



**Deliverable D-JIP2-4.5:
Report of available tools
and algorithms and
ranking of most valuable
features**

Workpackage 4

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REPORT OF AVAILABLE TOOLS AND ALGORITHMS AND RANKING OF MOST VALUABLE FEATURES

Aim

The aim of this research is the evaluation of available approaches, algorithms and tools for tracing, epidemiological analysis and visualization including whole genome sequencing (WGS) information. Specifically: Look for features that may be of interest for the development of a tracing platform including interfaces to other solutions!

The basis for this report is the information available on the internet. It may be available software tools, it may be information on websites, and it may be documentation of tools or software or similar sources of information.

Knowing that this exercise is not comprehensively solvable by a few persons it was decided to create a condensed online information table which is open for enrichment by the community. Thus, the main result at the end needs to be present within an interactive table in the internet, which may be updated and extended by the authors as well as by the interested community. This written report is a short summary and conclusion of the collected results.

Introduction

As a consequence of the STEC outbreak 2011 in Germany, the development of methods and tools for a systematic tracing analysis of suspicious food and feed data both backwards and forwards along the entire supply chain was started. One of these tools is FoodChain-Lab (FCL), which was developed by the German Federal Institute for Risk Assessment (BfR) [1]. FCL is free and open-source software and was successfully applied in several national and EU-wide foodborne disease outbreaks [2, 3]. This tool imports food or feed supply chain data via Excel templates and includes plausibility checks for improved data quality. In order to find the sources of foodborne disease outbreaks the tool calculates tracing scores for all stations in the collected dataset and allows analysis of geographical relationships and topological clustering of the tracing network structures. Additionally, it provides several different kinds of visualizations of the analysis.

The EFSA working group DEMOS in cooperation with PwC (PricewaterhouseCoopers) has performed an analysis and evaluation of existing tracing software tools (unpublished report, 2016). This analysis was based firstly on a short list of available tracing software tools and secondly on the answers of a questionnaire that was sent to the CEOs of the associated companies.

The aim for this task was to evaluate all available approaches, algorithms and tools for tracing, epidemiological analysis and visualization. This approach includes also the tools listed in the unpublished EFSA report. Additionally to the EFSA report, the goal was to provide a list of all tools dealing with tracing – not only in the sense of “supply chain tracing” as in the EFSA report, but also in the sense of “WGS tracing”. Therefore, the EFSA list needed to be extended, firstly by more tools available, but secondly also by another view on that topic: features of high interest for official authorities and available data interfaces should be found.

The objective was to find interesting features as well as promising data sources in order to implement these into the tracing platform FCL during the later phase of the COHESIVE project.

Methodological approach

The first goal was to find software systems able to trace along complete feed or food supply chains from the farmer to the final consumer that can be used by official authorities in the case of a foodborne disease outbreak. The search strategy to find appropriate tracing tools comprised an extensive web search, which revealed the Capterra portal (<https://www.capterra.com.de/>). This portal contains various software tools and the possibility to filter by pre-defined search terms. For this task, tools



tagged with the term 'Food Traceability Software' were screened. The 76 results were additionally filtered with the term 'Traceback and Traceforward' which resulted at the time of investigation in the following 43 commercial software systems ([https://www.capterra.com/de/directory/30563/food-traceability/software?features\[\]=Traceback+%26+Traceforward&sort=overall_rating](https://www.capterra.com/de/directory/30563/food-traceability/software?features[]=Traceback+%26+Traceforward&sort=overall_rating)):

QWerks	BatchMaster ERP for Process Manufacturers	ProVisions	FoodLogiQ
Minotaur Business System	iTrade	TempTrace	MyProduce.com
Wherefour	Food Traceability by Acctivate	TME MES	TraceAll
eQ Trace	farmsoft post harvest	Symphony	Nucleus
Radley Traceability	bcFood	Traverse Food	M-Squared Meat Manager
AuditComply	Produce Inventory Control System (PICS)	iTrace	ParityFactory
DEAR Inventory	Ecert	GSQA	Cashmere
Food Connex	SureCheck	Food Safety Management Software	3iVerify
Edible Software	Nautilus LIMS	Mar-Kov Software	Food Safety Management System
JustFoodERP	WinFDS	LINKFRESH	Muddy Boots Software
Vicinity	Trax-IT	ExtendAg	

In addition to the above list, also the following tools were taken into account having been investigated by EFSA:

BioStockManager	Emydex	Keendo
ChainPoint	FoodChain-Lab	Tracewise
(Ecert & Flowweb) => already in the Capterra list	QuaTIS	ValueGo
Interspec	I-Like	

The minimal requirement for including a tool in the evaluation was their data structure regarding food and feed traceability. Of most importance was the capability of a software tool to do tracing one step forward and one step backward as it is fulfilled when being compliant with the EU regulation 178/2002 [5].



These are the main topics taken into account for the evaluation of the tools:

1. Sources
2. Definition of tracing
3. Data interfaces
4. Languages
5. Supply Chains and Target Groups
6. Data Analytics
7. Visualization / Reporting
8. EU 178/2002 compliancy

The original idea was to download the software systems and evaluate them at first hand according to the above-mentioned criteria. Unfortunately, none of them is freely or easily available. Then a trial access to the most promising software tools was looked for. In most cases it was cumbersome or simply not possible to get a demo version. For only one case a demo version was accessible. For the product TraceAll access to a trial version available per remote desktop connection was granted for 16 days. Since it was not possible to get access to the other tools directly, information was retrieved otherwise, like from web pages, publications, manuals, white papers, video clips.

Information on each software system was gathered in a comparison table "Tracing Tools for Food Supply Chains" that is published on the SocialCompare portal - a public and crowdsourced platform that gives the possibility to publish comparison tables on any kind of items [4].

Concerning "WGS tracing", none of the tools listed in this section includes WGS data in their analysis functionalities. However, there are some tools and databases that may be of interest in this context:

- <https://www.ridom.de/seqsphere/>
- <https://nextstrain.org>
- http://mapserver.izs.it/gis_genpat
- <https://fda-riskmodels.foodrisk.org/genomegraphr>
- <https://microreact.org/project/zikavirus>
- <http://pangenome.tuebingen.mpg.de/tutorial>

These tools could be included in tracing software in the future to address the need to enrich supply chain data with information from WGS.

Results and Discussion

The main scope of most of the evaluated software tools was to help the customers to manage the business processes within their company (Enterprise Resource Planning, Manufacturing Execution System, Product Lifecycle Management, Warehouse Management System). The tools are usually big systems consisting of many different modules. Each of these modules fulfils the tasks of a certain business area like inventory management, financial calculations, logistics, planning, quality assurance and analytics. The main business purpose is listed in the result table [4].

All tools that are described in the comparison table at SocialCompare have something to do with "tracing", but sometimes in a different sense, e.g. some have only modules for managing product recalls. However, it was not always possible to characterize precisely the qualitative nature of these functionalities of interest as the sources of information were not always precise enough. When evaluating the data structure of the tools the main focus was on information that might be relevant for traceability and visualization functionalities of the supply chain. Here, "one step forward and one step backward" was counted as being significant. A meaningful indicator for that is the compliance of the software product with the European regulation EU 178/2002 [5] or comparable regulations [6]. The compliance with tracing regulations is listed in the result table in the section 'Tracing' [4].

At the moment, it looks like FCL is the only available tool for "supply chain tracing" applications for official authorities. Regarding the status of digitalisation in governmental institutions this finding does not surprise. FCL is free, open, extendable und tailor-made for the supply-chain tracing investigation during foodborne disease outbreaks. All other evaluated tools are commercial and have a different focus, which is managing processes of food business companies.



Nevertheless, the software tools listed in the comparison table [4] are able to provide relevant data and information for parts of supply chains under investigation in order to trace one or more steps forward and/or backward. This means that some of the tools are of high interest concerning data exchange and therefore should be taken into account for interface development. Promising tools are ChainPoint, BioStockManager, Ecert, farmsoft post harvest, FoodLogiQ Connect and JustFoodERP. Some of them have a well-defined API (Application Programming Interface) that can be directly accessed via web services.

Concerning the main topics for the evaluation of the tools the following summarizing results are found:

- **Sources:** For each of the tools more than one source was used for the evaluation. The Capterra platform provided initial information for most of the tools except FoodChain-Lab, BioStockManager, ChainPoint, Emydex, Tracewise, ValueGo and I-Like-Platform. Each tool is described on its own website.
- A **definition of tracing** is given for each tool. A more general description of that term like tracking of lot and serial numbers is provided by bcFood and Food Traceability by Acctivate, whereas other tools (e.g. BioStockManager, ChainPoint, Ecert, Tracewise, iTrade, TraceAll, farmsoft) provide a more detailed characterization of that term. For details have a look at the online table [4].
- **Data interfaces** are one of the most important topics. Such interfaces are needed for the exchange of data via excel sheets and other file formats (csv, xml, JSON). Information can be acquired from the tracing tool with the help of an API or web services. Those are described for FoodChain-Lab, BioStockManager, ChainPoint, Ecert, Tracewise, TraceAll, FoodLogiQ Connect, JustFoodERP and LinkFresh.
- Only two tools list the support for different **languages**, namely FoodChain-Lab and ChainPoint.
- The supported **supply chains** and **target groups** are described for almost all evaluated tools. Wherefour and the I-Like-Platform do not reveal information about supported supply chains and I-Like-Platform does not list target groups.
- Information about **data analytics** is given for more than 50% of the investigated tools. These are FoodChain-Lab, BioStockManager, chainPoint, eQ Trac, Tracewise, TraceAll, FoodLogiQ Connect, JustFoodERP, LinkFresh, I-Like-Platform Food Traceability by Acctivate and bcFood. Interesting here is the possibility of Blockchain traceability provided by LINKFRESH and real-time or on-time analysis (eQTrace, TraceAll, FoodLogiQ, LINKFRESH, i-LiKe Platform, bcFood).
- **Visualization and Reporting** capabilities are described for many of the investigated tools except for Cashmere, WindFDS, I-Like-Platform, Wherefour, Emydex, farmsoft and Trax-IT. Attractive features here are the graphical network visualization (BioStockManager, Ecert) and the graphical real-time visualization (FoodLogiQ) of supply chains. Furthermore, most of the listed tools are able to export reports in various formats (e.g. pdf, xls, csv) and create backward and/or forward traceability reports.
- **EU 178/2002 compliancy** is listed for the tools FoodChain-Lab, BioStockManager, chainPoint, eQ Trace, Ecert, Emydex, Tracewise and ValueGo.

Further Outlook and Recommendations

The tools mentioned above may not have the focus on tracing in foodborne disease outbreaks with multiple different data formats like FCL. However, they have a wealth of functionalities some of which would be very useful for the web-based tracing platform, which is in development:

- Many software tools accept reads from a barcode reader. A data template fed by a barcode read would speed up data entry for food safety officers.
- Almost all tools seem to have a database with foods that are used as ingredient in food producing companies. A list of generic food ingredients to choose from would make data entry into the template easier as well.



- Most of the above mentioned software solutions have a mobile app. Such an app would facilitate data entry and would make data visualisation more convenient.

Further functionalities that have the potential to go into the development of the FCL portal:

- Data collection pipeline with notifications and option to reject and correct
- A dashboard to give an overview about the current outbreaks, and show the current status and timeline for each outbreak based on a user dependent permission system
- Chat function between data collectors
- Single Sign-on (SSO)
- Interfaces to all other tools on the market dealing with reasonable tracing data, most important for the beginning seems to be GS1, SAP
- Camera, location sensor and barcode scanner
- API to query relevant outbreak data
- The Blockchain algorithm for improving the tracing functionality is a good candidate for further investigation
- A visio like visualization of supply chains.

All of these functionalities mentioned above are now (or will be) part of the issue list of the tracing platform development (<https://github.com/SiLeBAT/fcl-client/issues>).

The crucial point in processing and solving food borne disease outbreaks is the fast and reliable real-time collection of curated high quality data. Therefore, as many interfaces to already existing systems as possible need to be established. For this purpose, a contact to the system maintainers should be made in order to discuss access right conditions to their systems. In conjunction with access rights it may also be worth to discuss the other way around: the willingness of the maintainers of the other tools to make use of the tracing portal interface that is right now under development. At the end the cross-linking of all available and broadly used systems is crucial for being quick and successful in solving foodborne disease outbreaks.

The approach in providing a publicly available comparison table opens this review process to all interested parties. It is possible to comment on tools and to apply for changes. The interactive table [4] should become a living pool of information on tracing.

In terms of WGS tracing it seems to be urgently necessary to make the first step to fill the gap between WGS information and supply-chain tracing analyses. Therefore, the tracing portal needs to integrate WGS data information into the system and to establish new analytics that may be based on the systems mentioned above.

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References

- [1] Weiser AA, Thöns C, Filter M, Falenski A, Appel B, Käsbohrer A. FoodChain-Lab: A Trace-Back and Trace-Forward Tool Developed and Applied during Food-Borne Disease Outbreak Investigations in Germany and Europe. PLoS One. 2016;11(3):e0151977. 10.1371/journal.pone.0151977
- [2] Weiser AA, Thoens C, Falenski A, Appel B, Filter M, Kaesbohrer A. **FoodChain-lab: Tracing Software Supporting Foodborne Disease Outbreak Investigations**. Procedia Food Science. 2016; 7: 101-104; doi: 10.1016/j.profoo.2016.02.097
- [3] Weiser AA, Gross, S, Schielke A, et al.: **Trace-Back and Trace-Forward Tools Developed Ad Hoc and Used During the STEC O104:H4 Outbreak 2011 in Germany and Generic Concepts**



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for Future Outbreak Situations. Foodborne Pathogens and Disease. 2013; 10(3):263-269; doi: 10.1089/fpd.2012.1296

[4] <http://socialcompare.com/en/comparison/tracing-tools-for-supply-chains-4lh89xq0>

[5] EU regulation 178/2002: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32002R0178&from=EN>

[6] FSMA compliance dates:

<https://www.fda.gov/food/guidanceregulation/fsma/ucm540944.htm#HumanFood>