Food Science Sweden

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Bibliometric survey of Swedish food research performed between 2005 and 2017

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Chalmers University of Technology 2018

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1. INTRODUCTION

The 'National Research Programme for Food'[1] was initiated by the Swedish government within the framework of the National Food Strategy.[2] It is a ten-year research programme co-ordinated by the Swedish research council FORMAS. The aim of the programme is to support the knowledge and innovation system so as to contribute to increased productivity and innovation in the food supply chain and the sustainable production and consumption of food.

With this report we present a bibliometric analysis of the research carried out in the area of food science and food systems in Sweden between 2005 and 2017. The bibliometric study was commissioned by FORMAS and the National Committee for Food Science Research.[3]

FORMAS and the National Committee for Food Science Research were commissioned to define an agenda for national food science research with a 10-year perspective. The current report provides a part of the information and background to be used to develop this agenda. Bibliometric studies can be used in conjunction with other measures such as qualitative expert assessment to measure performance against national research missions.[4] However, excellence in locally important research fields may need to be protected, and variations in publication and citations between fields should be accounted for.

In this study the topic of the bibliometric search, 'food science or food systems', covers the whole chain from primary production of food to consumption of food, including health related to food intake, breast feeding and vitamins. The publication data, which was collected from Scopus and analysed using SciVal, has been divided into the following six categories:

- Primary Production
- Processing
- Consumption
- Safety
- Distribution and
- Waste

The categories chosen were requested by FORMAS and are based on the 2030 food systems categories.[5] The search criteria were supplemented to ensure that the FORMAS focus areas, namely health, digitisation and urbanisation, would be covered in the analysis.

The bibliometric data for each category is presented as total publication output, field-weighted citation impact (FWCI), outputs in top citation percentiles (10 and 1), publications in top journal percentiles (SNIP) (10 and 1) and the percentage of international, national and institutional co-publications. Further, we outline the most common collaborative nations in each category and show the broadness of scientific subjects represented by the chosen categories (e.g. consumption, production and processing) as defined in this report.

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[1] http://formas.se/Internationellt/Forskningsprogram/Nationella-forskningsprogrammet-for-livsmedel accessed 28th of January 2019.

[2] En livsmedelsstrategi för Sverige – fler jobb och hållbar tillväxt i hela landet. En kortversion av regeringens proposition 2016/17:104. Artikelnummer N2017.1. Diarienummer: N2017/00647/KOM. Näringsdepartementet.

[3] http://formas.se/sv/Internationellt/Forskningsprogram/Nationella-kommitten-for-livsmedelsforskning accessed 28th of January 2019.

[4] Hicks et al., The Leiden Manifesto for research metrics, Nature, 2015, 520: 439

[5] Assessment of Research and Innovation on Food Systems by European Member States, Policy and Funding Analysis by Standing Committee on Agricultural Research (SCAR) Strategic Working Group on Food Systems, 2018, Publication Office of the European Union in Luxembourg, ISBN 978-92-79-81843-1.

To ensure coverage that is as complete as possible, the process of collecting the publication data has been iterative, involving senior researchers from the different scientific subjects covered, research funding bodies and individual searches.

2. METHODOLOGY

In-scope: Peer-reviewed publications and reviews published from 2005 through 2017, with at least one author with a Swedish affiliation.

Out of scope: Editorials, book chapters, patents, reports, comments and conference contributions. Conference contributions are of especial importance in the area of IT; however, few conference papers were found in the Scopus searches. The impact of book chapters, editorials and conference papers on the overall research quality is judged to be low in food science.

Database: The publication data was retrieved from the Scopus database using its analysis tool SciVal. Scopus is the largest abstract and citation database of peer-reviewed literature: scientific journals, books and conference proceedings. It can be considered equivalent to the Web of Science (WoS), with the difference that Scopus also includes conference abstracts. The electronic IDs (EID) of all publications were divided into the above categories in order to create publication sets in SciVal for the bibliometric analyses.

Categories and subcategories: The chosen categories were requested by FORMAS, as stated in the introduction. For consistency in categorising, subcategories (in bold, after the dash) were employed. The subcategories are further defined below the category headlines.

1. Production – livestock, crops, inputs, fisheries, aquaculture
Studies covering animal, fish production and cultivation. Factors affecting production, such as fodder, manure, veterinary medicine. Effects of production on climate and environment, discharges from production, quality as an effect of the production process (such as choice of cultivar and fodder). Life-cycle assessment (LCA) studies on production.

2. Processing – food, feed, packing, transformation of ingredients
The step after production included articles on processing of primary products and transformation of ingredients, as well as analyses and functionality when not in the context of direct health, nutrition or dietetics, or for comparison of the effect of primary production. Packaging, storing, labelling. LCA studies on processed products.

3. Distribution – hotel-catering-restaurant, transport-storage-logistics, retail, marketing, advertising
Also food security, availability, school meals.

4. Consumption – research on nutrition and health, consumer research
The effect of food (including single vitamins and minerals) on the human body. Also in vitro and animal studies as well as analyses of known active substances in a health/nutrition context. Dietary effects. Probiotics. Sensory. Health claims. Preferences, consumption patterns and branding.

5. Food safety – production, processing, distribution, consumption
Chemical and biological risks/agents, allergens, toxicology.

6. Food waste – production, processing, distribution, consumption
Limit: not downstream processing of food waste, with poor connection to the production of waste itself.

Procedure: The publications used in the analysis were selected from database searches in three different steps (subject search within SciVal; subcategory terms; and collection of names of active senior scientists). After each search step, all articles were manually categorised based on their titles and, when applicable, their abstracts. An initial search was made in SciVal, using their benchmarking tool to select articles within the predefined subject area 'Food Science'. The resulting articles were categorised as indicated above. The initial search was complemented with a second search on the subcategory terms, as shown in Table 1. Duplicate articles were removed after each iteration. The results were then evaluated in a review within the Food Science Sweden network (FSS). Reviewers noted that the first two searches provided adequate coverage regarding the number of authors, but incomplete publication lists. That is, active researchers were largely covered by the subject search, but the list of their publications was incomplete. The search was therefore supplemented with Scopus searches on individual active senior researchers in all six categories (see Appendix 1 for a scheme). These researchers were identified from the subject search, the FSS network, the identification of relevant researchers via the homepages of Swedish research organisations and by grant holders of Swedish Research Councils (Vetenskapsrådet and FORMAS) grants as well as Handelsrådet (see Appendix 2). Each article or review identified in the three searches was manually assigned to one of the six categories. Duplicates and publications that were not within the area of food science were removed and not included in the subsequent analysis. The publication data produced was used for the bibliometric analysis. The output parameters chosen were total publications, citation rate (FWCI), outputs in top citation percentiles (10 % & 1 %), publications in top ten journal percentiles (SNIP) and collaborations. To account for discipline-related differences, FWCI was used for citation rate in the present study.

A minimum of 50 publications per year is considered necessary for analysis of bibliometric data in terms of FWCI, outputs in top citation percentiles and SNIP. Categories with fewer publications were therefore not described in these terms.

FWCI indicates how the number of citations received by a researcher's publications compares with the average number of citations received by all other similar publications, thereby moderating differences in research behaviour across disciplines. Similar publications are all publications in the Scopus database that are published in the same year, are of the same type and belong to the same discipline. Citations received during the year of publication plus the following 3 years are included in this metric.

A FWCI of 1.0 indicates that the number of citations matches the world average for similar publications. The FWCI of the 'world' (i.e. the entire Scopus database) is 1.00. A FWCI < 1.00 indicates that a publication has been cited less that would be expected based on the world average for similar publications, and a FWCI of > 1.00 indicates that a publication have been cited more than would be expected based on the world average for similar publications.[6] Moving averages of three-year periods were compared, rather than individual years, in order to moderate transient peaks and valleys. Self-citations were excluded where possible.

[6] Elsevier (2014) SciVal Metrics Guidebook Version 1.01, February 2014

3. RESULTS

3.1 Publication data

The initial search on the predefined subject area ‘Food Science’ in Scopus yielded a total of 2145 publications, which were categorised into the six predefined categories: production, processing, distribution, consumption, safety and waste. The second round of complementary searches in Scopus, using the subcategories in Table 1, added 777 articles to the list for a total of 2922 publications.

Table 1. *Additional search terms*

Search terms	Limitations		Score
"food waste"	2005–2017, Sverige.		63
food distribution	2005–2017, Sverige.		13
food AND retail	2005–2017, Sverige.		34
food AND restaurant	2005–2017, Sverige.		24
food AND marketing	2005–2017, Sverige.		62
food AND catering	2005–2017, Sverige.		88
food AND logistic* AND transport	2005–2017, Sverige.		16
food AND supermarket	2005–2017, Sverige.		35
food AND consumer (NOT web, NOT ecosystem)	2005–2017, Sverige.		467
food AND aquaculture	2005–2017, Sverige.		96
food AND fishery OR fisheries	2005–2017, Sverige.		207
seafood	2005–2017, Sverige.		225
food AND aquaponic*	2005–2017, Sverige.		0
food AND "urban farm*" OR "urban agriculture" AND “food production”	2005–2017, Sverige.		16
food AND horticult*	2005–2017, Sverige.		15

After consulting the steering group of FSS, which has representatives from Lund University, Chalmers, RISE, SLU and Örebro University, it appeared that the search had identified most of the authors active within food science, but that the number of publications from each author was incomplete. Comprehensive searches were therefore conducted for on individuals active in the field. Their names (> 420) were collected from the initial search on defined subjects and supplemented by the names of grant holders from Vetenskapsrådet (VR), FORMAS and Handelsrådet. Complete literature lists for these individuals were extracted, and their work was categorized manually, yielding a total of more than 5800 peer-reviewed national publications and reviews.

The publications identified were unevenly distributed across the six categories (Table 2). The largest output in terms of number of publications was in the field of ‘consumption’ followed by ‘production’, ‘processing’, ‘safety’, ‘distribution’ and ‘waste’.

Table 2. *Distribution of national publications over the six food science categories from year 2005 to 2017*

Category	Number of publications, 2005–2017
Total	5880
Consumption	2200
Production	1700
Processing	1000
Safety	620
Distribution	240
Waste	120

Figure 1 shows the variation in total publication output and publication in each category over the period studied. Increasing publication output was observed for 'consumption', 'waste' and 'distribution', while the output from 'safety' and 'processing' was steady over time. The field of 'production' strongly increased in 2010 and 2013. It should be noted that the categories of 'distribution' and 'waste' had too few publications (< 50 / year) to be further analysed for parameters such as FWCI and SNIP.

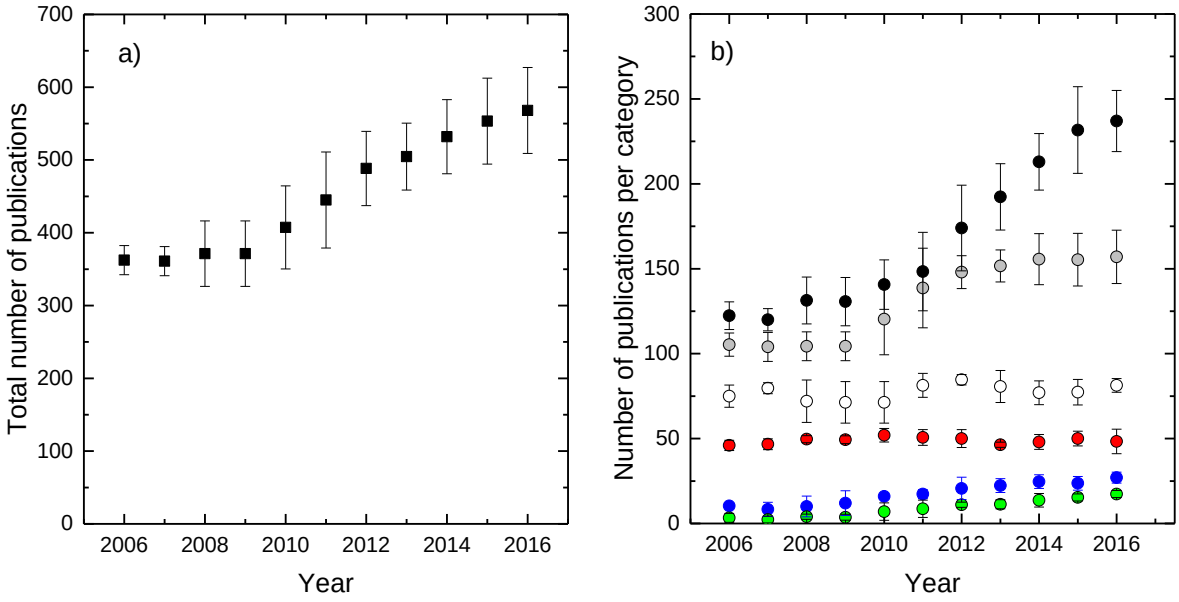


Figure 1. *Total publication (peer-reviewed papers and reviews) output in (a)the field of food systems and (b) per category: consumption (black), production (grey), processing (white), safety (red), distribution (blue) and waste (green)*

The total number of peer-reviewed publications and reviews published by national scientists active in the area of food science can be compared to the more than 30,000 publications put out by Wageningen University and Research (WUR) during the same period. WUR is the leading agricultural university according to the National Taiwan (NT) ranking, and number 156 in the general ranking of universities. The NT ranking is based on scientific paper performance, research productivity, research impact and excellence. After including education and industry income, as done by Times Higher Education (THE), WUR is ranked 59.[7] By the same measures, the total publication output from Sweden in the field of food science is 5880, which is considerably lower than the output from WUR in the Netherlands.

Researchers active in food science were affiliated with a broad range of organizations, as shown in Figure 2.

[7] https://www.wur.nl/en/Education-Programmes/Rankings.htm accessed on the 8th of November, 2018.

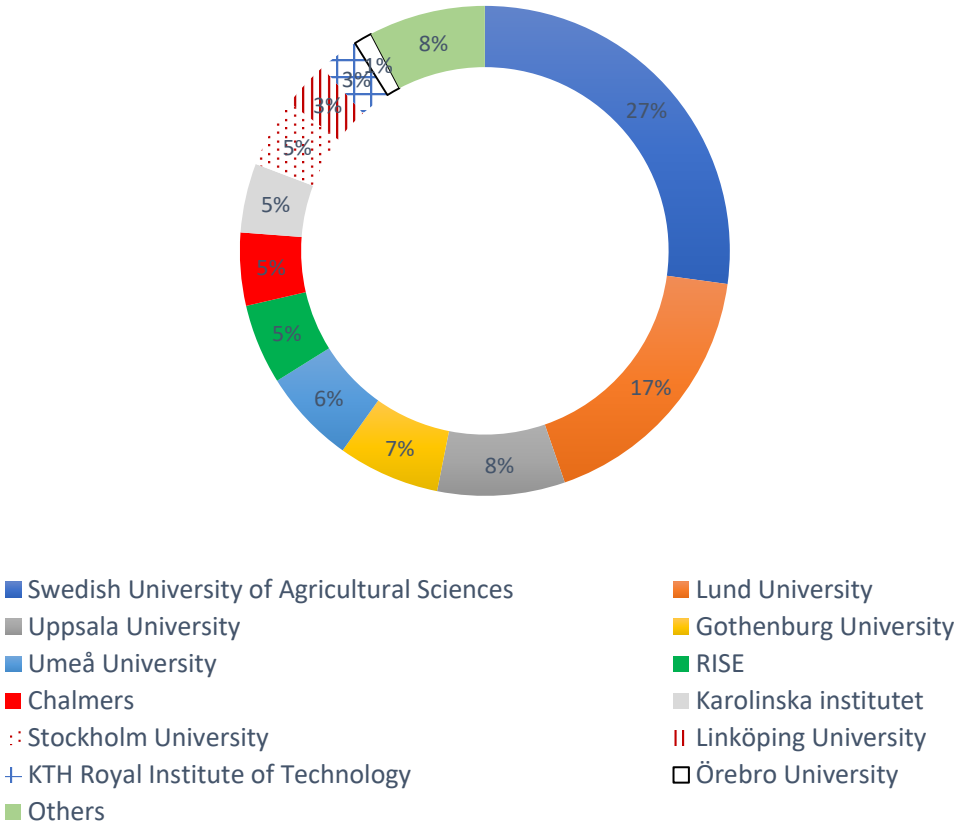


Figure 2. *Proportion of researchers publishing within Food Science across national research organisations.*

A broad range of scientific subjects is represented within the search, as illustrated in Figure 3. It should be noted, that while the subject area of agricultural and biological sciences is present in all categories, other subject areas are more category specific. For example, the category 'consumption' is dominated by medicine and nursing, followed by agricultural and biological sciences, indicating that health-related subjects are prominent in this category. The category 'production' is dominated by the agricultural and biological sciences and biochemistry, genetics and molecular biology, followed by environmental sciences. Like 'production', the category 'processing' is dominated by agricultural and biological sciences and biochemistry. The next largest category is chemistry, followed by genetics and molecular biology, and then engineering, indicating the processing aspects within this category. The field of agricultural and biological sciences is also important as regards 'safety', but medicine comes in as the second largest subject and environmental sciences as the third. The category 'distribution' is the most diverse in terms of subject areas included. Business, management and accounting, as well as social sciences, are relatively important subject areas in both 'distribution' and 'waste'. Environmental sciences and energy are the two largest subject areas within the category 'waste'.

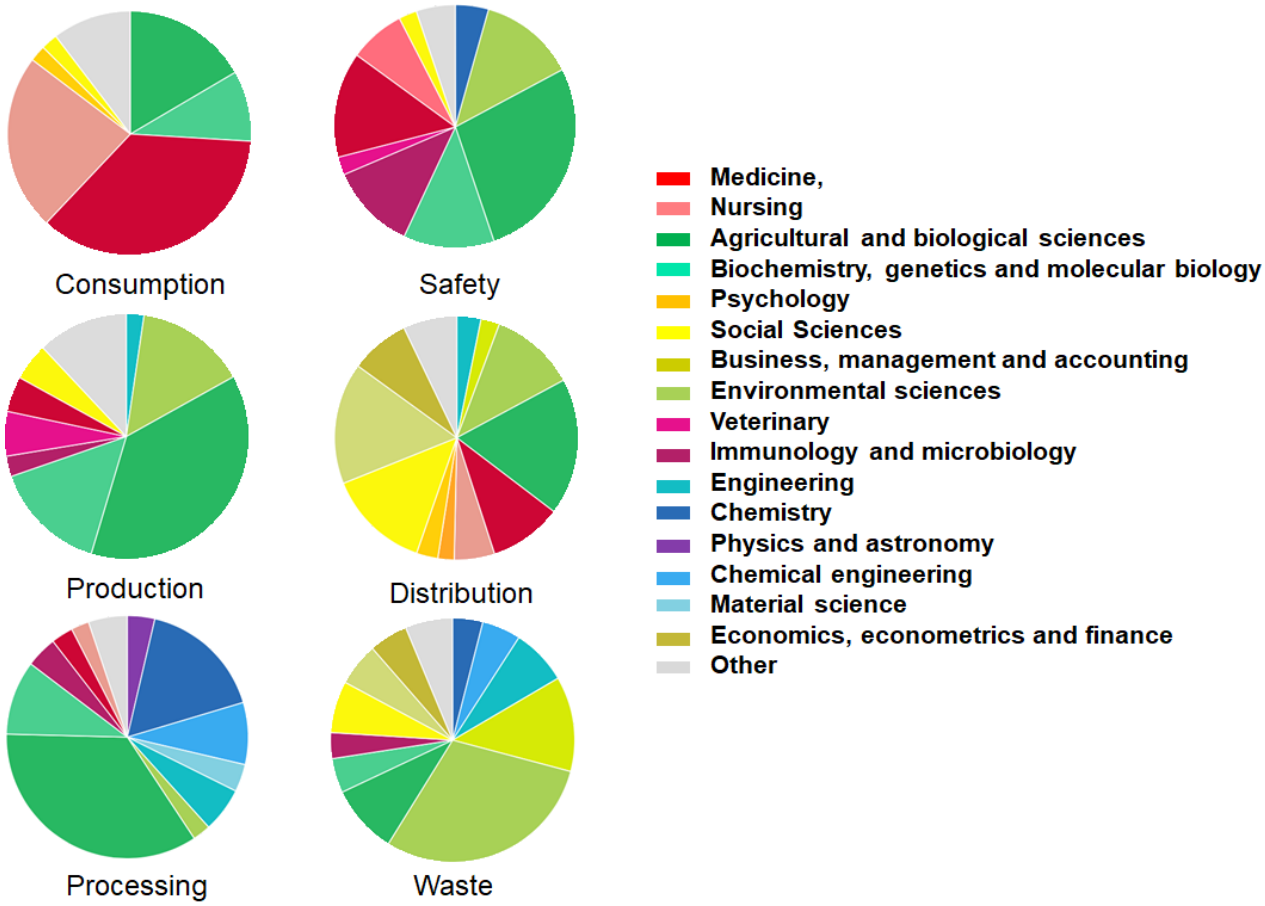


Figure 3. *Overview of subject areas within the categories of consumption, production, processing, safety, distribution and waste*

3.2 Bibliometric indicators and analysis

FWCI values of 1.5 or higher are generally considered well above average[8] and indicate that the publication outputs have been cited 50 % more than expected. On the contrary, a FWCI < 1.00 indicates that the publications have been cited less than would be expected based on the world average for similar publications, for example, a score of 0.85 means 15 % less cited than world average.

The total publications related to national food science or food systems have FWCI values above the world average of 1 (Figure 4a). The FWCI across the different categories (Figure 4b), show that 'consumption', 'production' and 'safety' are cited well above (i.e., ≥ 1.5) the world average of 1. The value of FWCI increases in the category of 'consumption' and 'production', whereas the FWCI of 'safety', which was the most cited during the period of 2005–2012, reduced after 2012. The values of FWCI for food science carried out in Sweden as a whole (Figure 4a) compare well with those of WUR over the same time periods. For example, the FWCI of WUR is 1.4, 1.5 and 1.94 for 2006, 2011 and 2016 respectively. It should however be noticed that the comparison might look different if publications from the Netherlands as a whole were included instead of WUR as single university.

[8] Elsevier (2014) SciVal Metrics Guidebook Version 1.01, February 2014

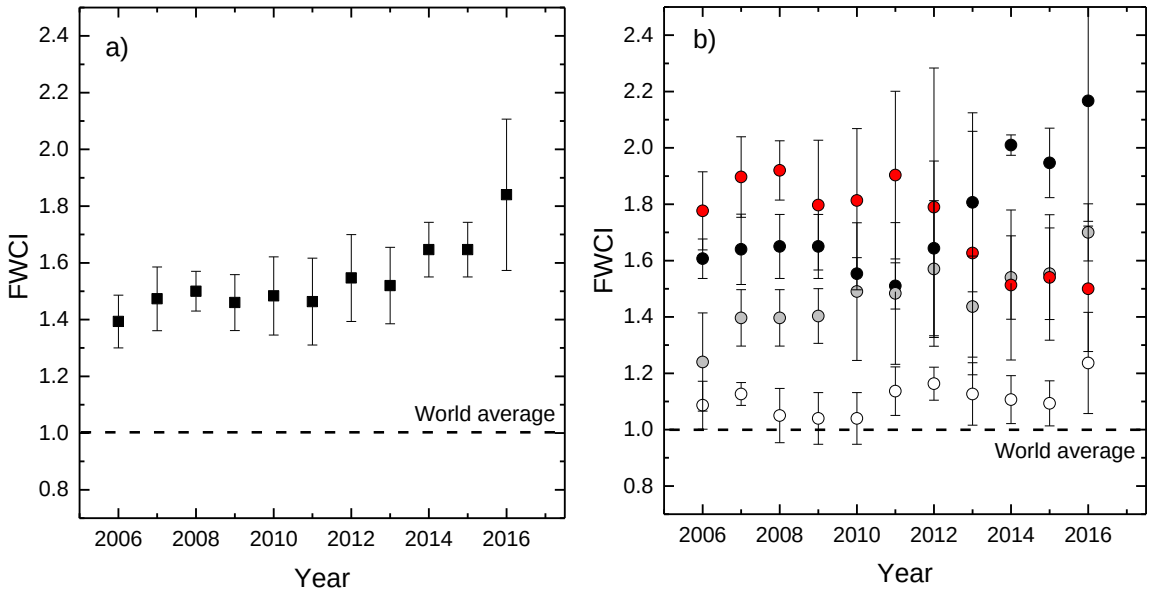


Figure 4. *Field-weighted citation index (FWCI) for (a) Swedish food systems as a whole and (b) for each category: consumption (black), production (grey), processing (white) and safety (red).*

3.3 Outputs in Top Citation Percentiles

Figure 5 and 6 show the share of the publications within each category which are among the top 10 % and top 1 % of the most cited publications in the world. SciVal includes self-citations by default when calculating top citation percentiles. This indicator is highly correlated with the FWCI, but is considered to be more stable and not as easily affected by extreme values. Between 18 and 28 % of the published material within the categories of 'consumption' and 'safety' is within the 10 % most cited publications in the world, followed by 'production', for which the share varies between 12 and 17 %. The share for 'processing' varies between 9 and 14 %. The indicator has been normalised so that all publications are compared to similar publications, that is, the same publication year, publication type and belonging to the same research area. A smaller share (< 5%), across the different categories of the published articles are within the 1% most cited, where 'consumption' is among the highest and 'processing' the lowest.

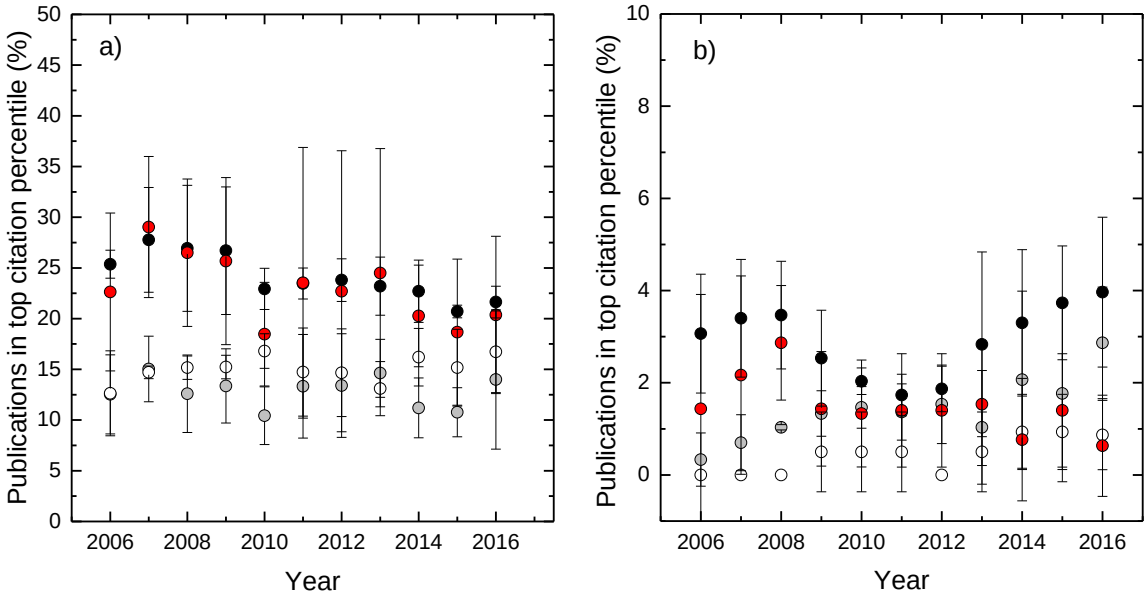


Figure 5. *Percent publications in top citation percentile (a) 10 and (b) 1, for each category; consumption (black), production (grey), processing (white) and safety (red).*

3.4 Publications in Top Journal Percentiles (SNIP)

The share of the publications that is published in the top journal percentile are shown in Figure 6, using the source-normalised impact per paper (SNIP indicator). The SNIP indicator shows the ratio of articles that were published in the most cited journals in the world (Scopus database). SNIP measures the number of citations in a journal, as compared to the normal number of citations for eight journals within the same research area.

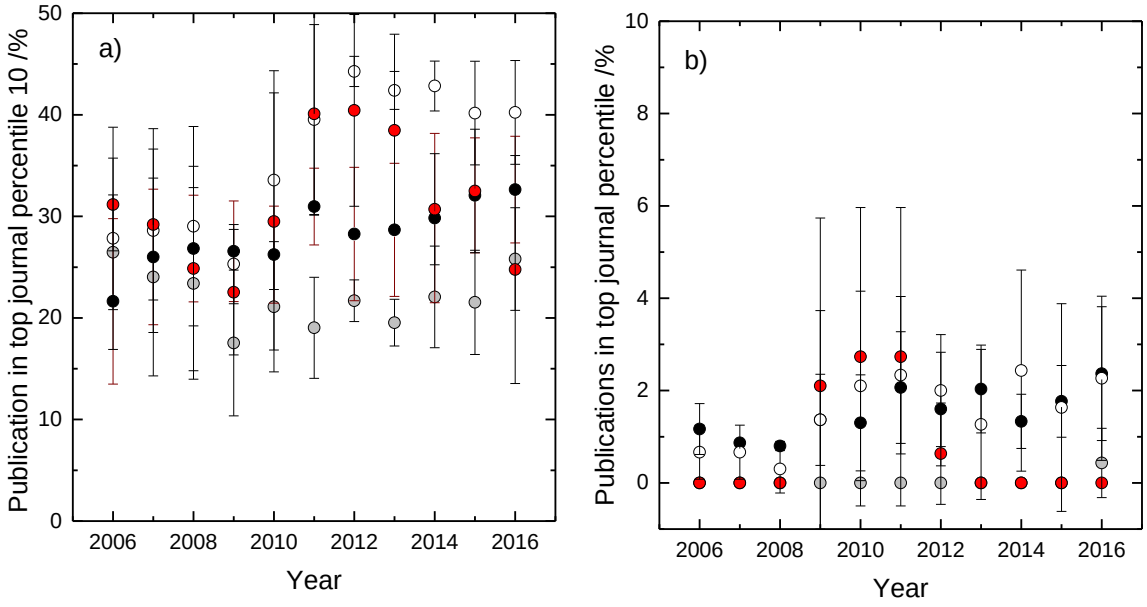
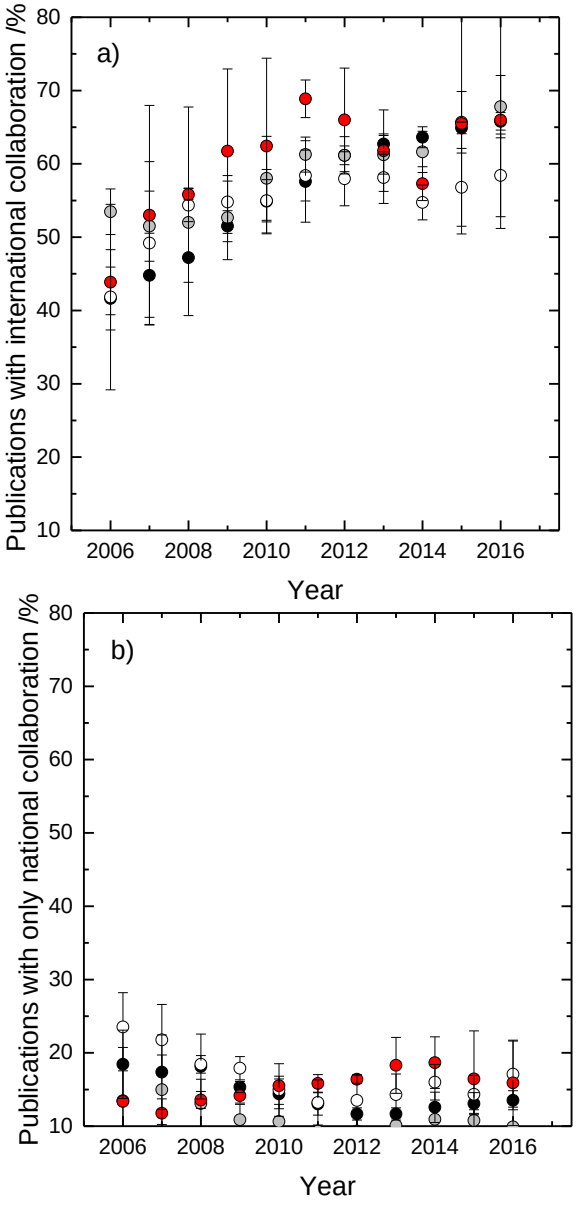


Figure 6*. Publications in top journal percentiles (SNIP) (a) 10 and (b) 1 for each category; consumption (black), production (grey), processing (white) and safety (red).*

3.5 Collaborations 2005–2017

Collaboration was determined using the address field of each publication; thus, we assume collaboration when a publication has one or several addresses. For a paper to be classified as showing international collaboration, it needed to have at least one author affiliated in Sweden and at least one author affiliated outside Sweden. Alternatively, one author should have both a national and an international affiliation. Figure 7 shows an increasing trend of collaboration between 2005 and 2011, after which a plateau was reached. It can also be observed that in all categories a large share of the work (> 50 %) was co-authored with international groups after 2010.



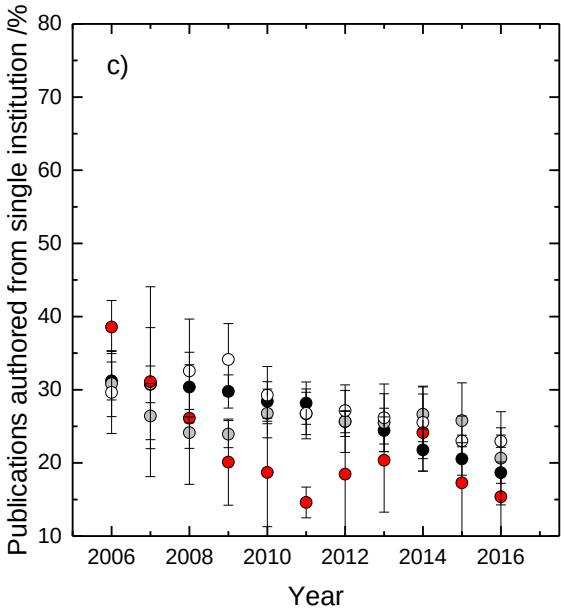


Figure 7. *Share of publications with (a) international collaboration, (b) only national collaboration and (c) institutional collaboration where black symbol represents consumption, grey symbol production, open symbol processing and red symbol safety.*

The five countries with which Swedish researchers co-publish the most scientific papers are shown in Figure 8. The institutes with which they share the most publications are also reported for each country (Figure 8). However, it should be noted that many other institutions are also involved in collaborations with national researchers. There is also great variation in the number of publications between categories; for instance, Italy is in 5th place in the category of consumption with a total of 181 co-authored papers with Swedish researchers, whereas there are only 5 to 6 co-authored papers produced in collaboration with other countries in the field of waste.

Consumption		
Country	# Publ.	Top institution
United Kingdom	231	Univ. of Oxford
United States	228	Harvard Univ.
Denmark	200	Aarhus Univ.
Germany	189	DKFZ
Italy	181	IRCCS Inst. Naz. dei Tumori

Safety		
Country	# Publ.	Top institution
Germany	24	Robert Koch Inst.
Spain	21	CSIC
Italy	20	Istituto Superiore di Sanita
Denmark	18	Technical Univ. of Denmark
Norway	18	Inst. of Bioeconomy Research

Production		
Country	# Publ.	Top institution
United States	100	UC Davis
Denmark	93	Aarhus Univ.
United Kingdom	93	Uni. Edinburgh
Germany	66	Uni. Vet. Med. Hannover
The Netherlands	64	Wageningen Uni.

Distribution		
Country	# Publ.	Top institution
United States	20	Univ. of North Carolina
United Kingdom	19	London School of Hygiene and Tropical Medicine
Australia	12	Univ. of Queensland
Norway	12	Univ. of Oslo
Canada	9	Centers for Disease Control and Prevention

Processing		
Country	# Publ.	Top institution
Denmark	36	Univ. of Copenhagen
Italy	29	Univ. of Bologna
Spain	18	Univ. de Oveido
United Kingdom	18	Harper Adams Uni. College
Germany	16	Univ. of Hohenheim

Waste		
Country	# Publ.	Top institution
Denmark	6	Aarhus Univ.
The Netherlands	6	Wageningen Univ.
Brazil	5	Univ. Federal Rio de Janeiro
Norway	5	Norweigian Univ. of Life Sciences
United Kingdom	5	Lancaster Univ.

Figure 8. *The five countries with which Swedish researchers co-author the most publications within each category. The institution in each country with which we co-author the most publications is also shown.*

National collaborations are publications written by authors with only national affiliations. A paper written with two Swedish affiliated organisations, for example, Chalmers University of Technology and SLU, will be counted as a national collaboration. However, if the publication has a third author who is affiliated with Denmark, for example, the publication will be assigned to the international category. Further, if the publication is written by persons affiliated with only one university, for example, Chalmers University of Technology, the publication is counted as an institutional publication and is not included in the national collaborations.

The number of co-authored publications with only national affiliations is reducing between 2005 and 2011 (Figure 7), except for the category of 'safety', where it increased.

The share of publications co-authored within single research organisations, for example, SLU, is decreasing over time for 'production' and 'consumption' (Figure 7). There is an indication that the share of publications co-authored within institutions is also decreasing with time for 'processing' and 'safety'. However, the trend is less clear compared to 'consumption' and 'production'.

Co-authored publications involving academic and corporate organisations are shown in Table 3, which shows the total number of publications as well as share of total publication volume. The companies acting as co-authors are Nestlé, Danone, Thermo-Fischer, NovoNordisk, TetraPak, Arla Foods, Lantmännen and Syngenta. While it could be interesting to evaluate

the numbers over time, we strongly advise against taking the share of co-authored publications as a measure of the actual extent of academic-corporate collaboration. There are many reasons for a specific corporation not being included as an author in a publication despite funding the study. For example, funding alone is usually not enough to be counted as an author, companies may not want to publically show interest in a specific field, or intellectual property rights may be a consideration. It should also be noted that the percentage of publications from WUR reflecting industry cooperation is 5 %, which is similar to the value for Swedish national food related-categories.

Table 3. *Percent of total publications and absolute number of publications co-authored by academia and industry within the different categories.*

Category	/%	Number of publications
Consumption	4	45
Production	1	9
Processing	9	30
Safety	2	5
Distribution	2	2
Waste	0	0

SUMMARY AND CONCLUSION

The publication base used for the report was generated in two steps. First, a general search of food-related subjects (for exact keywords, see the methods section) was done within SciVal and Scopus. As this search did not generate a complete publication list (only 50 % of the final total amount of publications was generated this way), a second step, a bibliometric search on individuals, was performed. Individual searches related to senior scientists doubled the number of publications. The total output of peer-reviewed publications and reviews over the 10-year period was close to 6000 publications. This suggests that meaningful bibliometric analysis in the area of food science and in-depth review of individual research outputs requires more powerful algorithms than were used in this study.

As demonstrated by the large number of organizations in which researchers are active, the terms “food system” or “food science”, as defined in this report, are very broad and spans widely different scientific subjects.

The largest publication output was found in the subcategory of ‘consumption’ followed by ‘production’, ‘processing’ and ‘safety’. The number of publications generated in ‘waste’ and ‘distribution’ was relatively low but was increasing with time.

The FWCI indicates that the national citation rate of publications on food systems or food science is well above the world average of 1. Dividing the national FWCI for food systems into the categories studied shows that the FWCI for ‘consumption’, ‘safety’ and ‘production’ are well above the world average (>1.5) from 2011 and onwards.

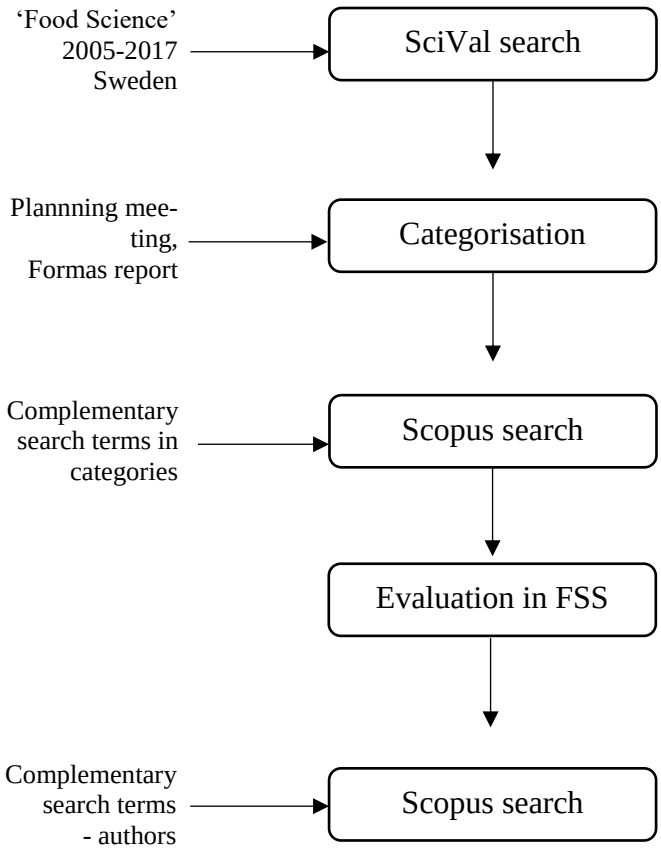
The share of publications with international co-authors increased until the year 2011, after which a plateau was reached with more than 50 % of publications being produced with international collaboration.

It is notable that the number of publications in some of the six categories is growing while others are stagnating both in terms of total scientific output and FWCI. Further analysis is needed to explain the variations between categories, and also to investigate the reasons for the difference in total publication output in comparison to groups like WUR. Available funding, overall national strategies, organizational aspects and number of active researchers are all measures known to influence scientific output.

ACKNOWLEDGEMENT

We are grateful for support and professional advice on bibliometric analysis from Stina Johansson (Chalmers), Peter Lundin (VR) and Henrik Almberg (VR) as well as the input from research councils and active researchers (Appendix 2).

APPENDIX 1: PROCESS OVERVIEW



APPENDIX 2

Table 1: Researchers and organisations who provided input to the literature search

Researcher	Organisation
Rikard Landberg (Prof.)	Chalmers
Karin Östergren (Prof.)	RISE
Ulf Sonesson (Prof.)	RISE
Yvonne Granfeldt (Prof.)	LTH
Maud Langton (Prof.)	SLU
Robert Brummer (Prof.)	OrU
Lena Strålsjö	Handelsrådet
	FORMAS
	VR