An inventory of nanotechnology applications in the agricultural, feed and food sector

EFSA EXTERNAL SCIENTIFIC REPORT - CFT/EFSA/FEED/2012/01

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European Commission – Joint Research Centre

4. FachDialog
Nanotechnologie im Lebensmittelbereich
Berlin, 15 June 2015

Serving society
Stimulating innovation
Supporting legislation

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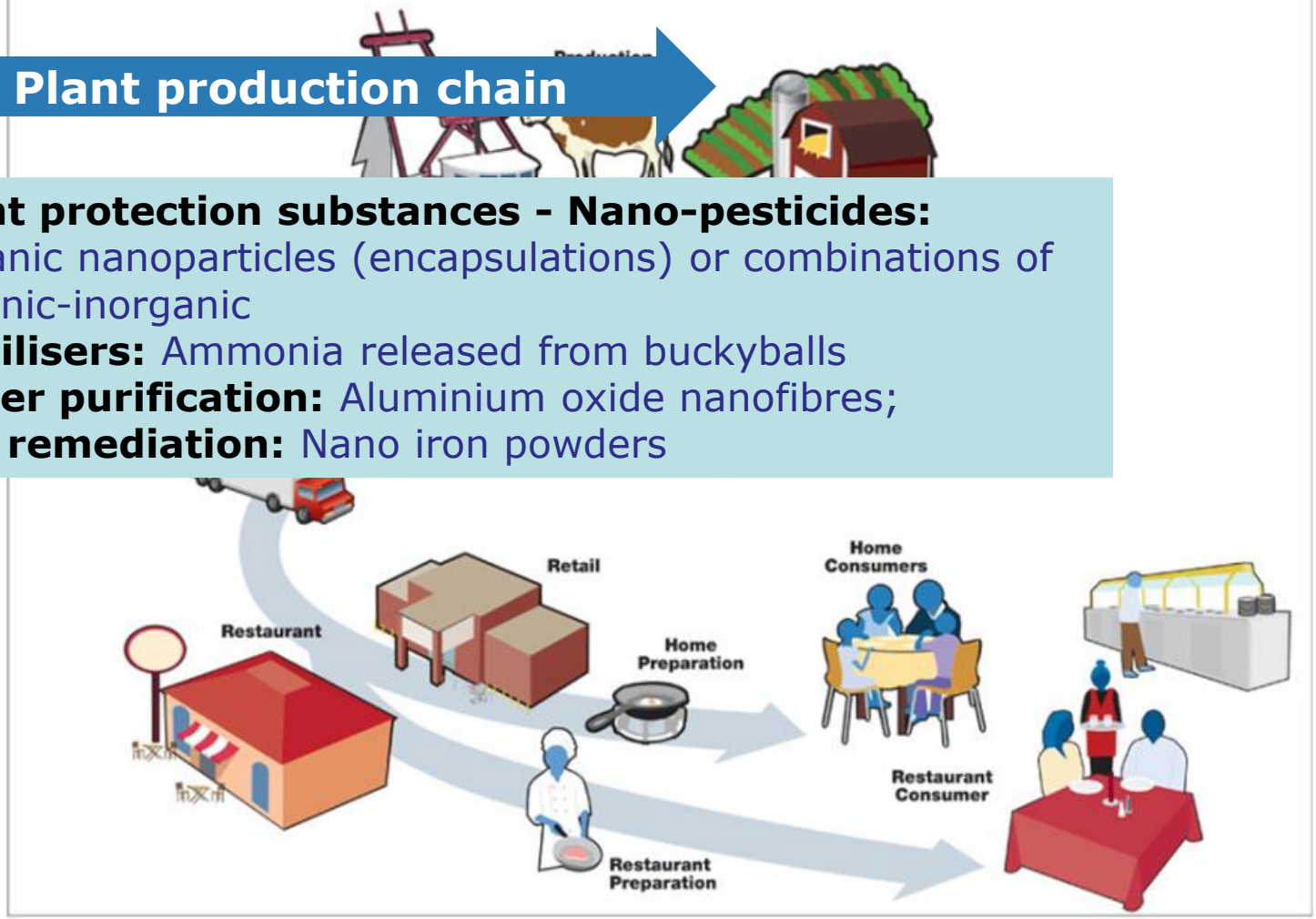
Plant production chain

Plant protection substances - Nano-pesticides:
Organic nanoparticles (encapsulations) or combinations of organic-inorganic
Fertilisers: Ammonia released from buckyballs
Water purification: Aluminium oxide nanofibres;
Soil remediation: Nano iron powders



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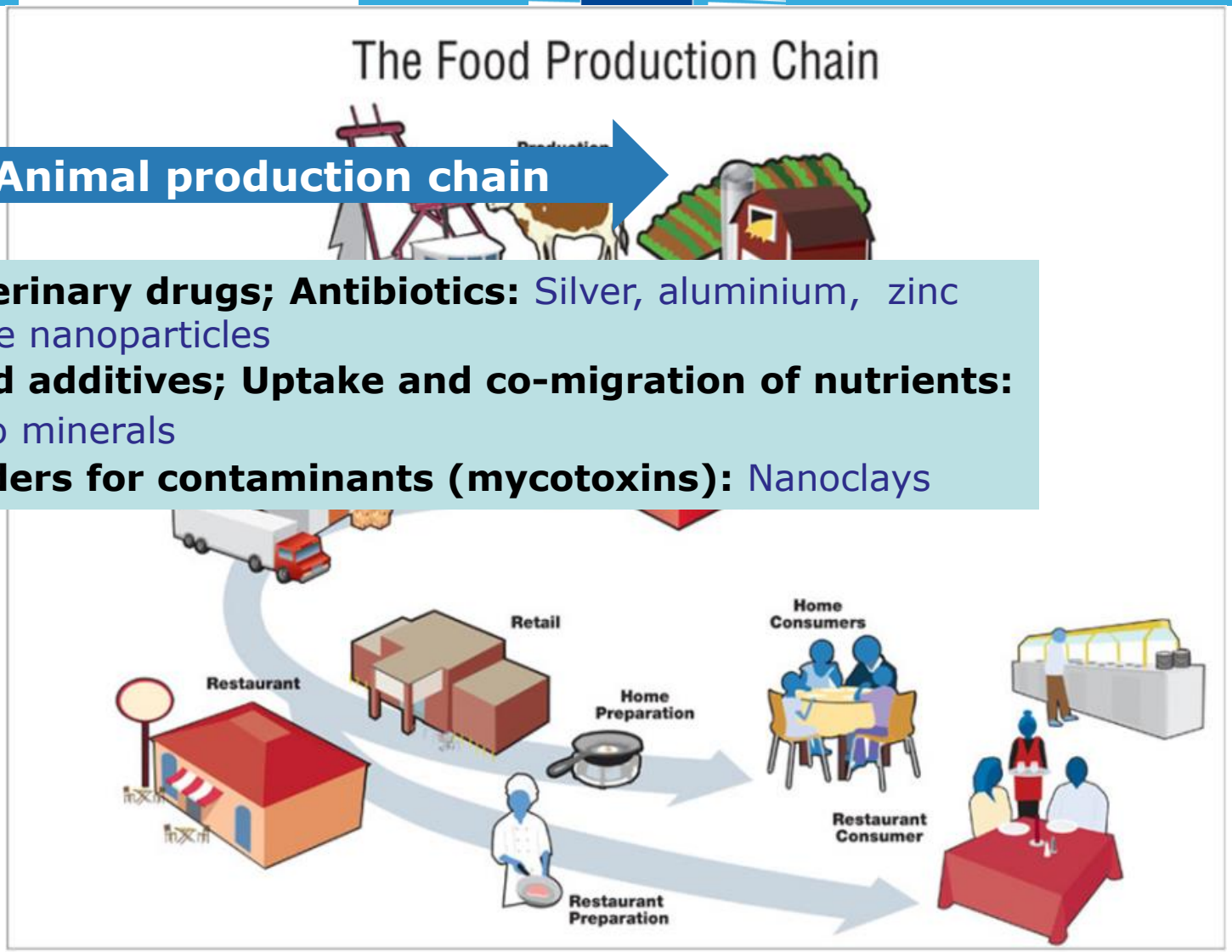
Animal production chain

Veterinary drugs; Antibiotics: Silver, aluminium, zinc oxide nanoparticles

Feed additives; Uptake and co-migration of nutrients: nano minerals

Binders for contaminants (mycotoxins): Nanoclays



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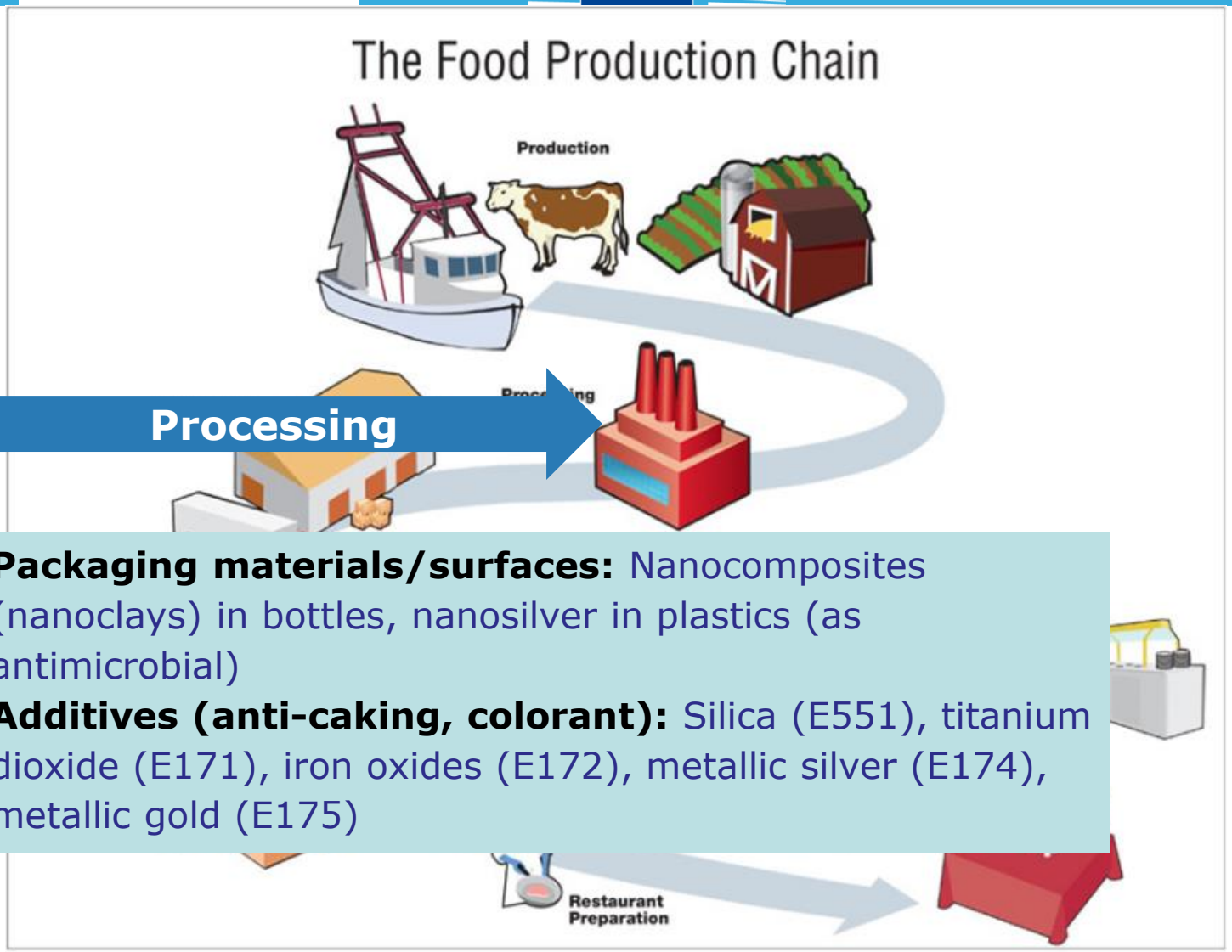

Packaging materials/surfaces: Nanocomposites (nanoclays) in bottles, nanosilver in plastics (as antimicrobial)

Additives (anti-caking, colorant): Silica (E551), titanium dioxide (E171), iron oxides (E172), metallic silver (E174), metallic gold (E175)

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How safe is nanofood? What is on the market?

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The EFSA Scientific Network for Risk Assessment of nanotechnologies in Food and Feed identified asked for **up-to-date information** on the **state of the art of nanotechnology applications** for the food sector.
EFSA launched a call for tender for an

Inventory of nanotechnology applications in the agriculture/food/feed sector

RIKILT – STICHTING DLO, Wageningen, NL

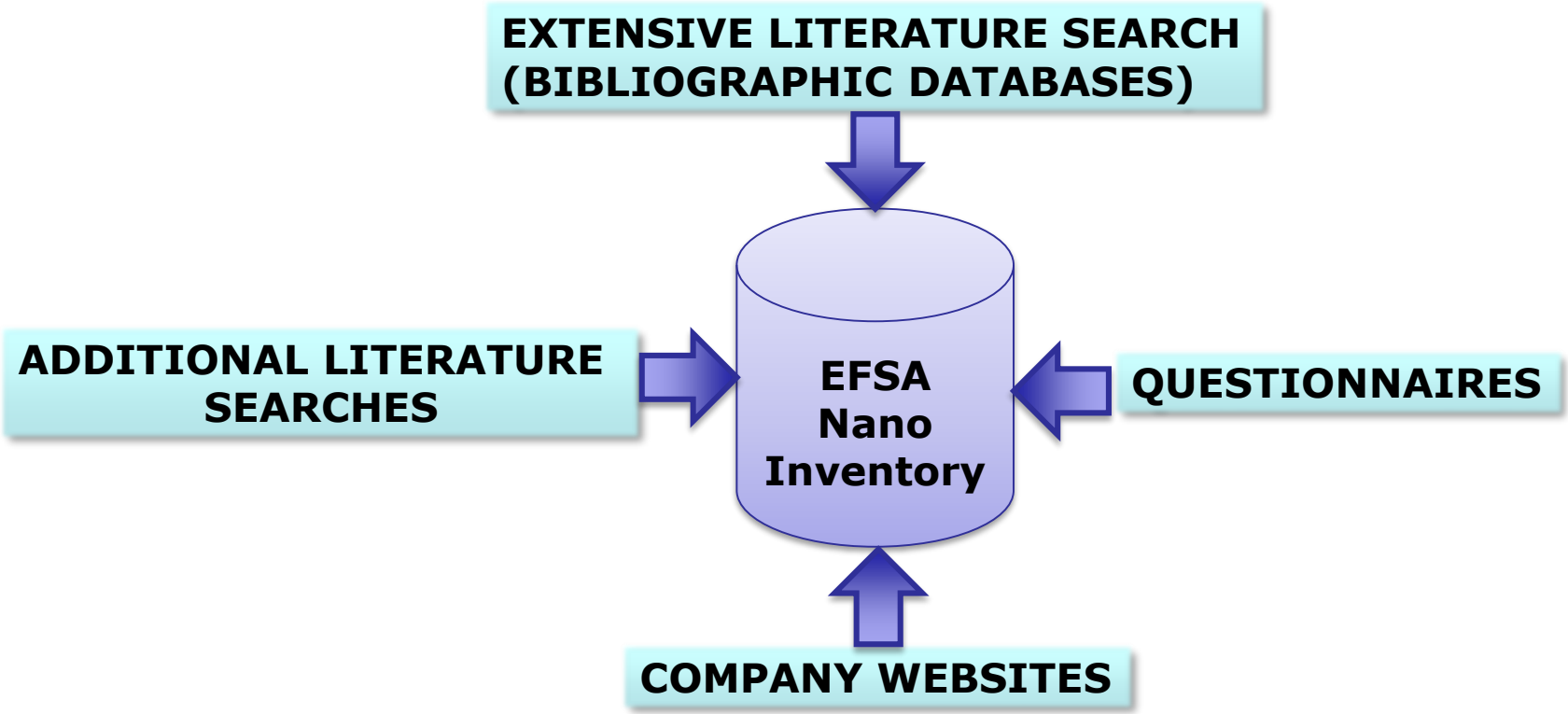
JRC-Institute for Health and Consumer Protection – Nanobiosciences; Ispra, IT

(Final report: July 2014)

Tasks in the project

1. Perform an **extensive literature search** of nanomaterials in the agri/feed/food sector
2. Produce **inventory lists** for applications of nanomaterials in the agri/feed/food sector
3. Provide detailed **descriptions** of the nanomaterials in (future) applications in the agri/feed/food
4. Review existing **legislation** for nanomaterials in non-EU countries

Sources of information: Nanoinventory



Search Results (see search strategy and exclusion criteria)

Bibliographic database	Identified hits	Selected relevant records
Scopus	4184	393
Web of Science	+ 2338	+134
PubMed Central	+ 1698	+64
NANOnet Base	+ 12	+4
SciFinder Scholar	+ 736	+55
Total	**8968**	**662**

Task 2: Nano Inventory

- Developed in Microsoft Access environment to facilitate collection, storage and extraction of data
- 3 predefined queries to generate inventory lists
  - Application
  - Toxicological data
  - Risk assessment status

Application fields

AGRI

- Pesticide
- Fertiliser

FOOD

- Food additive
- Food contact material
- Novel food
- Flavouring
- Enzyme
- Supplement
- Food ingredient (not specified)

FEED

- Feed additive
- Enzyme
- Supplement

OTHER

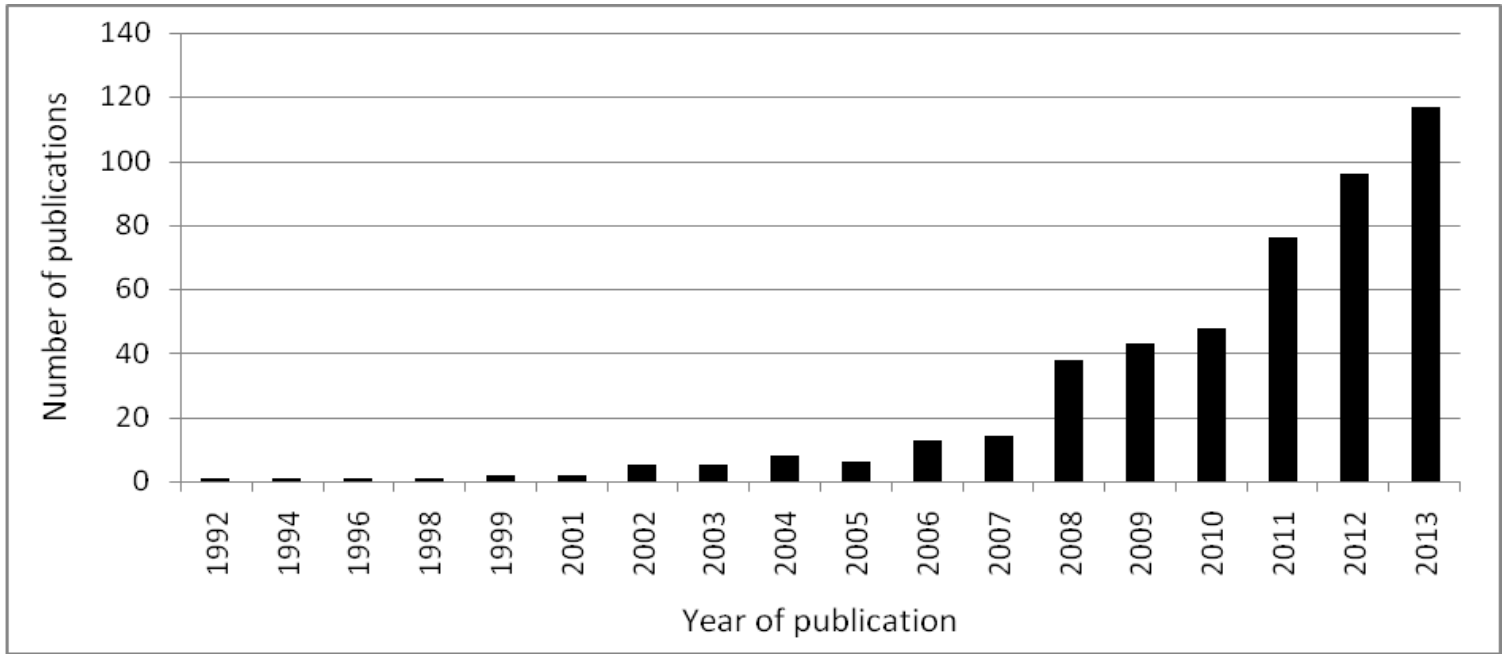
- Veterinary drug
- Biocide

Currently used

Foreseeable for future use

EFSA supporting publication 2014:EN-621 (adapted)

Task 2: Analysis of Nano Inventory



Year of publication (2013 not complete)

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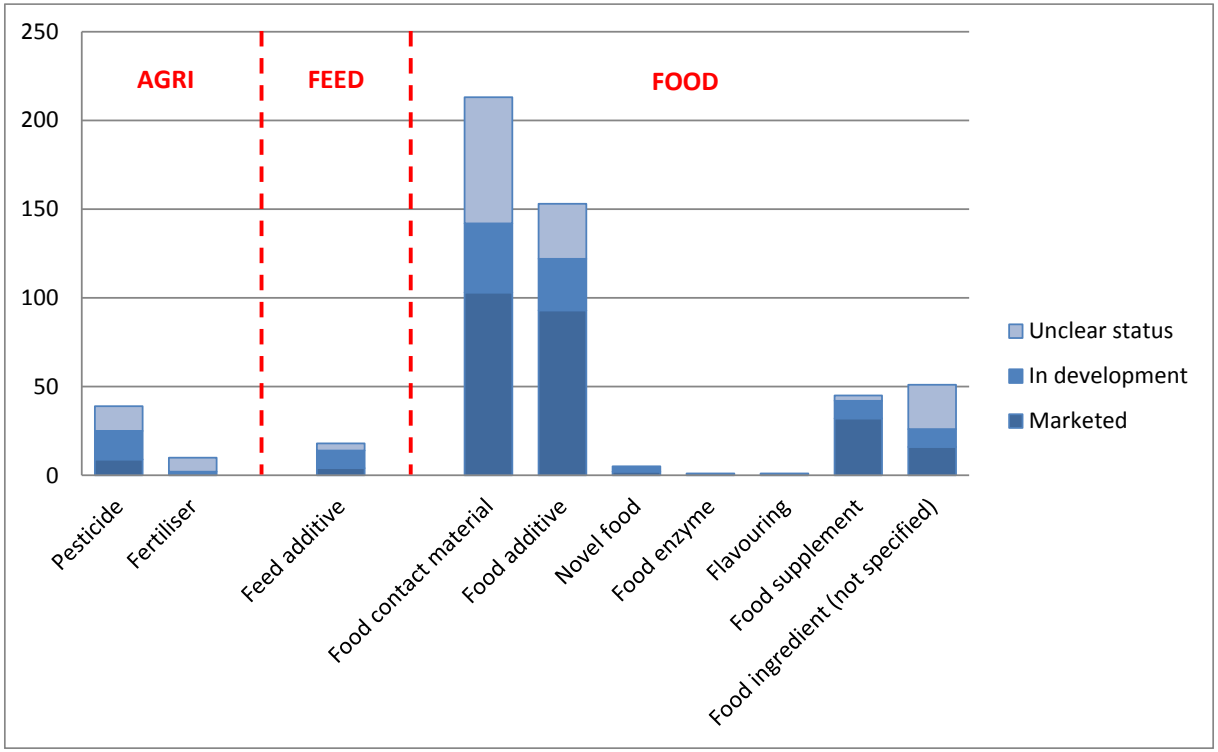
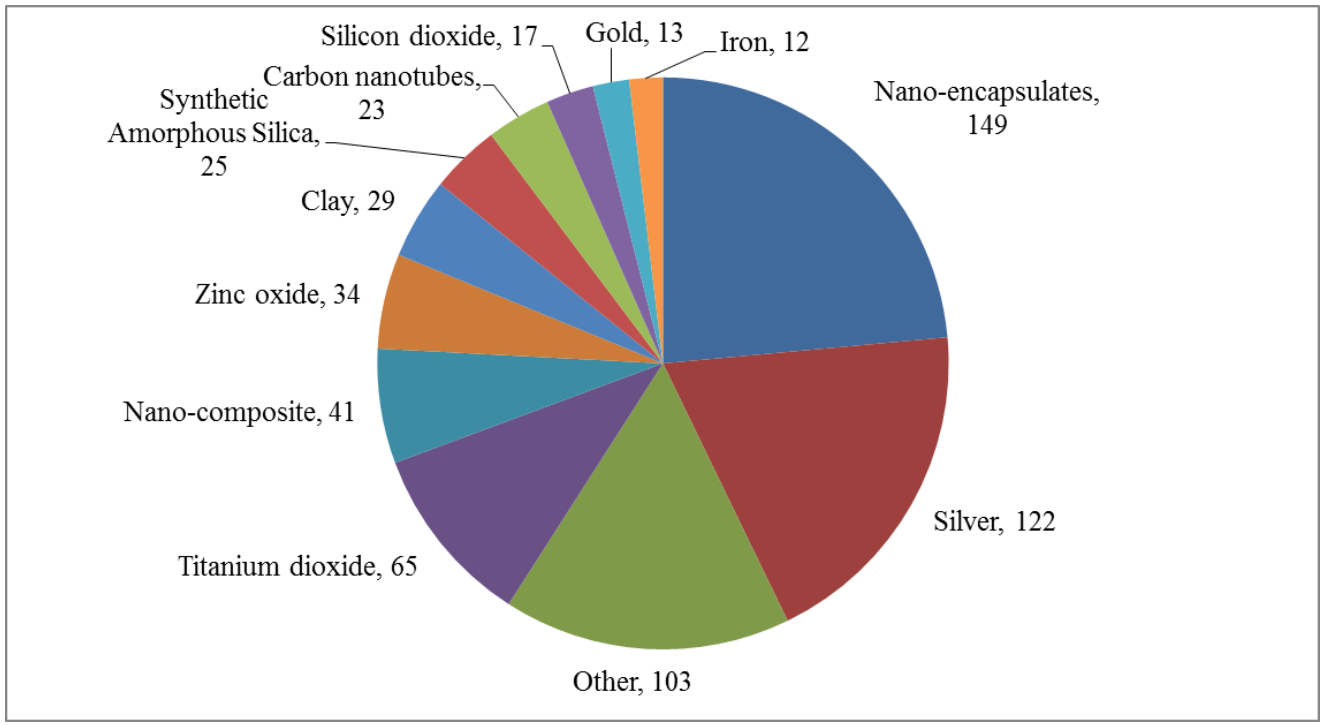
Task 2: Analysis of Nano Inventory



Peters et al. in preparation

Distribution of NM applications that are already marketed, in development or with unclear status over the most relevant application fields

Task 2: Analysis of Nano Inventory



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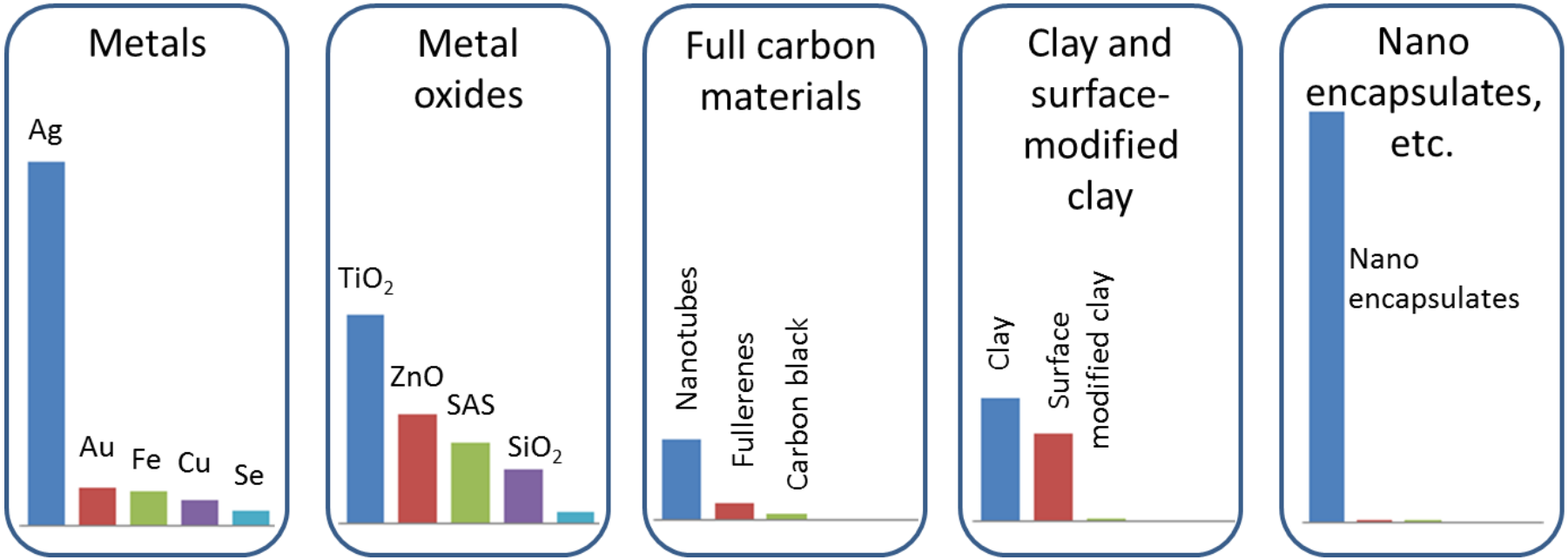
Overview of nanomaterial type mentioned in 633 records of the Nano Inventory (filtered with the query "current and future applications")

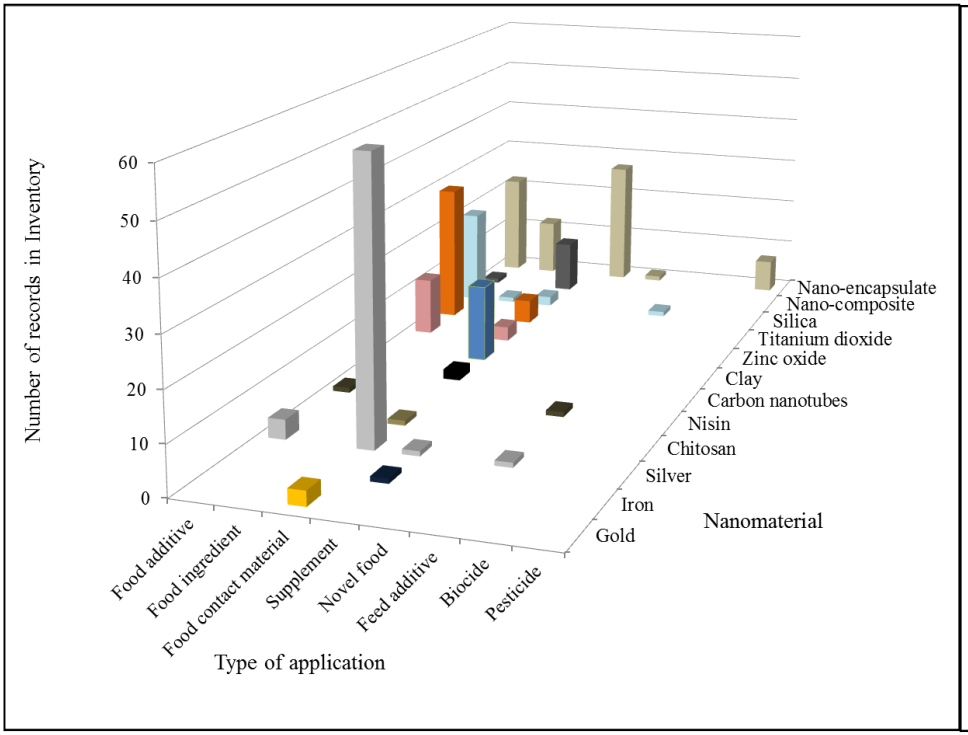
Task 2: Analysis of Nano Inventory



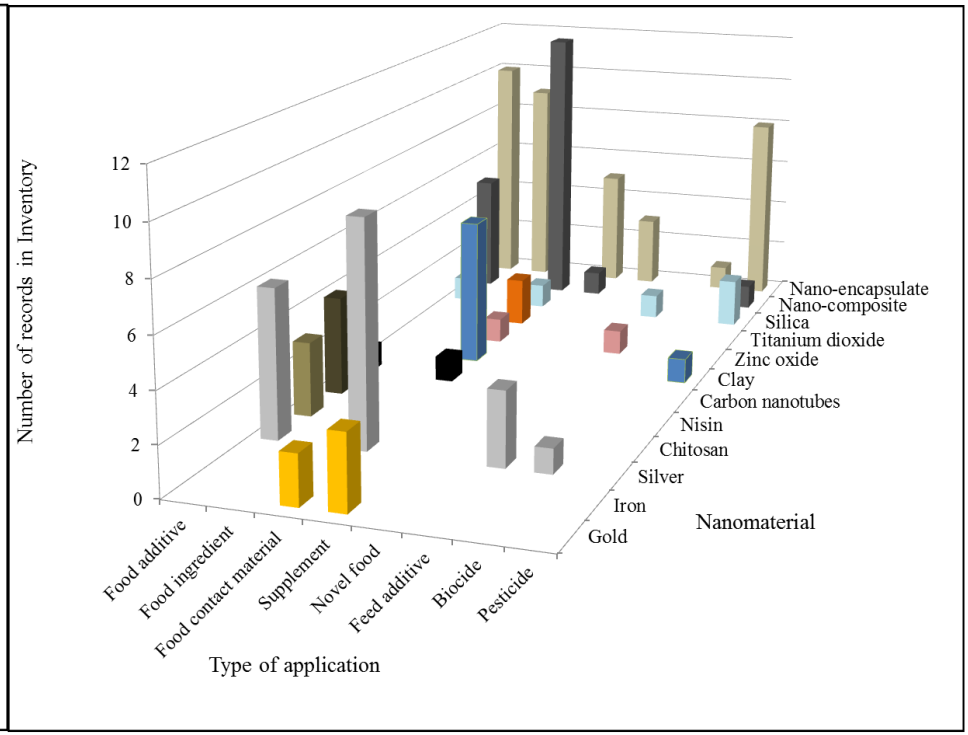
Peters et al. in preparation

Overview of the most often mentioned NM types and applications in the literature sources

Task 2: Analysis of Nano Inventory



available on the market



in development

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→ trend from inorganic materials towards organic materials

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Task 3: Nano-applications in agricultural production

Increase efficacy of agro-chemicals compared to conventional formulations

- Pesticides - Plant growth promoters - Animal feed additives
- Organic: encapsulations and solid lipid nanoparticles
- Inorganic: titanium dioxide, silver, silica, aluminia
- Commercialised products: Nanocid®(Ag), Chitosan (Chitin based polymer), PrimoMaxx (plant growth regulator), Nano-E (electrostatic atomized water particles)
- Naturally occurring: ashes, metals, nanoclay (fertilizer)
- Agri-waste management, water, soil cleaning

http://www.nanocid.com

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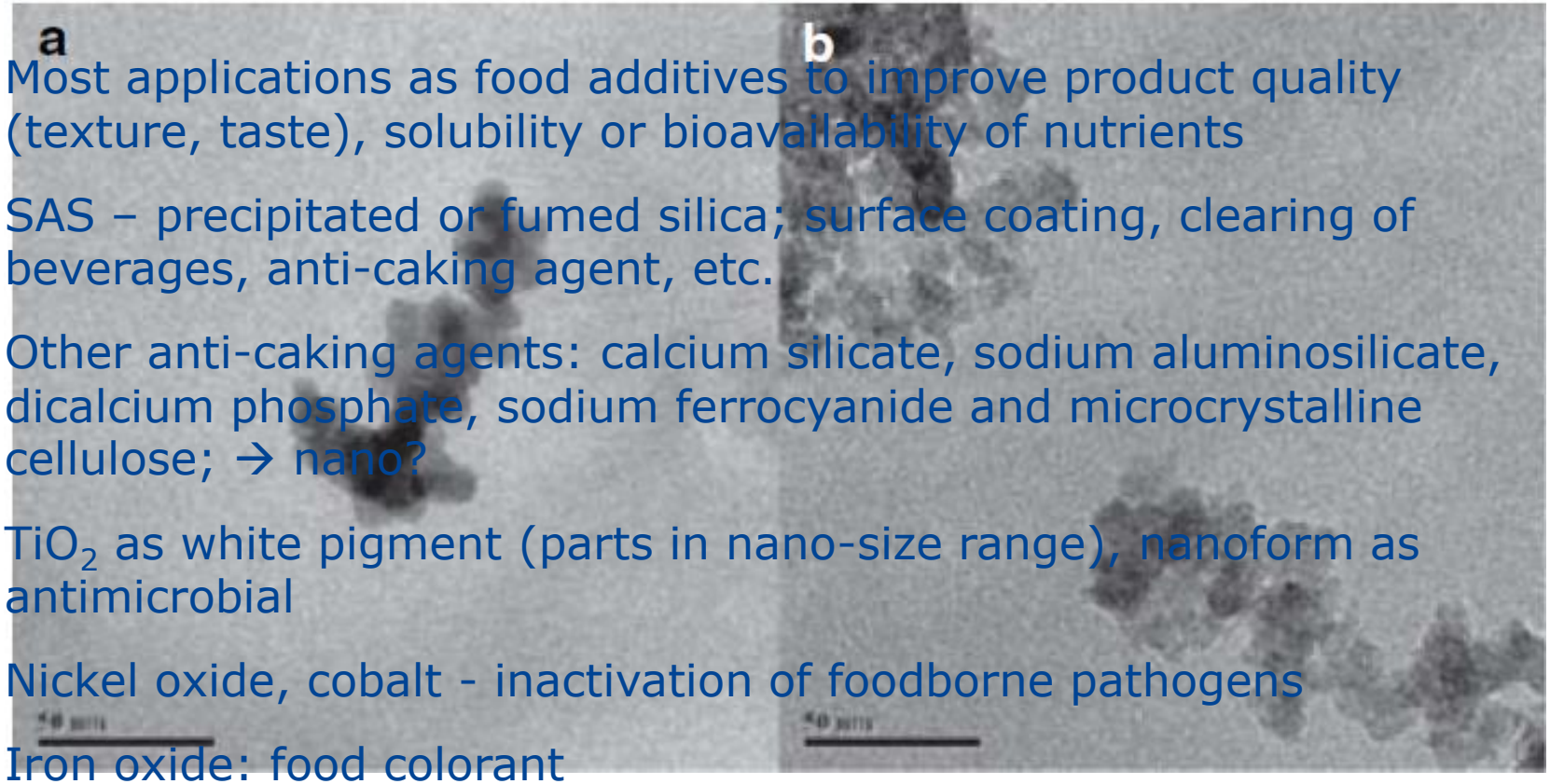
Task 3: Nano-applications in food (1)



Most applications as food additives to improve product quality (texture, taste), solubility or bioavailability of nutrients

SAS – precipitated or fumed silica; surface coating, clearing of beverages, anti-caking agent, etc.

Other anti-caking agents: calcium silicate, sodium aluminosilicate, dicalcium phosphate, sodium ferrocyanide and microcrystalline cellulose; → nano?

TiO_2 as white pigment (parts in nano-size range), nanoform as antimicrobial

Nickel oxide, cobalt - inactivation of foodborne pathogens

Iron oxide: food colorant

TEM images of Aerosil 200F (a),Aerosil 380F;
Dekkers et al. Nanotoxicology, 2011; 5(3): 393–405,

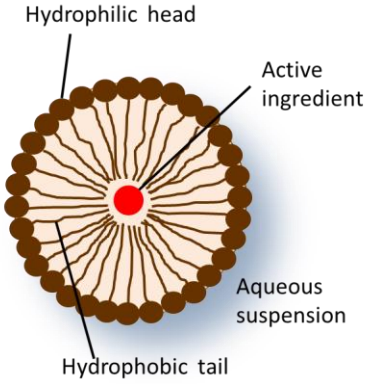
Task 3: Nano-applications in food (2)

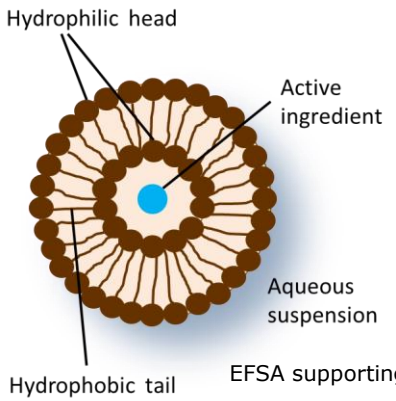
Nano-encapsulations and nanodelivery systems

Incorporation, adsorption or dispersion of bioactive compounds (vitamins, isoflavones, omegs-3 FA) in nano-sized vesicles

Improved stability, and solubility (hydro-lipophilic), increased bioavailability and delivery to cells/tissues

Lycovit™ (Lycopene), LifePak Nano™ (carotenoids, CoQ10), MicroHydrin™ (antioxidant)





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Task 3: Nano-applications in food contact materials

Coatings of machinery in food production, surfaces, kitchenware/equipment, nano-sieves, active and intelligent food packaging

Improved quality, freshness and storage time of food

UV-protection, anti-microbials, improved gas-exchange barrier of packaging, contaminant sensors for food monitoring

Improved mechanical and heat resistance (e.g. biodegradable composites

Nanoparticles of silver, titanium dioxide, magnesium oxide, zinc oxide, nanocomposites, chitosan, nisin

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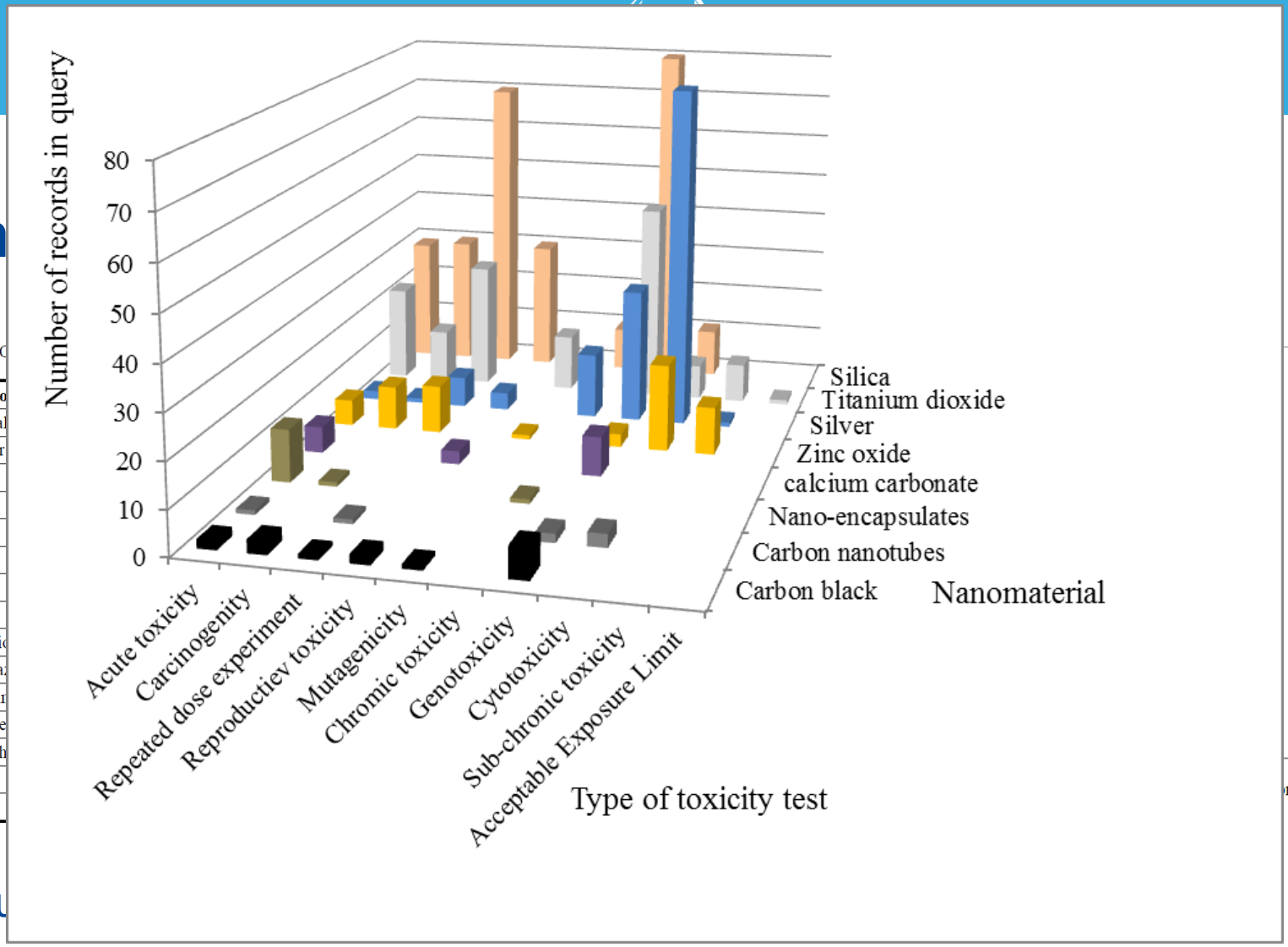
Table 8: C

Field in "To
Nanomaterial
CAS number
Parameter
Use stage
Mode of actio
Endpoint [haz
Endpoint [kin
Target specie
Reason for th

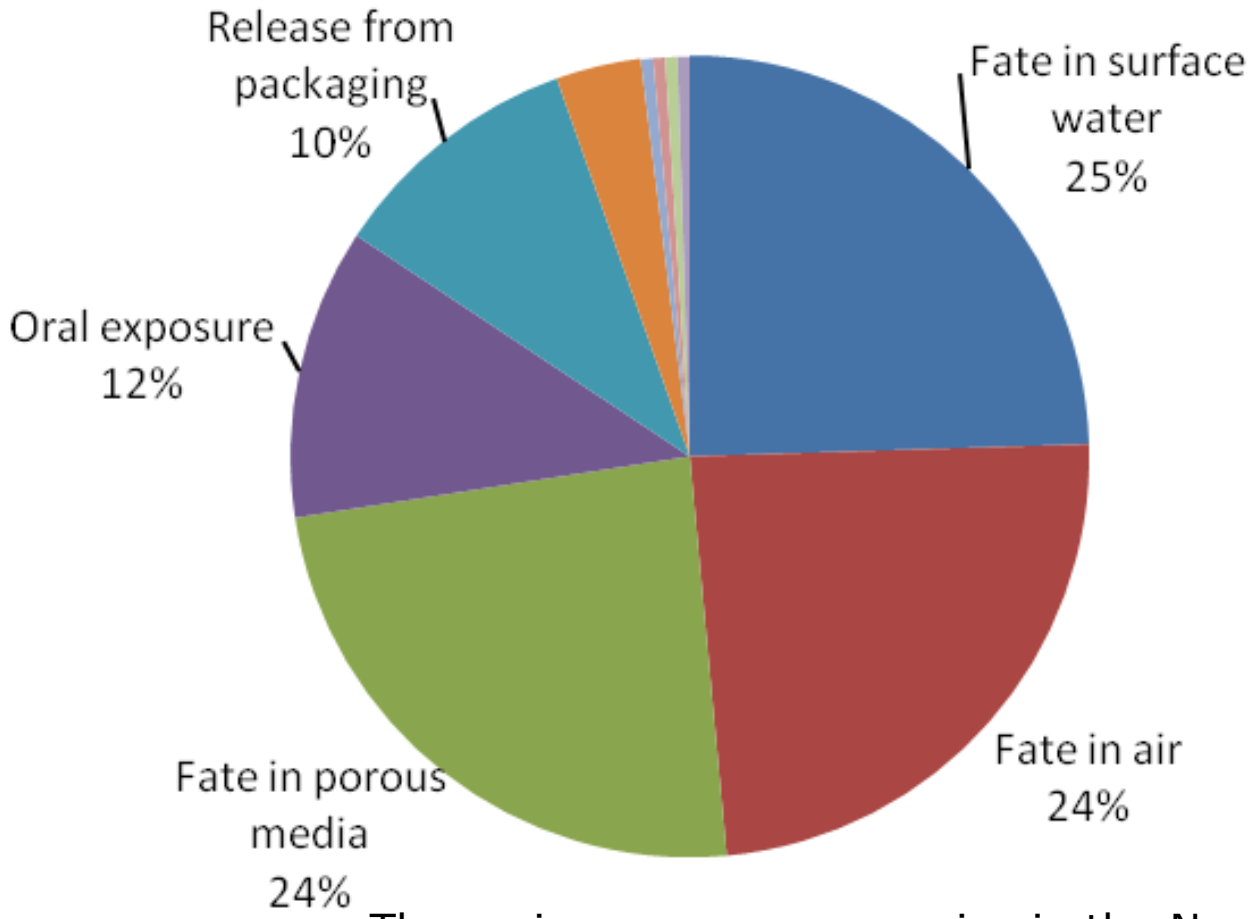


rted nanomaterials

Focu

Physico-chemical characterisation not always well reported – difficult to draw conclusions

Photo Stability in water



The major exposure scenarios in the Nano Inventory

24%

Figure 15: The major exposure scenarios in the Nano Inventory.

Main source: open literature

Difficult to get full risk assessments

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Task 4: Review of EU legislation

- General Food Law
  Regulation (EC) No 178/2002
- Novel foods and novel foods ingredients
  Regulation (EC) No 258/97 (proposal for revision)
- Food additives
  Directive 89/107/EEC
- **Food shall not be placed on the market if it is unsafe**
- Addition of vitamins and minerals
  Regulation (EC) 1925/2006
- Feed legislation
  various Directives and Regulations
- Food contact materials (FCM)
  Regulation (EC) No 10/2011
- Regulation on the Provisions of Food Information to Consumers (EC) No 1169/2011

  Definition, Labelling

Specific legislations apply, depending on types of food ingredients or FCM

Task 4: Review of EU legislation

- Pre-market approval required for many agri/feed/food applications, Risk assessment (implicitly) covers nanomaterials (food/feed additives, novel food, pesticides, etc.)
- NMs explicitly addressed by some Regulations e.g.: plastic FCM, Novel Food revision, Food Information to Consumer, Biocides, Active and intelligent materials and articles
- NM Definition: 1169/2011 (FIC); EC Recommendation 2011/696/EU
- Need to label NM in food applications (from Dec 2014)
- Re-evaluation of some materials of historical use ($CaCO_3$, SAS)
- EFSA guidance on risk assessment of nano-applications available
- NM as chemical substance regulated by REACH, C&L; ECHA guidance available

Task 4: Review of EU legislation

Application	Authorisation	Nano-Definition	Nano-Label	Guidance
Agriculture - Pesticides				
Plant protection products	(EC) No 1107/2009	No	No	EFSA guidance
Food/Feed				
Novel food/feed	(EC) 258/97	COM(2013) 894 final 2013/0435 (COD) reference to (EU) No 1169/2011	(EU) No 1169/2011	EFSA guidance
Food additives **Enzymes** **Flavourings**	(EC) 1333/2008 (EC) 1332/2008 (EC) 1334/2008	No No No	(EU) No 1169/2011	EFSA guidance
Food supplements	Dir 2002/46/EC	No	No	No
Feed ((EC) 767/2009) **Feed additives**	Not required (EC) 1831/2003	No	No	EFSA guidance
Food contact materials				
Food contact materials	(EC) 1935/2004	No	No	EFSA guidance
Plastic food contact materials	(EC) 10/2011	No	No	EFSA guidance
Active and Intelligent Materials and Articles	(EC) 450/2009	No	No	EFSA guidance
Biocides/Chemicals				
Biocides	(EU) No 528/2013	(EU) No 528/2013	(EU) No 528/2013	Pending (information requirements)
Chemical substances	(EC) 1907/2006 (REACH) (authorization required for certain hazardous substances)	No	No	ECHA guidance

Amenta et al. (in preparation)

Task 4: Review of non-EU legislation Main findings

- Many activities ongoing in several countries: mainly USA, Australia/New Zealand (FSANZ), Canada, China, Japan, Malaysia, Korea, Switzerland
- EU candidate states (e.g. Turkey) – similar approaches as EU
- Nanomaterials definitions: not legally binding recommendations/ guidance; beside size other specific properties considered (e.g. US)
- Nano-specific legislation for agri/feed/food not available, case-by-case approach for risk assessment often recommended (e.g. USA)
- System for certifying products in Taiwan, Iran, Thailand

Summary on food legislation for some selected non-EU OECD countries

Country	Responsible organisation	Existing legislation	Sources
USA	US Food and Drug Administration (FDA) Environmental Protection Agency (EPA)	Federal Food, Drug, and Cosmetic Act (FFDCA) Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)	http://www.fda.gov/regulatoryinformation/legislation/federalfooddrugandcosmeticactFDCAct/default.htm http://www.fda.gov/Food/default.htm http://www.epa.gov/oecaagct/lfra.html
Canada	Canadian Food Inspection Agency (CFIA) Public Health Agency of Canada (PHAC)	Food and Drugs Act	http://www.hc-sc.gc.ca/dhp-mps/nano-eng.php http://laws-lois.justice.gc.ca/eng/regulations/C.R.C.%2C_c._870/
Japan	Food Sanitation Law	Ministry of Health, Labour and Welfare	http://www.mhlw.go.jp/english/policy/health-medical/food/index.html http://www.jetro.go.jp/en/reports/regulations/
Korea	Food Sanitation Act	Ministry of Food and Drug Safety (MFDS) Korean food and Drug Administration (KFDA) Korean Agency for Technology and Science (KATS)	WHO/FAO report, 2013 http://www.kfda.go.kr/eng/index.do?nMenuCode=61 http://www.mfds.go.kr/eng/index.do http://www.kats.go.kr/english/home/home.asp?OlapCode=ATSU15

Conclusions

- nano-encapsulates, silver, and titanium dioxide are the most often mentioned nanomaterials in the literature
- food additives and food contact materials are the most often mentioned current applications
- future developments are expected for nano-encapsulates and nano-composites in applications such as novel food, food/feed additives, biocides, pesticides and food contact materials
- most toxicological data, was found for silica, titanium dioxide, and silver
- EU: binding NM definitions and specific provision for some applications
- non-EU countries: broader approach, mainly built on guidance

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Thank you for your attention

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