIntegrity study (IS)
Report on the Authenticate workshop in Norway

Geir Dahle from the Institute of Marine Research (Havforskningsinstituttet) in Norway presented the main outcomes from the Authenticate workshop that was held in Bergen on October 26th 2016. The workshop was primarily attended by professionals in the field of genetics and served as such an interesting role in bringing together leading Norwegian experts in that field. The workshop attendees generally agreed that the regulatory and monitoring system in Norway is capable of dealing with food fraud and food integrity issues. The competent institutions, such as NIFES, make sure that regulations are followed. The National Reference Laboratories are set up to monitor food safety and related regulations, which are important part of ensuring food integrity in Norway.

**Authenticate: Workshop in NORWAY**

Geir Dahle

**Laws and regulations related to food safety in Norway**

<table>
<thead>
<tr>
<th>The Food Act – food production and safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Gene Technology Act – rules on the use of GMO</td>
</tr>
<tr>
<td>Law on Public Administration</td>
</tr>
<tr>
<td>Feed Legislation</td>
</tr>
<tr>
<td>Regulations on labelling and sales of feed</td>
</tr>
<tr>
<td>Regulations on residues of pesticides in food and feed</td>
</tr>
<tr>
<td>Regulations on by-products</td>
</tr>
<tr>
<td>Regulations on additives in feed</td>
</tr>
<tr>
<td>TSE Regulations on feed</td>
</tr>
<tr>
<td>Regulations on public control</td>
</tr>
<tr>
<td>Regulations on sampling and analyses</td>
</tr>
</tbody>
</table>

**The main responsibility to follow up these laws and regulations lies with the individual businesses.**
Norwegian Food and Safety Authority (fish related activities)

- Governmental body, whose aim is, through regulations and controls, to ensure that food are as safe and healthy as possible for consumers and to promote fish and animal health.
- Role: to monitor food safety as well as fish health

The mission of the NFSA is to promote (fish related):

- Safe, healthy food and water
- Healthy fish and animals
- Ethical farming of fish and animals

NFAS (Continued)

- Participates in different international fora:
  - Codex Alimentarius (Food Safety, under WHO/FAO)
  - Standing committees and working groups under the auspices of the EU
  - Nordic Council Executive Committee for Fish and Aquaculture, Agriculture and Forestry
NFSA control

- Control of imported foods (different rules apply for food from EU/EEA and import from third countries)

<table>
<thead>
<tr>
<th>Program</th>
<th>Comments</th>
<th>Provider of analysis</th>
<th>Legislator</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Foreign substances in feed components produced from fish</td>
<td>Fish flour/fish oil; Establish limits for dioxins/PCBs</td>
<td>NFES</td>
<td>EEA</td>
</tr>
<tr>
<td>2. Genetic modification in food components and in feed to fish (removed)</td>
<td>Imported corn, soya, rapeseed, rice 3. country</td>
<td>VI</td>
<td>Norway, Certificate</td>
</tr>
<tr>
<td>4. Foreign substance program for fish</td>
<td>Farmed fish</td>
<td>NFES w/ contractors</td>
<td>EEA</td>
</tr>
<tr>
<td>5. National audit program for muscle production</td>
<td>Classified production areas, End product control</td>
<td>NIVEL, NFES, and more</td>
<td>ISKJ, ISK</td>
</tr>
<tr>
<td>6. Program - Imported products HCN/HC from 3. country</td>
<td>Fish, marine mammals, flour and oil; Risk-based</td>
<td>NFES, EEA</td>
<td>EEA</td>
</tr>
<tr>
<td>7. Fish feed</td>
<td>Risk assessment farming and food</td>
<td>NFES</td>
<td>EEA</td>
</tr>
<tr>
<td>8. Pollutants in fish</td>
<td>Fish oil, basilic-lobster</td>
<td>NFES</td>
<td>project</td>
</tr>
<tr>
<td>9. Polluted harbours and firths</td>
<td></td>
<td>NFES</td>
<td>project</td>
</tr>
<tr>
<td>10. Foreign substances in wild fish</td>
<td></td>
<td>NFES</td>
<td>project</td>
</tr>
<tr>
<td>11. Radioactivity in seafood</td>
<td>Map level in farmed fish</td>
<td>NFES</td>
<td>project</td>
</tr>
<tr>
<td>12. Authentication of seafood products (2015)</td>
<td>Pilot project; Coordinated control program</td>
<td>NF</td>
<td>EEA</td>
</tr>
</tbody>
</table>

Foreign substances in fish

- Program for surveillance of pharmaceuticals, prohibited and polluting substances in fish feed of animal origin and fish used for food.

Farmed fish

- EU- initiated surveillance and control program for food of animal origin. Norway have an obligation through the EEA treaty.

- NFAS responsible for the implementation

- NIFES (National Institute of Nutrition and Seafood Research) responsible for the analyses and reporting
NIFES (National Institute of Nutrition and Seafood Research)

- NIFES conducts research on feed for fish and fish as food
- NIFES is the National Reference Laboratory on PCR identification in animal feed
- Also works on genetic methods in addition to peptidomics to identify species and origin of species in seafood

Why monitor fish feed ingredients?

In 2015 over 1.6 million tonnes of fish feed in Norway (Source: Norwegian Directorate of Fisheries)

"Feed Legislation" of 7th Nov 2002: To secure safe feed, and thereby not presenting any harm to humans or animals, or make food from animals unfit for consumption. In addition the feed should not have an adverse effect on the environment.

Many regulations on feed

- Atlantic salmon diets were mainly composed of marine ingredients

Today - a blend of marine and plant feed ingredients
Marine undesirable substances

Dioxins (PCDF/PCDD), Polychlorinated biphenyls (PCBs), Organochlorine pesticides

Fish oil has been identified as one of the most important contributors to marine undesirable substances in salmon feed and farmed salmon.

Main objective

To evaluate time trends of levels of marine undesirable substances

1) Marine feed ingredients
2) Norwegian fish feed
3) Farmed Atlantic salmon

Norwegian surveillance programs

- Collected from Norwegian fish feed factories and fish farms
- Fish feed and feed ingredients: more than 5000 samples analyzed
- Farmed fish: Number is regulated by the EU Directive 96/23 (In 2014: 13 180 farmed fish were collected)
Surveillance program - fish feed

- Microbiology
- Heavy metals
- PCBs
- Dioxins and dioxin-like PCBs
- PAP
- Mycotoxins
- Polybrominated flame retardants (BFR)
- Antioxidants
- Selected vitamins and trace elements
- Pesticides

Detection of undesirable microorganisms in seafood

- Prions (TSE)
- Virus
- Bacteria
- Microscopic fungus
- Microscopic parasites

From: Bjern Tore Lunestad, NIFES

Most important bacteria in seafood: *Listeria monocytogenes*

- May cause serious illness in pre-weakened consumers, e.g. the «cheese case» from 2007
- 15 -25 cases annually of listeriosis in humans in Norway
- Mortality is approx 30 %
Baseline study *L. monocytogenes* RTE-foods
European Food Safety Authority, 2010 and 2011

3,053 packaged (not frozen) hot/cold smoked or cured fish
3,530 packaged heat-treated meat products
3,452 soft or semi-soft cheeses

From 3,632 retail outlets in 26 EU Member States and Norway.

Samples exceeding 100 cfu/g at the end of shelf-life was 1.7 %,
0.43 % and 0.06 % for fish, meat and cheese samples, respectively,
while for fish at the time of sampling it was 1 %.

Continues programs for the Food Authorities including microbiology

- *E. coli* and *Salmonella* in mussels and scallops
- Fish feed and the ingredients used
- Control of imported sea food from 3rd country

National reference laboratories (NRL)

Appointed by the Food Authorities and linked to the NRL’s in EU

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### National Reference Laboratories for Feed and Food in accordance with Regulation (EC) No 882/2004

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**National Reference Laboratories for Feed and Food in accordance with Regulation (EC) No 882/2004**
EU’s recommendations

ANNEXES
to the
COMMISSION RECOMMENDATION

on a coordinated control plan with a view to establishing the prevalence of fraudulent practices in the marketing of certain foods

Coordinated control plan for fish species substitution

ACTIONS AND SCOPE OF THE COORDINATED CONTROL PLAN

A. Objective

Competent authorities should carry out official controls in order to establish whether fish species found in unprocessed or processed fishery and aquaculture products complies with the species that is declared on the label or in other means of information accompanying the food product.

In case of non-compliance, Competent Authorities should try to identify the actual species, to the extent possible.

The methods or combination of methods used should allow, to the maximum extent possible, the identification of the real species in the case of noncompliance with the declaration accompanying the product.

IEF
PCR-RFLP
DNA-barcoding
RT-PCR
Member State Recommended number of samples

<table>
<thead>
<tr>
<th>Member State</th>
<th>Recommended number of samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany, Spain, France, Italy, United Kingdom</td>
<td>250</td>
</tr>
<tr>
<td>Czech Republic, Greece, Poland, Romania</td>
<td>160</td>
</tr>
<tr>
<td>Belgium, Denmark, Ireland, Croatia, Hungary, Netherlands, Austria, Portugal, Finland, Sweden</td>
<td>100</td>
</tr>
<tr>
<td>Bulgaria, Estonia, Latvia, Lithuania, Slovenia, Slovakia</td>
<td>70</td>
</tr>
<tr>
<td>Cyprus, Luxembourg, Malta</td>
<td>30</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3400</strong></td>
</tr>
</tbody>
</table>

Pilot-study

- **Samples of sea food products**
  - frozen, filet, dried, salted, fish burgers and - cakes
- **DNA** – “barcoding” (COI)
  - Started with several analyse setups, but ended with two as a “standard”
- Blasted the resulting sequences against the NCBI database

<table>
<thead>
<tr>
<th>Product</th>
<th>Labelled as</th>
<th>Result 1. yes</th>
<th>Result 2. no, DNA isolated again</th>
<th>Comments</th>
<th>COE</th>
<th>R</th>
<th>F</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish soup</td>
<td>Unknown</td>
<td>-</td>
<td>-</td>
<td>No label, no analysis</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Smoked salmon, lox, carpaccio, gravadlax, gravad</td>
<td>Salmon, carpaccio</td>
<td>-</td>
<td>-</td>
<td>Mixture of species, no analysis</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fish of cod</td>
<td>Cod</td>
<td>-</td>
<td>-</td>
<td>Similar product previously identified, no duplicates</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Breaded fish of fish</td>
<td>Unknown</td>
<td>-</td>
<td>-</td>
<td>Gadus chalcogramma</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Salts</td>
<td>Salt</td>
<td>-</td>
<td>-</td>
<td>Pollockus viruns</td>
<td>Ok</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fish tails in olive oil, halibut, halibut, and greater</td>
<td>Various species</td>
<td>No</td>
<td>-</td>
<td>Mixture of products and studio</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Fish cakes</td>
<td>Various species</td>
<td>Argolus sika</td>
<td>-</td>
<td>One of the species identified</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Breaded roe of salmon</td>
<td>Cod</td>
<td>Salmos salar</td>
<td>-</td>
<td>Identifiable, Need to check</td>
<td>Gadus holboe</td>
<td>Gadus holboe</td>
<td>Gadus holboe</td>
<td>Gadus holboe</td>
</tr>
<tr>
<td>Scallops</td>
<td>Scallops</td>
<td>No</td>
<td>-</td>
<td>Identifiable in NCBI database</td>
<td>No</td>
<td>No</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Breading fillets of cod with skin</td>
<td>Gadus chalcogramma</td>
<td>-</td>
<td>-</td>
<td>Identifiable species</td>
<td>Gadus holboe</td>
<td>Gadus holboe</td>
<td>Gadus holboe</td>
<td>Gadus holboe</td>
</tr>
<tr>
<td>Breaded cod</td>
<td>Cod</td>
<td>-</td>
<td>-</td>
<td>Extensive species chalcogramma</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

63
<table>
<thead>
<tr>
<th>Lateral name – labeled as</th>
<th>Specific identification</th>
<th>N.o identification</th>
<th>Deviant identification</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acanthias hirtus</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Brauva braun</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Gobius meridius</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>Identified as Gobius chatagranus (Filorgyna Ariston parvin)</td>
</tr>
<tr>
<td>Gobius macrolepidotus</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Gobius hubbsi</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Misgurnus sp.</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Aphanopus arenae</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Acarae roseni</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Dicentrarchus labrax</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Misgurnus anguillica</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Misgurnus anguillica</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Nemipterus boryanovskii</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Nemipterus labrax</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>Rainbow trout – not white fish</td>
</tr>
<tr>
<td>Nemipterus melas</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>Tiger pike – not white fish</td>
</tr>
<tr>
<td>Neogobius melas</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Pomatomus pelamis</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>Identified as Pomatomus berndti, probably from the wrong source declared on the label</td>
</tr>
<tr>
<td>Anguilla japonica</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Anguilla japonica</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Sellus sp.</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Sebastes sp.</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Thalassoma sp.</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>Yellow – not white fish</td>
</tr>
</tbody>
</table>

Total: 138 2 0
Report on the Authenticate workshop in Denmark

Jakob Hemmer-Hansen from DTU in Denmark presented the main outcomes from the Authenticate workshop that was held at the DanFish International fisheries exhibition in Aalborg on October 12th, 2017. The workshop was attended by researchers, managers and the fishing industry; and really good discussions were initiated at the workshop. The meeting was primarily aimed in explaining to the industry which methods for detecting fraud are available, in particular genetic methods. The use of Genetics to trace stock populations were also explained. The emerging technology of using portable devices for DNA species identification/authentications did get attention among the industry, which saw potentials in implementing such technology in the sector.

Tórshavn, November 2017

Authenticate workshop

Jakob Hemmer-Hansen & Dorte Bekkevold, DTU Aqua
Section for Marine Living Resources, Silkeborg, Denmark

Workshop in Denmark – DanFish Hirtshals
Participation from research, management and the fishing industry

DTU Aqua
National Institute of Aquatic Resources

Traceability at the species level

- DNA based tools and methods for species identification in fish (from egg to adult) and fish products (e.g. fillets)

- Next generation sequencing (NGS) applications for identification and quantification of species composition in complex samples (e.g. fish stomach content, fish silage, surimi, "cod" roe)

- Environmental DNA (e-DNA) applications, high throughput and automated systems for monitoring aquatic organisms (from virm to whales) in water samples (e.g. key ecosystem, important fisheries, protected and invasive species)
Traceability at the species level

Barcoding

The unambiguous identification of a species through a specific gene sequence

Cytochrome c oxidase I (COI) in animals

- High copy number in each cell (mtDNA)
- Suitable rate of evolution
  - Fast enough to accumulate differences
  - Slow enough to allow universal primers to bind
- Notable differences between species, few within
- Simple gene structure
- No introns

Barcoding of Life database: > 18,000 fish species

Traceability at the species level

Results

- 26 cans
  - 10 different brands (some brands sampled more than once)
  - 2 cans per sampling event

- 2 analysis replicates per can

- 52 samples for testing

-> 26 samples: only Atlantic cod (Gadus morhua) detected

-> 4 samples: no Atlantic cod detected
  All reads were Gadus macrocephalus, Pacific cod

-> 22 samples: Atlantic cod and other species detected
Traceability at the species level

Results

<table>
<thead>
<tr>
<th>Product A</th>
<th>Product B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replicate 1</td>
<td>Replicate 1</td>
</tr>
<tr>
<td>Can 1</td>
<td>Can 1</td>
</tr>
<tr>
<td>Can 2</td>
<td>Can 2</td>
</tr>
</tbody>
</table>

Atlantic cod (Gadus morhua)
Haddock (Melanogrammus aeglefinus)
Saith (Pollachius virens)

Traceability at the population level

- Identification of separate populations/stocks of aquatic organisms and their genomic characteristics, for identification of management units, aquaculture development and biodiversity conservation
- Tools (e.g. SNP chips) for determining the geographical or farmed/wild origin of fish and fish products (e.g. North Sea, Baltic or aquaculture cod), for fisheries management, environmental protection and for (food) forensic purposes
- Long term monitoring of the effects of exploitation and environmental change on important fish species through genomic analysis of DNA from archived material (e.g. scales and bones)

Traceability at the population level

Populations are genetically more similar than species

No categorical allocation, must identify most likely population of origin

-> Frequency differences

Individual assignment
Traceability at the population level

Cod in the Baltic Sea – statistical power

39 loci (SNPs)
WB: P (WB/EB) ~ 22 mio
EB: P (EB/WB) ~ 2 mio

Traceability at the population level

Cod in the Baltic Sea – population mixing

Traceability at the population level

Cod in the Baltic Sea – implications (split stock assessment)
Traceability at the population level

Cod in the Kattegat

Traceability at the population level
Cod in the Kattegat – population mixing

>40 cm

>40 cm, maturity=6

2015

2016

Traceability at the population level
Cod in the Kattegat – variation between cohorts

DTU Aqua, Technical University of Denmark

DTU Aqua, Technical University of Denmark
Traceability at the population level
Cod in the Kattegat – tracking of cohort proportions

Traceability at the population level
When do North Sea cod enter the Kattegat?

Traceability at the population level
Sandeel in the North Sea

Samples from all (new) sub areas (SA)
SA1 - 5 banks
SA2 - 2 banks
SA3 - 3 banks
SA4 - 2 banks
Traceability at the population level

...can be complicated
- Specific scenarios are preferable
- We can only assign fish to populations included in the baseline
- Fish from an un-sampled baseline may still assign to one of the included baseline samples (the most likely of the possible baseline samples)

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...but definitely feasible
- genomics technology facilitates major advances
- target new species and areas

Next steps?

Portability
Authent-Net & the FARNHub

Patrick Sørdahl from Norway introduced the H2020 project Authent-Net project and the FARNHub that is being developed within the project. Authent-Net is a Coordination and Support Actions (CSA) project that has the aim of bringing together R&D institutions in Europe that are working on food authenticity, collect information on national status on research and food fraud incidents, collect information on food frauds and available methods for detections for selected food items (including seafood), bring together and network with funding bodies across Europe that are funding food authenticity projects, try to initiate ERA-Net projects and finally to develop a web-based portal where users can get an overview of currently available resources related to food authenticity. This web-based portal is called the FARNHub (Food Authenticity Research Network Hub).
Authent-Net: Food Authenticity Research Network

- Anti-food fraud capabilities are poorly coordinated and not consolidated
- National research funding bodies need to be brought together

To facilitate sustainable cooperation between national and international research funding bodies in the area of food authenticity, to improve the competitiveness of the food supply chain and the consumer confidence in it, by means of better-coordinated, cost-effective R&D

Authent-Net will:

- Bring together relevant member states R&D budget holders to coordinate inter-disciplinary research effort and build a cohesive and sustainable network
- Undertake stocktaking of existing national research and assess against the international landscape
- Establish transnational mechanisms and instruments for collating and exchanging information on food authenticity research
- Develop a high level research and innovation strategy for transnational research and a rationale for a potential ERA-NET on food authenticity

Expected impact

- Improved coordination and communication between relevant member states research budget holders
- Enhanced cognisance of existing national research
- Joint strategy for food fraud R&D
- Agreed priorities and capability to deliver transnational European research on food fraud
Selected project outcomes

- Mapping and gap-analysis of todays status on food authenticity in Europe
- White-paper identifying the rationale for an ERA-NET on food authenticity
- Develop a low-level European Standard
  - CEN WS 86 – “Authenticity in Feed and the Food Chain – General Principles and Basic Requirements”
- Establish a dynamic and sustainable information platform
  - The Food Authenticity Research Network Hub

Low-level European standard

- CEN WS 86 – “Authenticity in Feed and the Food Chain – General Principles and Basic Requirements”
- Will develop “consensus-based recommendations for definitions of key terms and concepts, and outline principles and basic requirements related to food authenticity”
- Program ahead
  - Public hearing (late-November 2017 -> late-January 2018)
  - CEN Workshop Consensus meeting (March 2018)
    - In the context of the Authent-Net Final meeting
    - Time and date not set
  - Publication of CWA by CEN (May 1st 2018)

The FARNHub

- “The Food Authenticity Research Network Hub”
- Web-based portal where users can get an overview of currently available resources related to food authenticity
- Includes:
  - Publications (scientific or other)
  - Projects
  - Online databases
  - Funding body overview
  - News stories
  - Regulations
  - Analytical methods (through the “FoodIntegrity Knowledge Base”)
Discussions

Food fraud and food authenticity is apart of international seafood trade that is becoming increasingly noticed. Processors, retailers, food service sector, consumers and other stakeholders are aware of this problem, which seems to be growing. In some cases, food fraud is in many cases a part of what is considered organised crime and larger retail chains have reacted by setting up their own laboratories or contracting research institutions to authenticate their supplies. Large research projects have been initiated to address the issue and authorities have created task-forces to try to tackle the problem.

A growing societal demand for food authenticity, safety and broader food security is creating both new opportunities and increased challenges for Nordic seafood suppliers, manufacturers and retailers. Seafood from the Nordic countries have many favourable characteristics that provide competitive advantage on high paying markets, which is why their products are often subjected to fraud. This does however also create opportunities; if it is possible to ensure that Nordic products are traceable and if retailers & food service sector can fully trust their Nordic suppliers.

The Authenticate project has facilitated networking amongst Nordic stakeholders in the field of food authenticity and has served as important venue to raise awareness and understanding. The national workshops organised by the project gained considerable attention and the final workshop, which was broadcasted on Facebook, was viewed by around 200 persons. This highlights the growing attention that the issue is getting. The figure below shows a screenshot from Facebook during the broadcasting.

As follow-up on the Authenticate project are projects such as the Authent-Net project and facilitation of cooperation between researchers and industry to ensure authenticity of Nordic seafood products. There are available tools for detecting fraud, both analytical methods and other, which we have more understanding on as results of projects such as Authenticate. The Nordic seafood sector should therefore look at the issue as an opportunity to further highlight the many favourable characteristics of the fantastic seafood that the region has to offer.
Acknowledgements

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