Honey authenticity: collaborative data sharing feasibility study

Area of research interest: Emerging challenges and opportunities
Project status: Completed
Authors: Infoculture Limited and Food Standards Agency
Conducted by: Infoculture Limited
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Honey authenticity: collaborative data sharing feasibility study overview

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According to the UN,1 there are more than 90 million managed beehives around the world producing about 1.9 million tonnes of honey worth more than £5 billion a year. That honey will then be packaged, as single origin or a blend of honey from different sources, and sold for consumption. Given the size of the market and the immense environmental benefits of beekeeping – three out of four crops depend on pollination by bees – it is an industry on which both livelihoods and lives depend.

Target for adulteration

As a labour-intensive, high-value expensive product with an often complex supply chain, honey is subject to internationally and nationally agreed definitions – and is a target for adulteration. Testing honey is therefore critical, but there is no single universal analytical method available which is capable of detecting all types of adulteration with adequate sensitivity. A variety of methods are used to detect honey adulteration, each test has strengths and weaknesses, and there are issues with interpretation.

NMR analysis

Testing for honey adulterated with added sugars may be based on analytical techniques using analytical tools, such as those using nuclear magnetic resonance spectroscopy (NMR). This is especially helpful in detecting certain types of adulteration, such as the addition of cane or beet sugars. Bees generally forage on plants that use the same photosynthetic pathway as beet sugars. This makes it difficult for traditional tests based on isotopic differences to provide effective

results. The ‘chemical fingerprint’ provided by NMR is specific to the sample that has been tested and can be compared with the fingerprint from other sample results enabling the user to assess consistency.

Reference databases

Interpretation of results depends on comparison against a reference database of authenticated samples. The reference database needs to be representative of the variation that can occur, which includes differing beekeeping practices, origins, seasonality and variations in climate. Information is also needed on the collection of reference samples, curation of databases, interpretation and reporting of data. The nature of the reference databases is key to understanding how the results have been interpreted.

However, these reference databases are owned by and commercially sensitive for the testing laboratories that have developed them. How can such data be shared in a trustworthy way between key stakeholders along the honey and analytical supply chain so that all parties can have confidence in honey authenticity test results?

This research is looking into the implications of these hidden databases, especially in terms of the trust related to the validation certificates and the value that they have in the honey supply chain.

Honey authenticity: Introduction exploring the authenticity challenge

The challenge

Honey is a complex, naturally occurring product that has become a target for adulteration, like other high-value food products such as olive oil, whisky and wine.

Technology is increasingly playing a role in tackling many of the pressures facing food production and the supply chain, such as availability, quality, safety, nutrition and authenticity.

However, unlike other food products at risk of adulteration, which are made from harvested produce such as olives or grapes, honey is sourced from free roaming bees and their hives, which are not always pinned to a fixed location. As such, the tech-enabled provenance trails that have been suggested for other high-value food products are not as straightforward for honey.

Contested tests

In addition, testing protocols are contested due to the very nature of honey. There is a range of technical tests that can be applied to test the various components of the official honey definition (see p7). However, across the community of stakeholders in the honey sector, there is no consensus on exactly how these technical tests should be applied.

While the various tests that are used by labs to produce Certificates of Analysis (CoA) are inherently sound, there is a human element involved in understanding the nature of the variability of honey samples and how that is interpreted in results when it comes to application and interpretation. This is reflected in the language used in the analysis.

Consensus and compliance challenges

All of this matters as there are significant areas of disagreement and ambiguity. These include over the application of the test processes, the representativeness of the databases, the interpretation of the test results (with regard to the official definitions of honey), and the sharing of the data that underpins some of the tests. The legal ramifications are also complex. While technologies such as blockchain exist for food chain security, these do not address the challenges faced by regulators and food business operators when it comes to sharing data from certain testing methods such as nuclear magnetic resonance (NMR) technology and stable isotopic analysis. In particular, information is required on the collection of reference samples, curation of databases, interpretation and reporting of data.

In recent years there has been discussion and investigation into how tests can be combined and interpretations aligned, but there remain challenges in obtaining consensus for regulatory compliance. The recent reports2 from the Government Chemist set out these challenges clearly.

Data trust frameworks: a way forward

A potential route forward could be a new mechanism to achieve trusted and trustworthy data sharing between key stakeholders along the honey analysis and supply chain. Previous work on how a data trust framework might enable the permissioned sharing of data among collaborating stakeholders offers one such approach to the challenge of regulatory compliant testing for honey authenticity.

This report has been produced to present the findings and recommendations of a short investigation carried out on behalf of the FSA. The work offers a way forward to this challenge and builds on the recommendations from a previously funded FSA project on data trusts, which included a honey case study.

Approach

We see honey authenticity as a socio-technical challenge, recognising the interaction between people and technical systems.

The Data Trust Framework as described in the previous FSA reports and a paper in the journal Nature6 offers a solution that adopts these principles and builds on similar approaches implemented elsewhere, for example iSHARE in the Netherlands.

iSHARE: a successful and evolving example of a data trust framework

iSHARE is a Dutch initiative comprising a set of identification, authentication and authorisation agreements that enable organisations in the transport and logistics sector that participate in the iSHARE scheme to share data effortlessly. iSHARE enables them to:

- avoid costly and time-consuming integrations in order to share data
- share data with new and previously unknown partners
- maintain full control over their own data at all times. They have the final say about the terms under which their data will be shared, why, with whom and for how long.

The iSHARE Foundation, as the governing data institute, plays a crucial role. By signing up with the Foundation, logistics enterprises can join the network of organisations that all operate in line with the iSHARE Agreements.

The iSHARE Foundation works independently, transparently and not for profit. Among other things, the Foundation ensures that the agreements are upheld, manages the accession-related processes and facilitates further improvements to the scheme.

What is a data trust framework?

A trust framework can be defined as a legally enforceable set of specifications, rules and agreements that govern a multi-party system established for a common purpose, designed for conducting specific types of transactions among a community of participants, and bound by a common set of requirements.

Who does a trust framework serve?

A trust framework can therefore be implemented as a club established to meet the needs of members who have similar needs that they cannot easily satisfy on their own and are not met elsewhere. A key component of the implementation is the identity framework that ensures that not only trust is maintained, but that the underlying legal guarantees can be appropriately implemented. Multilateral agreements can then be used among participants to enable secure collaboration and thus provide business models that extend the value that can be created from existing resources and processes.

An outcome driven collaborative approach

The secure sharing of data offers new business models. Peer-to-peer intermediation is enabled by an initiative that captures the needs of the community through collaboration of participants. This is supported by a collection of agreements necessary to sustain the ecosystem.

Honey - the context

What is honey?

Honey is tightly defined under a 2001 European Directive, implemented in each of the member states, which defines honey as:

“the natural sweet substance produced by Apis mellifera bees from the nectar of plants or from secretions of living parts of plants or excretions of plant-sucking insects on the living parts of plants, which the bees collect, transform by combining with specific substances of their own, deposit, dehydrate, store and leave in honeycombs to ripen and mature”.

Internationally, the Codex Alimentarius Honey Standard has a wider coverage than the EU directive. Rather than exclusively covering honey from Apis Mellifera (European honeybee), it applies to all honeys produced by honeybees and covers all styles of honey presentation offered for direct consumption.

It establishes requirements for naming and labelling of honey, limits for essential composition and quality factors, requirements for hygiene, additives and contaminants, and provides methods of analysis for the determination of the compositional and quality factors

How is honey regulated in England?

The Honey (England) Regulations 2015 provide the basis for the marketing of honey to consumers. The key aims are to:

- protect the use of the reserved description ‘honey’ by setting a minimum expected compositional standard for our market

- instil consumer confidence in UK that the honey is what it says it is
- create a level playing field for industry and fair trading
- prevent misleading or fraudulent practices on our market

The 2015 Honey England Regulations cover honey from the Apis mellifera (European honey bee) and lay down reserved descriptions that must be used which relate to:

- the source from which the honey is obtained (for example, blossom, honeydew)
- the processes by which it is extracted (for example, drained, extracted)
- the way it is presented (for example, comb, chunk honey, filtered honey, baker's honey)

Honey must comply with set specifications. There are a range of general quality criteria for honey focused around its colour, consistency, flavour and aroma. No additions are permitted. No pollen or constituent particular to honey may be removed except where this is unavoidable in the removal of foreign inorganic or organic matter. The honey must be free from organic or inorganic matters foreign to its composition. It must not have any foreign tastes or odours, have begun to ferment, have an artificially changed acidity, or have been heated in such a way that the natural enzymes have been either destroyed or significantly inactivated.

As well as the quality criteria above, for honey to be labelled as honey it must comply with a set of specific compositional requirements, including set prescribed levels for:

- sugar content: fructose and glucose content
- moisture content
- water-insoluble content
- electrical conductivity
- free acid (a measure of honey condition deterioration)
- diastase (used as an indicator of honey freshness. It is also a parameter used to determine whether the honey has been extensively heated during processing)
- HMF (HydroxyMethylFurfuraldehyde – used as an indicator of heat and storage changes in honey)

UK regulations are still aligned with EU regulations in terms of limits allowed.

How are honey regulations enforced in England?

Regulation of the honey market is necessary to protect the use of the reserved description 'honey' by setting a minimum expected compositional standard and instil consumer confidence in the UK that the honey is what it says it is. It is also necessary to create a level playing field for industry and fair trading, and prevent misleading or fraudulent practices.

The Food Standards Agency (FSA) has oversight for food enforcement policy. Rules are enforced on the ground by local authorities such as trading standards officers and environmental health officers who adopt a risk-based approach on enforcement. The tendency is to take an improvement notice approach with backstop criminal sanctions for failure to comply.

Product of Animal Origin (POAO) imports, which includes honey, are subject to mandatory checks (100% documentary; 15% minimum additional checks) by Port Health Authorities.

While key quality indicators (such as HMF, diastase etc) are set in honey rules, other non-permitted additions such as added sugars are not specifically provided for but are implicit in the rules that "No pollen or constituent particular to honey may be removed except where this is unavoidable in the removal of foreign inorganic or organic matter".

Example: testing throughout the honey supply chain

Below is the text version of the flowchart that explains the different routes for testing honey through the supply chain:

- Commercial lab database (s)
- Commercial testing lab (commercial certificate of analysis)

Domestic honey producer to:

- The bulk distributor
- The honey packer
- Distributor
- Packager
- Retailer
- Customer

Regulatory checks, UK Port Health Authority

- physical check
- document check
- sample taken

The Retailer can submit a honey sample for testing:

- Domestic honey producer
- Distributor
- Retailer
- Trading Standards (regulatory tests)
- Public Analyst Official laboratory (sample submitted)

Department for Environment, Food and Rural Affairs (Defra): Regulations

Food Standards Agency (FSA): Oversight

Public Analyst Official laboratory has access to the official lab database(s).

Non-domestic, non-nomadic honey:

- Processing factory
- Packaging
- Official testing
- Exporter
- Regulatory checks
- Bulk distributor
- Honey packer
- Packager
- Retailer
- Customer

Manuka from New Zealand:

- Processing factory
- Packaging
- Official testing
- Exporter
- Regulatory checks
- Bulk distributor
- Honey packer

- Packager
- Retailer
- Customer

Nomadic bee keepers in for example, China:

- Collection station
- Exporter
- Regulatory checks
- Bulk distributor
- Honey packer
- Packager
- Retailer
- Customer

Where test results are queried, the government recommends applying a weight of evidence approach. This approach includes gathering information on product traceability – from beehive to jar – and results from any other testing that has been undertaken. This can also involve carrying out follow-up discussions with the relevant business.

Where the honey originates from the UK, there is no requirement for a business to test their honey but it is considered good due diligence and business practice to do so, to ensure the product meets the required standards.

How is honey adulterated?

Honey adulteration can be direct – sugar/syrup added to the honey at some point in the supply chain – or indirect, in the form of deliberate inappropriate bee feeding with sugars when nectar is

naturally available. Direct adulteration is thought to be the most common. Other varieties of adulteration are shown in the diagram below.

‘Immature’ honey, where the honey is removed early from the hive and then the moisture reduced, is a matter of much discussion. It falls foul of the Codex definition.

Direct adulteration of the honey:

- Original mislabelling (organic)
- Botanical origin and mono -v multi-floral
- Geographical including PDO, PGI honeys

Production (organic):

- Cheaper honey (blending) - Organic - Botanical origin and mono-v multi-floral, geographical including PDO, PGI honey.
- Inappropriate filtration
- Resin treatment
- Marker of pollen addition
- Thermal treatment

Production - Contaminants (pesticides, heavy metals, veterinary residues, GMO, toxins), fermentations microbiology).

Substitution - by cheaper similar ingredients (water added)

Indirect adulteration by inappropriate bee finding:

- Sugars and sugar syrups - sugars: sucrose (as is or invert): Cane sugar (C4), Beet sugar (C3). From starches: corn (maize) syrup (C4), rice syrup (C3), high fructose cassava syrup (C3/C4), Chicory syrup (C3), Wheat syrup (C3). Others: high fructose inulin syrup (C3)*, date syrup (C3), Jaggery syrup (mainly C4).
- Inappropriate antibiotic treatment

*Inulin produced from many plants industrially but mainly from chicory.

Honey authenticity: methods available for testing

Analytical techniques to authenticate honey include the following:

1. Classical methods

2. Modern methods

Classical methods:

- **Physiochemical parameters:** pH, sugar content, Proline, Enzymatic activity, moisture content, ash content, diastase activity, free acidity, HMF content.
- **Melissopalynology (microscopy study of pollen grains)**

Modern methods:

- **Chromatographic methods:** HPLC, GC. Sugar profile, Amino acid profile, Phenolic profile, Flavanoid profile.
- **Mass spectrometry:** LC-MS, GC-MS, Stable isotopic ratio. Volatile profile, sugar profile, Phenolic profile, Flavanoid profile.
- **Infrared spectroscopy:** Fourier transform infrared (FTIR), Near infrared (NIR), FT-Raman spectroscopy. Sugar profile, Amino acid profile.
- **Nuclear magnetic resonance (NMR):** 1H NMR, 13 C NMR. Identification of individual compounds (targeted analysis), molecular fingerprint of a sample (non-targeted analysis), combined techinques such as LC-IRMS.
- **Molecular techniques:** SDS-PAGE, Western-Blot, Real-time PCR, DNA sequencing. Protein, DNA.

There are significantly different perspectives on the ways in which testing methods are applied to honey. These relate to different perspectives on how honey should be defined, and also how rules and regulations should be applied as practices.

Honey authenticity: the NMR issue

Honey authenticity

- is impacted by consumer demands ie the product consumers know as ‘honey’ at an affordable cost.
- is multi-faceted, involving the nature of honey itself, different production methods, processing methods, testing methods, testing processes, global supply chains etc.
- contains a wide divergence of perspectives and interpretations on the application of regulations, testing practices and interpretation of
- results
- involves issues unique to NMR testing where it is being used to test honey for exogenous sugars while not being universally accepted, and
- comparison data is a challenge in terms of it being fit for purpose for all honeys and furthermore not accessible as part of an audit or for comparison purposes.

NMR testing is of primary interest because it is at the centre of the current debate on testing methods for the detection of exogenous sugars in honey.

The reference database challenge

The ‘chemical fingerprinting’ of NMR testing can detect exogenous sugars from both C3 and C4 plants. However, interpretation of results from NMR tests depends on comparison against a reference database of authenticated samples of known, verifiable origin and authenticity.

To ensure it is robust, the reference database needs to be representative of the variation that can occur in a product such as honey. This includes differing beekeeping practices, different origins, seasonality and variations in climate. This should ideally be publicly available or available for scrutiny by all.

A particular concern is that most NMR tests of UK honey are conducted by European labs. While European countries tend to consume primarily European honey, UK blended honey tends to be composed of honey from further afield, such as China, Mexico and Argentina.

Due to the different beekeeping practices and higher humidity in some of those regions, it is more likely to include immature honey.

Uncertainty, frustration and urgency

NMR testing is being widely used but is producing contested results, and is not currently accepted as a yes/no test within the UK regulatory system, nor is it in the European Union. However, it is widely used.

For example, the United States of America Customs and Border Protection USA have adopted the use of NMR to test all honey imports.

The Indian government has requested that the Indian Export Inspection Council (EIC), which comes under the Commerce Ministry, makes NMR- testing mandatory for all consignments of honey exported from India.

This is causing uncertainty, a lack of clarity, and frustration throughout the honey supply ecosystem. It is also creating inefficiencies, especially for local authorities who act as a primary

authority and deal with referrals from other local authorities and port authorities, who may be using a range of testing labs and processes.

There is a palpable sense of urgency to address this in a robust and practical way that works for all perspectives and so that all may have confidence in the honey testing regime.

> The current situation is causing uncertainty and frustration throughout the honey supply ecosystem.

Honey authenticity: what needs to be done and the solution

What needs to be done

Greater confidence in honey testing processes requires a way to identify which reference database is being used when a sample is NMR tested, along with a means to verify the results while maintaining a laboratory's commercial confidentiality.

This scenario is explored further below with the data services and dashboard solution.

The solution

Work to date has focused on clarifying the scope and depth of the problem. These problems will continue to be considered and mechanisms incorporated to be addressed in the 'data and dashboard services' solution.

Ongoing activities addressing this include further investigation of NMR processes, further analysis of positions in the community, legal aspects and implications for these positions, and the mapping and modelling of what data needs to be captured and made securely accessible.

Data services

The research undertaken for this report has confirmed a coherent community willing to collaborate. These data services can play a role in enabling further collaboration.

Facilitated discussions can then be arranged that extract and interlink services between stakeholders. These services can address existing practices, overcome existing challenges and ultimately offer new business models that save money and create tangible benefits. This is a virtuous circle iterating between the social and the technical.

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A roadmap for collaborative approach

The proposed data services framework provides a roadmap for a collaborative approach that establishes a coalition of willing, community of interest and practice around:

- agreement about purpose
- interoperability of systems
- mapping operations between organisations
- governance and oversight among organisations (to include regulations and legislative compliance

Following the example of iSHARE in the Netherlands (see p6), and using the experience of other projects (such as Trusted Bytes with Innovate UK), funding for the data services framework would come through creating a not-for-profit body that would be self-sustaining through added-value services. Seed funding would come from existing government initiatives designed to support digital transformation and enable communities to collaborate on building services already shown to deliver value.

The following diagram captures the types of data that can flow between stakeholders in the honey supply chain, with their permission. This information has been distilled from our research and stakeholder interviews.

Data model

Port sampling data:

Permitted view:

- Anonymised Producer ID
- Batch ID
- Volume/Quantity

Upload:

- Port Location ID
- Sample test results (linked to Batch ID)
- Arrival/departure date
- Volume/Quantity

Honey Packer:

- Batch ID
- Producer ID
- Volume/Quantity
- Previous stops
- Arrival/Departure dates
- Sample test results
- Harvest date

Upload:

- Packer ID
- Batch Blend Data (uses pre-blend Batch IDs)
- Output Batch ID
- Destination (if possible)
- Label code

Production Data:

Permitted view:

- All stops/processors
- Arrival/Departure date
- Sample test results
- Test Centre ID
- End Destination

Upload:

- Producer ID
- Location
- Food Service
- Volumes
- Harvest Dates
- Batch ID

Consumer:

With code from Product, can view:

- Test result/composition
- Travel data (locations/dates)
- Harvest dates
- Food Sources
- Certifications

Regulation Data - Defra:

Permitted view:

- All

Upload:

- Regulation set/policy
- Testing centre data
- Producer business data
- Certificates issued by batch

Regulatory Compliance - FSA:

Permitted view:

- All

Upload:

- Test results (Historic)
- Producer compliance testing
- Packer compliance
- Enforcement actions
- Contamination data

- Additives identified
- Certificates issued

Testing data (with UKAS and NMR (private testing):

Permitted view:

- All

Upload:

- Test type (official/commercial)
- Results by sample
- Certifications
- Linked to production IDs
- Physical sample storage ID (physical sample stored for future testing)
-

Governance over visibility and access to data will be enabled by the community of participating members in the scheme.

Honey authenticity: proof of concept

Dashboard services

Contained's BlueRing supply chain coordination system provides a switchboard and a dashboard for users to enable interoperability and visualisation of their data sharing activities. The proof of concept is focused on developing a solution for the use case of someone wishing to a submit a sample of honey for testing.

The BlueRing system allows registered users to coordinate supply chains from their perspective by creating order manifests and adding and managing data associated with a batch of goods. This has been

expanded to incorporate the case of a sample from this order being sent for testing.

The data trust framework solution is technology platform agnostic. Contained's BlueRing system is used here as an example to show how the protocols and agreements can be implemented.

A system for the honey sector

This has involved creating new 'actor types' to prepare the system for the honey sector. Beyond the proof of concept, the next stage is to tailor these to specific roles from the sector and iteratively co-create new interoperability services. These can subsequently be adopted for testing regimes in other sectors.

Work is ongoing on developing these services. The proof of concept enables a request to be made to a test centre, a sample to be submitted and then the resultant Certificate of Analysis can be viewed online together with details of the component tests.

The secure configuration of the system allows the data owners to give access to regulatory bodies and others, if permissioned, and access certain parameters of the test results.

Enabling secure analysis

This allows an independent body to be given access to the test results but also, importantly, the approach in conducting the test and interpretation of the results. In cases where there is a dispute or a confirmation check needed, the test process can be securely analysed and ratified.

The aim is that this platform will enable and support the discourse among the community. This will be facilitated through a trust framework implementation assembled from the participants in this research activity who have indicated an interest in taking this further forward. Once the initiative is established, others will be welcome to join.

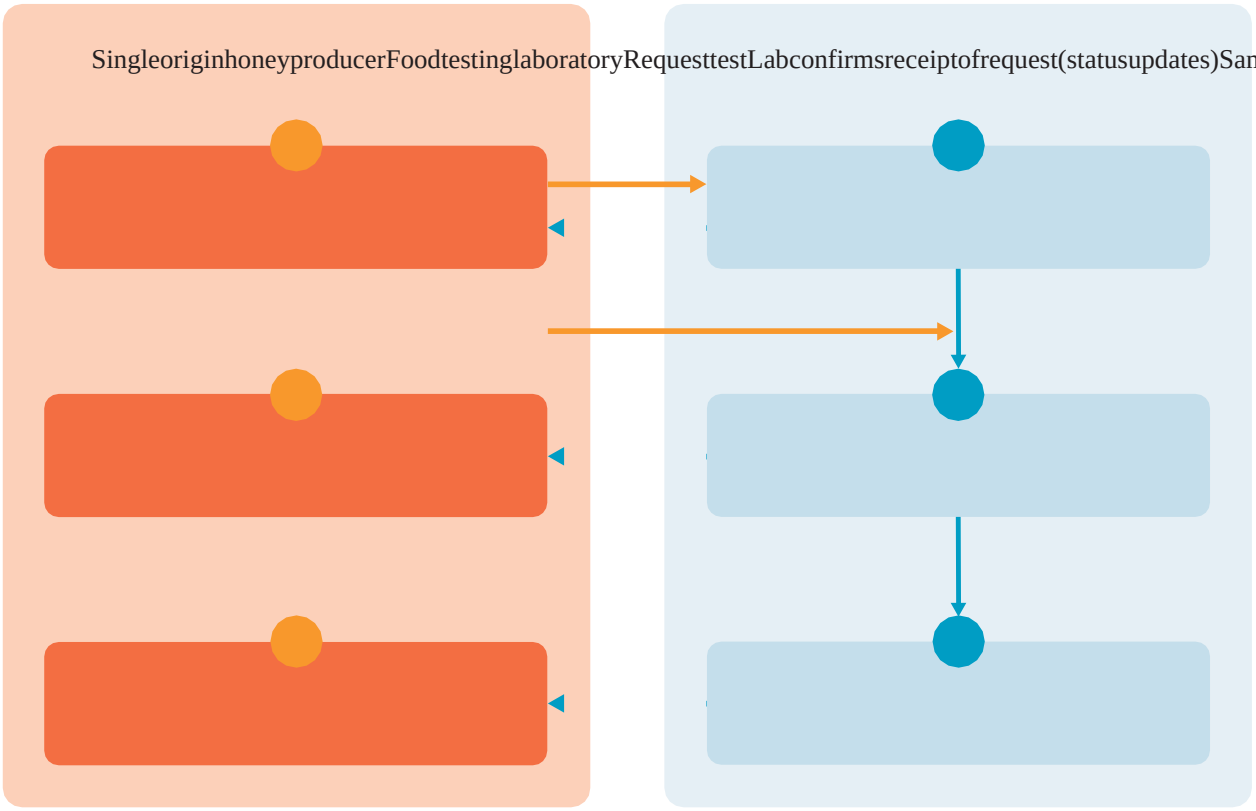
The Containd.io development team has created processes to enable use cases, as an exemplar of how the system could work:

- Key stakeholder roles can be represented: commercial test lab, producer, lab test requester
- Lab test can be requested
- Commercial certificate of analysis can be uploaded can be uploaded
- Certificate can be accessed by requester
- Further analysis of use case to add granularity to steps is ongoing, including second step to NMR lab, and interrelationship with FSA as regulator with oversight of NMR databases

Commercial honey test service process flow

High level description of the commercial honey test service for the single origin UK-based honey producer. The BlueRing system demonstrates how data-sharing can enhance the process.

1. **Single origin honey producer:** Request test
2. **Food testing laboratory:** Lab confirms receipt of request (status updates)
3. Sample sent
4. **Single origin honey producer:** Status update
5. **Food testing laboratory:** Lab confirms sample receipt (status updates)
6. **Food testing laboratory:** Lab submits results (status update
7. **Single origin honey producer:** Commercial certificate of analysis



Commercial honey test request service

Contained.io's BlueRing system as an example of a data exchange between a single origin honey producer and a commercial laboratory.

1. Honey Producer adds and submits new order request.
2. Lab Analyst receives notification of order and sends acknowledgement of order request
3. Honey Producer receives confirmation or order and sends sample.
4. Honey producer receives results (order is completed)
5. Lab Analyst receives sample and sends receipt confirmation and performs test(s)
6. Lab Analyst sends results (order is completed).

"This approach to honey testing not only makes good Health and Safety sense, but also good Honey sense." – Honey Producer

Implementing the data sharing governance ecosystem

Further work is being conducted on how to design and implement a sustainable solution that could persist beyond the project. This involves working with a small study group drawn from a coalition of the willing who are interested in exploring how permissioned access to certain test data can help develop a consensus within the community around honey authenticity assurance. Other bodies involved with test data analysis and food product certification may wish to participate in this activity.

The need is to implement a data trust framework that supports the secure and specific data sharing services needed by this community to address the concerns regarding testing and authenticity in the honey sector.

The framework will enable the community to agree on the data sharing services they need. These formal agreements would be available to enable them to share and access data securely in the

honey production supply chain.

Any such solution will require a governance system to enable the community to build trust among the data sharing users as well as agree definitions of rules and roles. This approach will enable the integration of the technical data sharing mechanisms developed as a proof of concept with existing services from regulators, trade bodies and other stakeholders.

There will be a minimalist start to this process with a basic data sharing agreement to further test this approach. However, the goal is to move towards a more ambitious governance model similar to the approaches we have previously explored.

Two tier governance structure for data exchange collaborations

The two-tier structure is designed to optimise the balance between federated input from the participating stakeholders and an efficient delivery executive that satisfies the agreed needs of the community.

- Sponsor(s) appoints the Supervisory Board who supervises the Executive Board
- The Supervisory Board appoints the Members Council who advises the Executive Board
- The Supervisory Board also appoints the Experts Group Advisory Board (technical, ethical, legal) who advise on the scheme management and adoption.

Honey authenticity: follow-on activities

This project has taken the form of a research investigation and also the development of a technical proof of concept for the data trust framework approach. Focusing on the delivery of a relatively straightforward transaction – the request and satisfaction of a commercial honey authenticity test – has enabled us to unpick the wider complexities of such a service.

In addition to further development of the data and dashboard services solution, there will be three academic papers:

- Data sharing club: between the marketplace and the aggregator (submitted)
- Barriers to sharing closed data: a case study (in development)

- Policy implications/opportunities for application of the data trust framework as an entity (data-sharing club) (conference identified for autumn 2022)

The papers will each contribute to the theory and practice and be interdependent for example, Business model innovation literature (marketplace); Collaboration and co-creation (communities of practice); Sharing of closed data (aggregation).

Honey authenticity: methodology

Research/stakeholder engagement

Individuals from the organisations listed below were interviewed at least once in video calls of typically an hour long each. All interviewees have been interested and engaged. We appreciate the input of all our interviewees but emphasise that this work is the authors' alone. Interview involvement does not signify endorsement of the contents by the interviewee or their organisations.

We spoke with at least one person from the following organisations:

- Bermondsey Street Bees
- Defra, Food Compositional Standards Team
- European Commission, Joint Research Centre
- Food Industry Intelligence Network (fiin)
- Fera Science Ltd
- Intertek
- LGC Group
- Minerva Scientific Ltd
- Morrisons
- Open Identity Exchange
- Oxfordshire County Council, Food Standards
- Premier Foods
- Public Analyst Scientific Services
- Surrey County Council, Food Standards
- Tesco
- Valeo Foods UK

Literature review and academic research

Around 20 papers were identified related to the challenges and opportunities of sharing and accessing data. While this covers the spectrum of open and closed data, it is all useful for our purposes. In a separate strand papers are being examined related to NMR testing practices. Distilling the literature is enabling us to design an analytic framework that will be used to guide further, formal interviews and analysis of wider findings. Complementing this is our development of the implementation of the trust framework.

Honey authenticity: references and acknowledgements

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16 Food data trust a framework for information sharing (food.gov.uk)

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Steve Brewer and project team
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Project team:

- Steve Brewer, project lead (Infoculture and University of Lincoln)
- Alex Szymborski (Contained Technologies UK Ltd)
- Dr Phil Godsiff (Infoculture and University of Exeter)
- Michelle Pauli (Infoculture)
- Professor Simon Pearson (University of Lincoln)
- Professor Jeremy Frey (University of Southampton)
- Dr Kyle Alves (Infoculture and University of Exeter)
- Lisa Bamford (Stoats & Weasels)

Contact details

Steve Brewer

steve@infoculture-lab.com

Infoculture Ltd