Agri-food traceability, quality and safety in Italy: integrating new technological and methodological systems of statistical indicators for citizens, institutions and policy makers[1]

Gianni Betti,* Daniela Evangelista,** Francesca Gagliardi,* Emanuele Giordano,* Angelo Riccaboni***

* DEPS, University of Siena
** CNR/ISA National Research Council, Institute of Food Science
*** DISAG and Santa Chiara Lab, University of Siena

Abstract

We performed an exhaustive review of the literature on indicators of agri-food quality and safety. Our interest concerned creation of information systems of indicators to guide consumer, policy-maker and institutional decisions. Since we found little literature on all such aspects together, we propose an original *step-by-step* procedure for integrating new technological and methodological systems of statistical indicators for these actors.

1. Introduction

One of the most urgent and difficult challenges facing the world today is reconnecting agriculture (and production systems linked to it), the environment, food and health. Meeting this challenge requires a change of perspective in the so-called agri-food sector, involving integration of all the environmental, economic, ecological and social bodies involved. This cannot be achieved without making appropriate use of modern information on what is rightly an eco-socio-economic system. It is necessary to measure the current state of the system and describe its evolution according to monitorable processes.

Here we report an exhaustive review of the literature on indicators of agri-food quality and safety concerned with the creation of information systems of indicators to guide consumer, policy-maker and institutional decisions. Since we found little literature on all such aspects together, we propose an original step-by-step

[1] This study was carried out within the Agritech National Research Center and received funding from the European Union Next-GenerationEU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR) – MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.4 – D.D. 1032 17/06/2022, CN00000022). This manuscript reflects the authors' views and opinions, not those of the European Union or the European Commission.

procedure for integrating new technological and methodological systems of statistical indicators for these actors. We considered the experience of Italy, but the procedure is readily extended to other countries or sub-regions. For the latter, we introduce and explain small-area statistical methods.

The step-by-step procedure will be implemented in the next 24 months under PNRR-funded Agritech Project, Spoke 9 "New technologies and methods for traceability, quality, safety, measurements and certifications to enhance the value and protect typical traits in agri-food chains", becoming a best practice at international level.

The four main steps are:

- **Step 1**: Focus groups to investigate how different stakeholders perceive the definition, qualification and quantification of agricultural production and agri-food chain sustainability. The insights gained from these engagement activities contribute to a deeper understanding of the key factors influencing sustainability in the agri-food system at national, regional and city level.
- **Step 2**: Analysis of major providers to understand the present situation through an in-depth search of official secondary sources on agricultural production and agri-food chain sustainability, identifying the availability or lack of indicators and measures identified in Step 1. An integrated database of the available information will be created at the end of this step.
- **Step 3**: Sample survey to obtain measures for missing information by comparing the results of Step 2 and Step 1. Sample surveys of producers and consumers are developed to collect information considered important in Step 1 but not provided by Step 2.
- **Step 4:** A user-friendly online database for ready access is created.

The nine sections of the paper are Introduction, followed by a description of the scopes and organisation of the Agritech project. Sections 3 to 6 concern data sources from the literature. Section 7 describes the information system and the step-by-step procedure developed so far. Section 8 proposes a pilot study for the first smart database of agri-food products. Section 9 concludes the paper.

2. The Agritech Project

The Italian National Research Centre for Agricultural Technologies (Agritech) was funded by the Next Generation EU – PNRR ("Piano Nazionale per la Ripresa e la Resilienza) in 2022. The motivations of the project were drawn directly from the European Green Deal (COM2019 640 final), a fundamental part of the United Nations 2030 Agenda. The project has specific goals for the agricultural sector, aimed to preserve the stock of natural capital and achieve climate neutrality by 2050.

The Agritech project has nine Spokes, and here we refer to Spoke no. 9 on "New technologies and methods for traceability, quality, safety, measurements and certifications to enhance the value and protect typical traits in agri-food chains". These new technologies and methods treat special issues using well-defined working packages: WP1 integrates new data and metadata on origin and sustainability, WP2 integrates information

on productivity, efficiency and sustainability for businesses, clusters and agri-food chains. WP3 is Spoke 9 of the project. WP4 and WP5 use blockchain (BT) and distributed ledger (DLT) technologies to construct "METRIQA", an overall digital information platform. The present paper mainly focuses on the link between these new technologies and methods and METRIQA by integrating statistical indicators useful for citizens, institutions and policy makers.

3. Step 1: Focus groups

Focus groups are a type of qualitative survey, very different from group interviews. The latter use targeted questions to elicit fairly precise answers, whereas the former are discussion groups on predefined topics in which a moderator elicits opinions, ideas and discussion in a natural and spontaneous way (Corrao, 2000). The basic idea is to create discussion between the subjects and to collect the information and ideas that gradually arise through dialogue and exchange of opinions. The moderator's task is to direct the focus and keep the conversation on track. The preliminary phase is formation of a study group: the number and the heterogeneity of the participants are two dimensions to be considered. If one opts for a large heterogeneous group of opinions, the discussion is likely to focus exclusively on common opinions (Fern, 2001), without leaving space for differences. This problem is tackled by inviting participants to express their ideas. Otherwise, less numerous and less heterogeneous groups may be preferable, or numerous homogeneous groups. Group cohesion, i.e. a sense of closeness of ideas and goals between group components, is a key for an effective focus group: participants' desire and interest in contributing depends on this. Sometimes group cohesion is more important than group composition, as in the case when the aim of the focus group is to verify a theory and the project's budget (money and time) is limited (Corrao, 2000).

Focus groups and privileged witness surveys are qualitative research techniques widely used in agri-food economics and marketing studies to explore the opinions and attitudes of the various stakeholders in the supply chain (consumers, producers, trade associations, etc.) towards product or process innovations, communication and marketing strategies, and other research activities or topics related to production. The focus group is an analysis technique suitable for understanding food choices as it encourages participants to express their opinions by leveraging interactions between group members, thereby eliciting insights not otherwise accessible without co-presence and exchange between participants (Morgan, 1996). In the same way, privileged witness surveys, as highlighted in Tolomeo (2013), are based on structured interviews with a statistically non-significant sample of privileged witnesses. More than an analysis, it elicits a story on relevant themes and issues. The story is not precise, but gives an idea about complex issues such as agri-food chains. With particular regard to the sustainability and traceability of the Italian agri-food chain, Sacchi (2018) investigated the values and factors that influence the attitudes of ethical consumers who prefer short-chain commercial channels and highlighted that links between consumers and producers are the major aspect for participation and involvement in alternative agri-food networks, such as solidarity purchasing groups.

Vecchio (2011) used focus groups to explore the relationship between consumers and local products in farmers' markets and found that in some contexts, consumers are interested in this type of purchasing channel in order to support farms and promote development of their communities. The literature on consumer focus groups therefore shows that sustainable consumption habits linked to short supply chains are influenced by the degree of accessible information on the product and by social and environmental concerns, such as fair remuneration for the producer and the reduction of carbon emissions (Vecchio, 2011; Altamore et al., 2017; Sacchi, 2018). Crovato et al. (2022) explored consumer perception, especially ethical and social concerns about the consumption of rabbit meat, integrating the qualitative technique with a quantitative survey (structured questionnaire). The results showed that major aspects for consumers were animal well-being, which leads them to prefer meat raised by extensive farming methods, and food safety and hygiene, which prompts consumers to shop at supermarkets, considered to offer greater safety guarantees. The case study also brings out an almost contradictory perception regarding traceability and sustainability: on one hand, participants link intensive farming to unsafe meat and poor animal welfare, while on the other they believe that meat purchased at supermarkets is better controlled than that from rural/domestic farms, if the origin of the meat and the treatment of the farmed animals is ignored. Similar conclusions are reported by Crovato et al. (2019), who investigated the perception of risk and the habits of Italian consumers regarding the purchase, management and consumption of shellfish. The study indicated that focus group participants showed very different and confused points of view on the risks associated with shellfish. Nonetheless, consumers agreed on the fact that denominations of origin, local products and food traceability provide reassurance about the wholesomeness of food, as if quality and food safety were two overlapping concepts in many ways. These studies suggest that lack of knowledge of the production chain and the concept of traceability and safety underlie a certain contradictory or confused consumer awareness. Concerning sustainability, Ingrassia et al. (2022) evaluated the opinions of producers and consumers on the sustainability certification of "SOStain" wine by the focus group method. The survey found that while wine producers are aware of the need to change to more sustainable production models, not all companies are ready to respond favourably to this transition because of its higher costs. The authors therefore reflect on whether the higher costs footed by companies should be repaid by public aid or the market in the form of a premium price for the certified product. The study also reports information asymmetry between producers and consumers regarding certification. Indeed, communication on sustainability certification is ineffective, that communicated by producers being different from what wine consumers understand. Similar results were reported by Blasi et al. (2015) who used the same survey technique to explore farmers' opinions on the introduction of a technological innovation that allowed more sustainable cultivation of durum wheat. The research found that innovation was appreciated by farmers for its ease of use and low cost. However, the low technological capability of farmers and uncertainty about sources of funding and support from public institutions were recognized as the main barriers to the spread of technological innovations. On the other

hand, Menozzi (2014) investigated introduction of geographical indication as a tool for sustainable development for olive growing and for the production of extra virgin olive oil in the provinces of Emilia. Part of the analysis was conducted through focus groups with local olive growers, highlighting the main weaknesses and strengths of the sustainable strategy proposed with particular reference to the specificity of the supply chain and the places considered (e.g. climate variability, soils, exposures, quality of productions, etc.). An interesting example of qualitative survey using privileged witnesses and focus groups was carried out by the University of Trieste with MIPAAF (Tolomeo, 2013). Stories and testimonies of agri-food company development and transformation were collected by qualitative survey, while focus groups with representatives of trade associations explored supply chain characteristics by tracing critical elements and strengths. Galli et al. (2015) compared local and large supermarket supply chain sustainability by multidimensional analysis based on 19 criteria. A focus group of experts evaluated the method's discriminatory capacity for the local bread supply chain and large-scale distribution. In recent years, there have been many focus groups on sustainability issues in the agri-food sector, organized by various trade associations and local stakeholders, with the aim of enhancing local production.

This brief excursus of the scientific literature on focus groups concerning the traceability and sustainability of the Italian agri-food system allowed us to highlight various empirical and methodological aspects. The survey tool proved to be very effective for exploring a broad and little-known topic, precisely because it allows a flexible approach and obtains data suitable for generating hypotheses (Morgan, 2018). The technique has only however obtained significant relevant results when the focus group was based on a well-defined product, territory or supply chain. Precisely because the method is based on idea-generation derived from group interactions (the ideal number of group members should not exceed six) over a limited period, its effectiveness is closely linked to correct delimitation of the survey object and to a sample of participants that reflects the target population.

4. Step 2: Analysis of major providers to understand the present situation

It is now agreed that one of the main obstacles to implementation of a sustainable model and circular economy in the agricultural sector is the lack of information about supply chains and the stakeholders involved in them (Ahumada et al., 2009), while data sources that meet the information requirements of consumers (including food safety and quality) are also needed. Consumers play a central role in steering the market towards sustainable models (Mehrabi et al., 2022). It is clearly necessary to identify existing data sources for an agri-food system in order to build a set of indicators that can enable a shift from farm-level solutions to a focus on interactions in the value chain as a whole, from production to consumption.

If we are to identify and quantify appropriate indicators to monitor the sustainability of the agri-food system, we need to build an integrated database by collecting the information sources currently available on the subject. This is the central objective of Step 2. A first survey of existing databases found many databases of a

general nature, extremely different from each other in the characteristics and nature of the data collected. The results of the search are described below.

For data on the agricultural sector, the agricultural data collected by ISTAT census provides a great deal of detailed information every ten years, including, for example, the characteristics of agricultural holdings, their regional distribution, the types and areas of crops, livestock numbers, the agricultural workforce and other remunerative farm activities besides agriculture. We also have RICA (Italian acronym for Farm Accountancy Data Network) which collects data of a sample nature annually using an approach harmonised among EU member countries. In Italy, the RICA survey is carried out by CREA and is a consistent source of microeconomic data on the economic and structural dynamics of agricultural holdings and the evolution of incomes (economic and productive results, structural, social and environmental characteristics). Since 2003, it has been conducted annually in coordination with the Farm Economic Performance Survey (REA), based on ISTAT data, which again records information on cost and revenue structure, labour costs, subsidies received, stocks, stock purchases, sales of fixed assets, the value of plant and livestock products reused by the holding as means of production in the same financial year, etc. The REA survey is based on a sample of small companies (standard output <€8000 per annum), whereas RICA considers medium to large companies (standard output ≥€8000 p.a.). Other relevant ISTAT agricultural databases are: i) crops and farms, including crop statistics, sowing intentions, milk and milk product statistics, dairy products and livestock; ii) quality products and agritourism, including data on DOP/IGP and STG quality and on agri-food products and agritourism services; iii) means of production, namely information on the distribution of fertilizers and pesticides. For plant protection there is the FITOGEST portal created by a private company, namely Image Line. Regarding the agro-industrial sector, the Statistical Archive of Active Enterprises (ASIA), an ISTAT survey, provides an annual census of all active enterprises and their personal, demographic and stratification characteristics (economic activity, legal form, number of employees, turnover and so on). The ASIA agricultural register extends ASIA with economic activities of the agricultural sector, excluded from the general register. Another source of data on crops, specifically wheat production, is the database monitoring the technological and qualitative value of wheat varieties cultivated in Italy 1963-2014, made available by the Ministry of Agricultural Food and Forestry Policies (MIPAAF). It contains scientific notions for employees in the industry on the qualitative-technological characteristics of wheat varieties, soft and hard, grown throughout the country. Still in the field of crops, MIPAAF provides the National Register of vine varieties, accessible on its website. It contains vine and clone varieties listed in the national register with the administrative details of registration, designation of origin and geographical indication of wines, data on the production of rooted cuttings by variety, clone and category, a brief description of the main characteristics of the clones and a photo-gallery of the different clones. In the livestock sector, the MIPAAF website maintains the national register of producers of hatching eggs and chicks, with the following information:

registration number, name and address, legal representative, name and address of the establishment, ASL code, date of registration and bird species.

Economic data on prices of agricultural products can be found in price lists on chambers of commerce websites. The data is updated weekly and grouped by goods category. A summary of the main markets for major products is proposed by ISMEA. Data on the prices of agricultural products can also be found in ISTAT's Prices of Agricultural Products database, updated monthly with national details. Coeweb, on the other hand, is the ISTAT database that collects monthly foreign trade statistics and provides information on the value and quantity of agri-food products traded by Italy with other EU and non-EU countries.

Regarding the demand for agri-food products, one of the main sources is the ISTAT database of household consumption expenditure, which collects information on the annual consumption habits of Italian households: average monthly expenditure, composition of the shopping basket and changes in habits with respect to previous years. Other important consumption surveys are those carried out by the private agencies IRI and Nielsen, which scan data from major supermarket chains and provide information on sales (value and volume of agri-food products), types of products and the producers who market them.

In terms of sustainability, ISTAT provides the data and indicators of the BES project (Italian acronym for fair and sustainable well-being) which annually monitors and evaluates the quality of life and well-being of society from economic, environmental and social points of view. It is therefore an extremely variegated database that can provide spatial assessments of economic well-being (e.g. risk of poverty, low labour intensity, per capita gross disposable income, etc.), social relations (e.g. social participation, voluntary activities, non-profit organisations), landscape and cultural heritage (e.g. erosion of rural areas by urban sprawl or abandonment) and environment (e.g. CO2 emissions and other climate-altering gases; air quality, consecutive days without rain).

For information of a strictly social nature, the ISTAT annual multi-branch family survey "Aspects of daily life" collects information on citizens' habits and lifestyle, such as leisure, political and social participation, health, school, work, family, social life and satisfaction with public utilities.

Regarding environmental sustainability in the strict sense, the Yearbook of Environmental Data edited by ISPRA is a database that describes the characteristics of different environmental matrices such as air, soil, water and biodiversity and changing conditions over time. Concerning environmental issues, the National System for Environmental Protection maintains the Soil Consumption Database for Italy, which provides agricultural, urban and industrial land cover on a national scale. In the panorama of databases/repositories on environmental sustainability, there is the Carbon Footprint of Italian Farms, an electronic report by CREA, containing the carbon footprints of companies in the RICA sample for the year 2014.

As regards databases with information of a chemical-biological nature, food safety, traceability and anti-counterfeiting, there are CREA's Germplasm database, the Database of Italian Monovarietal Oils by ASSAM (Agenzia Servizi Settore Agroalimentare Marche) and the Private Isotopic Database of Italian wines by the

Edmund Mach Foundation and the Italian Wine Union. The first contains the genetic makeup of 60 plant species of agricultural interest cultivated in Italy. The second is an accurate description of the organoleptic profile of monovarietal oils evaluated during the "National Review of Italian Monovarietal Oils" (ASSAM) and the profile of their main fatty acids. For each monovarietal type, the average organoleptic profile, the confidence limits (95% probability) of the profile, fatty acid composition, total phenol content, the regions from which samples were analysed and the reference years of the Review are listed. The Private Isotopic Database of Italian wines, currently accessible only to operators in the sector, contains the isotopic abundances of carbon, hydrogen and oxygen for each harvest, of wines with a trademark registered with the Italian Wine Union.

Table 1 of the Annex lists the databases found and a brief description. There is also a classification of databases according to the relevant target/s of the new PAC 2023-2027. There exist collections of data on various aspects related to agriculture at municipal or provincial level provided for their jurisdictions by the Regional Agencies for Environmental Protection. There is also a noteworthy extra-national source providing regional environmental data (NUTS 2), namely the portal Greenhouse Gas Emissions (EDGAR), a reliable independent source of information supporting analysis and development of regional climate action policies. The portal provides data on greenhouse gas emissions from 1990 to 2021, also by Italian region.

5. Step 3: Sample survey to obtain missing information

The central objective of the third step of the proposed method is to implement specific sample surveys aimed at collecting the information necessary to define and build the indicators: information highlighted as important in Step 1 but found missing in Step 2. The search for the latest notions on sustainability and traceability of agri-food products therefore focused on the scientific literature on consumer and producer behaviour at national level. On the consumer side, we found many papers regarding the Italian market (often but not only on individual supply chains), while on the supply side, there was less literature and it mainly concerned technical/economic aspects of applying traceability systems to the supply chain. We ignored papers about blockchain technology.

5.1 Consumer surveys

We now report the main articles on consumer preferences and willingness to pay for sustainability certifications on agri-food products. The eligibility criteria were: i) study focused on consumer preferences regarding sustainability labelling of food products; ii) study aiming to elicit consumer willingness to pay; iii) study conducted on a sample of Italian consumers. The surveys fell into four groups.

5.1.1 Product certification and labelling studies

Fitzsimmons and Cicia (2018) investigated consumer preferences for environmental (organic, "environment-friendly", carbon footprint) and social (SA8000, which certifies compliance with workers' conditions) sustainability certifications in Italy and Germany. They evaluated how these preferences are influenced by

individual values. Using the Schwartz scale (Schwartz Portrait Values Questionnaire), they demonstrated that the value category "Self-Transcendence", which identifies persons moved by interest in others and respect for the environment, is positively related to preferences for sustainability certifications. Janssen and Hamm (2012) conducted a consumer survey to determine whether consumers prefer certain organic labelling schemes over others and to provide recommendations for market stakeholders in the organic sector. The research is based on a sample of 2441 consumers of organic products in six European countries, including Italy. Many papers concern wine certifications.

Bazzani et al. (2020) explored consumer preferences for information, such as sustainability certifications, on the naturalness of wine. The case study considers organic certification, biodynamic certification and “biodiversity friend” certification. Gallenti et al. (2019) investigated the preferences of millennials for two sustainable wine labels: the carbon footprint and the "winescape aesthetic" claim which certifies the landscape value of the product. Stasi et al. (2014) evaluated the preferences of Italian consumers for de-alcoholised wine and organic certification of its characteristics. Vecchio (2013) analysed the value attributed by consumers to the following social and environmental sustainability certifications: i) the carbon footprint; ii) Centopassi – Libera Terra (social commitment in the fight against organized crime); iii) Cosmina et al. (2016) evaluated the importance of certain honey traits for consumers, including sustainability certifications. The biological attribute was more important than other factors, such as landscape value, but less important than country of origin. The preferences of Italian consumers for different food products were studied together with the choice attribute traceability for beef (Merlino et al., 2018) and fresh-cut salad (Massaglia et al., 2019).

5.1.2 Surveys on consumer willingness to pay more for certified products

Bazzani et al. (2017) explored consumer evaluations of local and organic food products and the influence of consumer personality on their preferences. Consumers were willing to pay more for local and even more for organic products. Canavari and Coderoni (2020) investigated Italian consumers' willingness to pay for carbon footprint certifications. Other studies by Lerro et al. (2018) and De Magistris et al. (2015) explored consumer willingness to pay for Corporate Social Responsibility (CSR), whereas Ruggieri et al. (2021) evaluated consumer willingness to pay for Fairtrade certification and verified the effect of information on consumer preferences for the social sustainability attribute. Fairtrade purchases were also studied by De Devitiis et al. (2008), Besnard et al. (2006) and in the case of coffee by Rotaris and Danielis (2011). Further studies concern specific products: fish (Menozzi et al., 2020; Carlucci et al., 2017; Mauracher et al., 2013), dairy (Scozzafava et al., 2020; Moro et al., 2015; Tempesta and Vecchiato, 2013; Vecchio et al., 2016), wine (Mazzocchi et al., 2019; Piracci et al., 2022; Pomarici et al., 2018), olive oil (Aprile et al., 2012) and beef (Napolitano et al., 2010).

5.1.3 Surveys on consumer perception of alternative cultivation systems

These surveys investigate consumer perception and preferences for alternative cultivation systems. Moser and Raffaelli (2012) investigated the preferences of apple consumers for alternative types of production,

such as organic, or those with integrated pest control or biocontrol agents. Besides preferring organic production, interviewees did not seem to perceive the potential benefits of other sustainable production methods. In fact, they were indifferent to indications on the label or even requested a discount for choosing a product with these characteristics. Consumers showed that they did not perceive the importance of production methods with low GHG emissions. Scarpa et al. (2007) analysed consumer preferences for different eco-sustainable production systems for carrots (organic, biodynamic, integrated pest management). Integrated pest management was preferred to biodynamics as an emerging method. However, consumers show a preference for organic products. Local production was also a popular attribute.

5.1.4 Consumer sensory surveys

The impact of sustainability information on consumer perception, in terms of liking and sensory properties, has been extensively studied by the sensory sciences (Aschemann-Witzel et al. 2019). Some studies have used the paradigm of expectations, comparing evaluation and tasting of a product under blind conditions. Comparison of evaluation based only on information (e.g. packaging) and on the product presented under informed conditions (tasting + information) showed that information on sustainability changes the perception of the product, increasing approval (Napolitano et al. 2007, Caporale and Monteleone, 2004). Information relating to sustainability has been found to impact liking and modify the perception of sensory properties, e.g. of salami (Hwang et al. 2021). It is clear that certain reasons for choosing food, such as concern for the environment, can underpin sustainable food choices, while others may raise barriers against sustainable choices (e.g. when sustainable food is perceived as less tasty or more expensive). These reasons and information can have different effects on product evaluation by different consumers (Proserpio et al., 2020). For example, in a study on yoghurt, information on sustainability only contributed to an increase in liking by subjects interested in sustainability or uncertain about it, but not by uninterested persons (Laureati et al., 2013). In fact, the importance assigned to sustainability is not the same for all consumers. The Sustainable Food Choice Questionnaire (SUS-FCQ) (developed by Verain et al., 2021) makes it possible to distinguish between the general importance of sustainability for an individual, considering environmental, ethical and animal welfare, and a concept of sustainability more linked to consumption of local and seasonal products, by means of a self-report questionnaire. This tool responds to the increasingly pressing need to distinguish consumers on the basis of individual differences.

From a methodological point of view, different sensorial methods can contribute to the study of sustainability perception and can be implemented to study expectations. Besides measuring consumer satisfaction, they can measure the latter's' perception of the sensory properties of products and how this is influenced by information provided or by beliefs. In the last ten years, several reliable protocols have been developed for increasingly direct involvement of consumers in the sensory description of products, especially in the development of "rapid methods" of guiding consumers to express acceptability and preferences, but also to indicate sensorial, cultural and affective drivers of choice (Delarue, 2015), fundamental for designing

products. Besides intensity scales, other effective methods include Check-All-That-Apply (CATA) (Vigneau et al., 2022) which provides elements for correlating product characteristics and preferences, and for segmenting consumers on this basis. The RATA (Rate-All-That-Apply) variant also evaluates selected elements (Vidal et al., 2018) and can be implemented by Penalty Analysis (Ares et al., 2014) which more precisely defines the dynamics of consumer satisfaction and is useful for creating or reformulating a product. To better investigate the interest in products and the relative importance of the attributes that characterize them, including economic and logistic aspects (packaging, purchasing methods...), Conjoint Analysis (Asioli et al., 2016) and/or Discrete Choice (DCE) models (Vass et al., 2017; Predieri et al., 2018) can be used. There are also quick methods that can be proposed in person, where consumers complete answers to the questionnaires with tasting assessments, or remotely on expectations and preferences, "virtual" products, or assessments of products delivered to the home (Dinnella et al., 2021). Online or telephone surveys (by the CATI method) are useful for contacting large numbers of consumers, profiling them, segmenting them, then involving a selected group (e.g. those considered most "open" to trying a new food) in a second more operational phase. CATA has been used to determine consumer attitudes to sustainability-related aspects, such as packaging and food waste (Aschemann-Witzel et al., 2020). RATA has been used to study consumer preferences for various products, including those of the fruit and vegetable chain (Seninde et al., 2021). DCE has been used in research on the acceptability of bio-fortified apples (Kleine-Kalmer, et al., 2021) and Conjoint Analysis for evaluation of consumer perception of functional foods (Annunziata et al., 2013).

5.2 Production-side surveys

The recent literature on producer-side traceability revealed six lines of research on the Italian context.

5.2.1 Integration and identification of sustainability indicators to support agri-food companies

Poponi et al. (2022) investigated indicators to monitor progress and areas of intervention for a transition towards circular economic models for various food-sector operators. They created a dashboard that can be used at various spatial levels to guide the agri-food sector towards a circular economy and sustainable development. They identified 102 indicators from the literature, classified in three areas of sustainability (environment, economy and social sphere) and spatial dimensions (macro-meso-micro) in eight areas. The dashboard made it possible to highlight missing aspects related to 1) new indicators not covered by the tool; 2) new fields not yet explored in the literature; and 3) the need for cross-cutting indicators.

Gallo et al. (2021) analysed GIS infrastructure that manipulates heterogeneous traceability data collected along the food chain to calculate a dashboard of multidisciplinary indicators related to safety, cost and environmental sustainability. A real-world distribution process involving three batches of fresh fruit, handled and shipped by a logistics service provider in northern Italy, was analysed. The tool helped shed light on the impacts that occur during food distribution, enabling logistics and quality managers to make decisions, while improving consumer awareness of the shelf life and ecological footprint of the products.

Baudino et al. (2017) conducted a case study of two alternative fruit chains in a Piemonte production area. To enable a systematic approach and support for decision-making, they evaluated the environmental impact of two production chains (field and storage/warehouse phases) from a technical-operational point of view. The evaluation was conducted through interviews with producers, field and warehouse technicians and commercial managers, in order to highlight the strengths and weaknesses of the two systems. Life cycle assessment was used for the field system, and SWOT for the entire supply chain (field and warehouse management). Finally, TOWS analysis integrated the results of LCA and SWOT, making it possible to highlight development strategies.

5.2.2 Life cycle assessment (LCA) in the agri-food sector

Since this line of research is particularly active, we only cite a few of the most recent articles on supply chains. Del Borghi et al. (2018) investigated the environmental sustainability of legumes (peas, beans and chickpeas) produced in Italy by a major European agri-food company. This made it possible to guide the eco-design measures of the product-packaging system. The LCA approach made it possible to identify the environmentally critical points in the life cycle. Blanc et al. (2019) considered the environmental, economic and social aspects of the sustainability of bioplastics used in the fruit supply chain, with a case study on raspberry supply chains in north-western Italy. Life cycle costing (LCC), LCA and externalities assessment were used to evaluate impacts along the supply chain by an integrated approach. The results show that biobased plastic has a lower environmental and social impact than conventional plastics, whereas the latter are the best choice under a classical economic approach.

5.2.3 How supply chain operators and consumers perceive traceability

Tessitore et al. (2022) explored supply-chain-operator (HO.RE.CA) and consumer perception of traceability. Qian et al. (2020) evaluated the perception of traceability of various stakeholders in the agri-food chain, comparing different countries, including Italy.

5.2.4 Analysis of the economic impact of adopting traceability systems

Several studies have explored the costs and benefits possible from application of traceability systems. Asoli et al. (2014), for example, addressed the issue of costs/benefits in the field of fish processing; Urbano et al. (2020) investigated the design and validation of a traceability system, based on radio frequency identification (RFID), intended to solve the interconnection and cost implementation problems typical of traceability systems.

5.2.5 Impact of adopting traceability systems on production efficiency

One line of research analyses the application of traceability systems to increase various aspects of the efficiency of production systems, such as innovative traceability systems to increase the perceived value of the final product (Guido et al., 2020), production system efficiency, information management (Barge et al., 2013) and safety (Cocco and Mannaro, 2021). Other research concerns voluntary traceability systems in the

meat (Banterle et al., 2006), cheese (Mania et al., 2018), fruit and vegetable (Latino et al., 2022; Porto et al., 2014) and wine sectors (Stranieri et al., 2018).

5.2.6 Communication of traceability to consumers

Various researchers have examined the link between traceability and systems for communicating it to the consumer. For example, Tessitore et al. (2020) analysed the role of food labels in supporting consumer information on food traceability. Cortese et al. (2020) studied some Italian companies to determine whether they conceived and used social media for disseminating and amplifying their sustainability, responsibility and traceability results. Penco et al. (2021) recently looked at the efficiency of new technologies for traceability communication.

6. Step 4: User-friendly database

The main objective of Step 4 is to develop an integrated user-friendly database, to include in the METRIQA digital information platform containing the databases produced in Steps 2 and 3. This integrated database should provide data and indicators at any possible level of disaggregation and allow users to choose indicators and the level of analysis. The research on the state of the art for Step 4 was therefore aimed at agri-food products in the database literature and at web and stand-alone software systems containing information on products of interest. In-depth literature analysis did not reveal many appropriately maintained databases that disseminate information on the products of the agri-food supply chains identified in the study, namely: olive oil, wine, dairy and cereals. The data was approximate and the results dated, heterogeneous, redundant and unstructured. This underlines the need for innovation in the agri-food sector. However, the examples listed below can be considered a basis.

Wine sector: https://vitisdb.it and http://www.vinium.it/elenco-docg-doc.php. *The numbers of wine* (http://www.inumeridelvino.it) contains databases on import, export, production statistics, consumption and financial data on wine by product and at different spatial and temporal scales.

Olive-oil sector: http://www.cerealab.unimore.it/jws/cerealab.jnlp

Various sectors: Data warehouse CREA-PB (http://aries.crea.gov.it:8080/dwh-inea/) is a data warehouse created by the Agricultural Research and Analysis Council (CREA). It allows fast interactive analysis of large quantities of data on agricultural production by product groups, agricultural production by region and product, production, intermediate consumption and added value, main intermediate consumption of agriculture, added value of the food industry, food industry employees, credit, agricultural machinery, registrations, expenditure by the Regions on agriculture, and persons employed in agriculture.

Agrifood Monitor (https://www.agrifoodmonitor.it) is the first online platform on the Italian agri-food chain. It provides figures and skills to companies and policy-makers and market intelligence solutions to support strategic decisions of companies and the entire supply chain. It contains reports (which can be downloaded but not queried or filtered) on markets, production, market structure and financial performance and on

consumption preferences. The Agrifood Monitor is promoted and coordinated by Nomisma in partnership with CRIF S.p.A. The FAO John Hopkins and GAIN Site (https///www.foodsystemsdashboard.org/) is of similar structure and relevant to environmental and agro-industrial data, not solely for Italy.

On holdings: the Veterinary Information System (https:///www.vetinfo.it/) was created at the request of the Ministry of Health to collect and present health and other data useful for the National System of Animal Health and Food Safety, with particular attention to the definition of health risks throughout the production chain, from the production of animal feed to the marketing of food for human consumption. The statistical calculations for livestock concern the data recorded (by census) in the National Database of the Livestock Registry (BDN) for the different animal species. The information is shown in reports with interactive graphs. Using buttons and links, users can filter the data, highlight that of interest and export it to Excel or CSV files. Various indicators are reported on a regional basis. The portal also contains maps showing geographical data in relation to statistical data.

On sustainability: the Yearbook of environmental data (https:///annuario.isprambiente.it) contains environmental data, statistics and information on the state of the environment in Italy. It is created and curated by the Institute for Environmental Protection and Research (ISPRA) in collaboration with regional agencies and autonomous provinces in the National System for Environmental Protection (SNPA). It describes the conditions of environmental matrices such as air, soil, water and biodiversity, and the time trends of different phenomena by sector. The data is mostly in databases that admit searches with filters by region, year and sector.

Our study of the literature and the web showed that collating and disseminating information has been neglected, as have been integrated databases on agricultural production and the food industry, both in general and in relation to the sectors identified as of interest.

7. Towards implementation of the step-by-step-procedure

From our analysis of the literature and data sources undertaken in previous sections, we were able to develop steps to meet the needs of stakeholders and consumers in the agri-food sector. We report some examples.

7.1 Example of Step 1

Below is a summary of the results obtained by the first focus group. Five participants (indicated by letters) and a moderator took part:

R - small farm;

S - small farm;

B – wine producing company, involved in some research projects;

C - medium-sized company;

E – university agri-food researcher.

The key points emerging from group discussion were:

- poor (if any) participant knowledge of data sources
- adoption of good practices depends on economic feedback ("there are significant expenses").

The transcript of the discussion was analysed by quantitative methods, namely such as adjacency matrix and LDA (Latent Dirichlet Allocation). The adjacency matrix is a valuable technical tool for assessing the level of interaction within a focus group. It takes the form of an n x n square matrix, where n is the total number of participants in the focus group. The matrix provides a standard approach for depicting relationships between actors. Table 2 shows the adjacency matrix of focus group 1.

Table 2- Adjacency matrix Focus Group 1

	R	S	B	C	E	Tot. Emissions
R		1	0	7	0	8
S	1		0	1	0	2
B	0	0		2	0	2
C	7	1	1		2	11
E	1	0	0	2		3
Tot. Receptions	9	2	1	12	2	

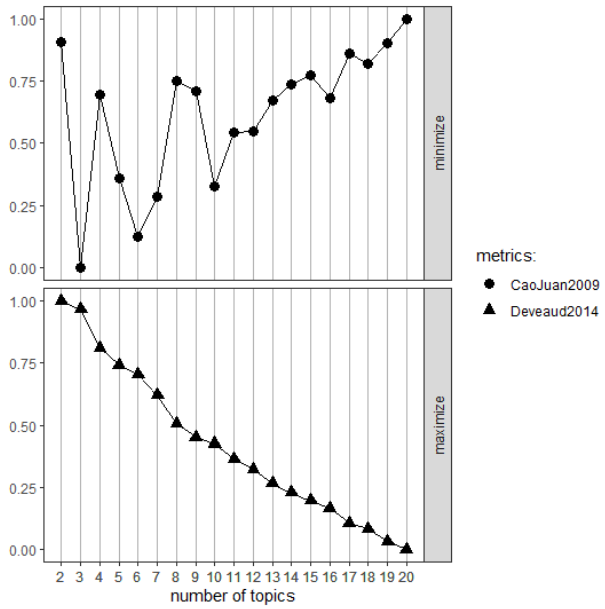
The adjacency matrix shows that C took a leading role in the discussion, with 11 emissions and 9 receptions, most of which were with R. The two subjects were from medium-sized companies, run by a few employees, and both demonstrated a knowledge of sustainable practices. The discussion involved few interactions between participants, who often only responded in turn to the moderator.

In LDA it is assumed that the corpus is divided into a series of documents, and that there are k latent topics on which documents are generated. Each topic is represented as a multinomial distribution over words in the documents. A document is generated sampling a mixture of these topics and then sampling words from that mixture. Since the multinomial distribution that generates the documents cannot be observed, in order to make inferences on the distribution, a conjugated distribution is used, i.e. the distribution of Dirichlet. From inference on the parameters of the Dirichlet distribution we can evaluate the latent themes that generate the corpus of documents. This model provides a membership function where each word belongs with a certain probability to each theme. The result of the procedure is an estimation of conditional probability. Various algorithms are used to simulate sampling from the Dirichlet distribution, many are Monte Carlo methods based on the Markov Chain (MCMC), that estimate parameters by searching for the steady state of the Markov chain. We used a method of this type, namely the Gibbs sampling method. One of the parameters that must be decided *a priori* to implement the LDA is the number of topics. To estimate this number, we used the CaoJuan and the Griffith methods, which are complementary.

The first is a measure of similarity between possible word clusters; it optimizes the number of themes through the minimum of the similarity index. The second method is based on the distance between possible words-

clusters, where the optimal number of themes corresponds to the maximum distance. For this task, all procedures were implemented with R software, TM package. For an in-depth discussion of the methods used, see Blei et al. (2003). Figure 1 shows that the estimated number of themes (topics) converges to 2, although the moderator's aim was to generate interactions on many more themes.

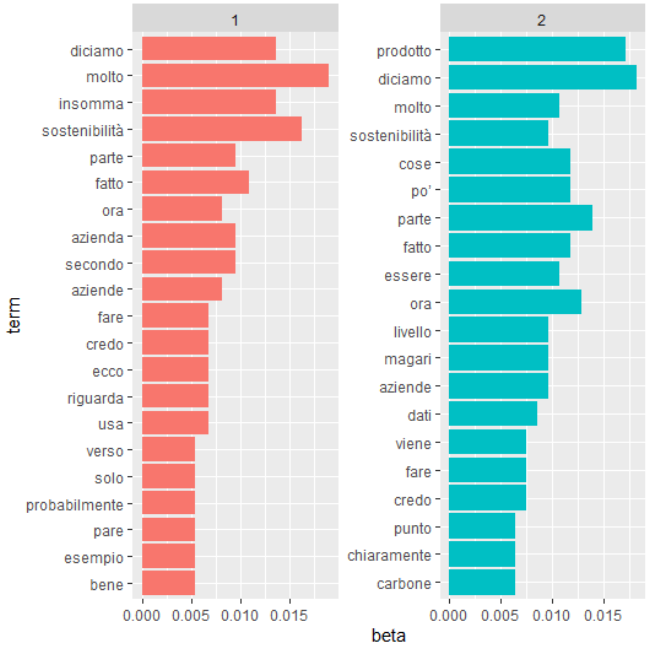
Figure 1 - Estimation of topics by the methods of CaoJuan 2009 and Deveaud 2014



To define these two topics, the LDA procedure was implemented (number of themes = 2) aimed at identifying the latent themes of the corpus (results in Figure 2). "Sustainability" is most likely attributed to topic 1, which seems to be characterized by a discussion of what the participants believe (considering the frequency of terms such as "believe", "say", "according to me") without any concrete references.

Topic 2, on the other hand, was characterized by more concrete interventions, linked to personal experience or knowledge (see terms such as "product" and "coal"), linked to the theme of measurement ("data", "level"). The number of latent themes and their characterization reflects and refines the qualitative analysis of transcription. The corpus can be divided into two parts. The first shows that companies lack knowledge of sustainability issues and try to give the topic a subjective meaning (topic 1). The second shows a desire to monitor aspects that are considered in some way related to sustainability, through reporting of personal experience, but only towards improvement of productive performance ("product").

Figure 2- LDA procedures for the Focus Group 1 transcript corpus



7.2 Example of Step 2

After identifying and organizing the information available on the Italian agri-food system, we used the following framework to construct the first database and develop shared indicators for monitoring the agri-food sector in Italy.

The online secondary sources we identified were of three types:

1. datasets with microdata (sets of records containing information on enterprises or small territorial aggregates) from which information, such as ISTAT provincial crop data (http://dati.istat.it/Index.aspx?QueryId=37850) or RICA (https://rica.crea.gov.it/ricercatori-751.php), can be downloaded;
2. datasets, such as the Database of structural agricultural indicators RNN-ISMEA (https://www.ismeamercati.it/flex/FixedPages/IT/IndicatoriDati.php/L/IT/ID/ALL001/SEZ/A2) from which individual or group indicators at all levels of territorial detail, developed from microdata absent from the dataset, can be downloaded;
3. a) Tables (often in pdf format) by theme or territorial level, such as those on the site of the National System for the Protection of the Environment (https://www.snpambiente.it/2022/07/26/consumo-di-suolo-nel-2021-il-valore-piu-alto-degli-ultimi-10-anni/) that can be downloaded; b) Reports containing the tables of point a, such as National emission inventory (province level) on the ISPRA site (https://www.isprambiente.gov.it/contentfiles/00003600/3620-rapporto-85-2008-inventario-nazionale-agricoltura-alta.pdf/), which can only be downloaded in full.

The types of data in points 1 and 2 are not frequent, while those of points 3a and 3b are frequent and very frequent, respectively. The heterogeneity and fragmentation of the sources is evident, and the content shows a lack of homogeneity in the definitions and methods of detection. Once the data sources have been identified, they are selected on the basis of the possibility of harmonising the data to obtain indicators with the properties required by international regulations. Table 3 describes the desirable properties (with their definitions) of indicators according to the literature and international standards.

Table 3 – Properties of statistical indicators

Property	**Definition**	**Source**
Accessibility	Accessibility refers to the general conditions under which users can access statistical information.	Accessibility Statement https://ec.europa.eu/eurostat/about/policies/accessibility
Accuracy	The accuracy of statistical information is the degree of correctness with which the information describes the phenomena for which it was designed.	OECD (2006) https://stats.oecd.org/glossary/detail.asp?ID=21
Clarity	Clarity refers to how readily a source's indicators and underlying data are clear and understandable to users.	European Commission (2014); https://www.agenziacoesione.gov.it/wp-content/uploads/2021/02/CPT_AnalisiDEFR.pdf
Coherence	Indicators should be logical and consistent. complementary and coherent	Eurostat (2014)
Comparability	the quality of being similar and able to be compared between different geographical areas, non-geographical domains or periods; comparability may be temporal or internal.	Eurostat (2017); OECD (2008); https://www.agenziacoesione.gov.it/wp-content/uploads/2021/02/CPT_AnalisiDEFR.pdf
Feasibility	The data needed to define an indicator must be available for measurement, replication and updating.	Committee for Fair and Sustainable Welfare Indicators (2017); https://www.agenziacoesione.gov.it/wp-content/uploads/2021/02/CPT_AnalisiDEFR.pdf
Measurability	The indicator should be measured effectively and practically from a cost-benefit perspective. A regular data collection mechanism should be able to be developed at a reasonable cost.	Eurostat (2014)

Parsimony	Indicators should reflect the simplest scientific explanation that fits the evidence.	Eurostat (2014)
Relevance	The indicator should provide a representative picture of the phenomenon it describes, and in the case of performance indicators, is clearly linked to the objective it intends to measure. It must be sensitive to changes and to the actions implemented. It provides a basis for international comparisons and reflects time trends. It is easy for policy makers, the general public and other stakeholders to understand.	Eurostat (2014)
Sensitivity to economic policies	Indicators for the evaluation of public policies should reflect the effects of such policies, possibly within a three-year period, or the reference horizon of public finance documents.	Committee for Fair and Sustainable Welfare Indicators (2017); https://www.agenziacoesione.gov.it/wp-content/uploads/2021/02/CPT_AnalisiDEFR.pdf
Specificity	Indicators should measure a particular set of governance institutions or a defined output, such as that of an agri-food supply chain.	Eurostat (2017)
Timeliness, extent and frequency of time series	The timeliness of data reflects the time lag between its availability and the event or phenomenon it describes. The time context should allow the information to be valuable and usable.	(OECD, 2008); https://www.agenziacoesione.gov.it/wp-content/uploads/2021/02/CPT_AnalisiDEFR.pdf
Transparency	The proposed indicators should be replicable by a well-documented process and the data should come from official sources.	Committee for Fair and Sustainable Welfare Indicators (2017); https://www.agenziacoesione.gov.it/wp-content/uploads/2021/02/CPT_AnalisiDEFR.pdf

7.3 Example of Steps 3 and 4

These two steps are still being developed. Surveys representative of consumers and producers at national level will be implemented. In the meantime a Relational Data Base Management System will be created for the information collected.

Figure 3 – Structure of the online dashboard

8. The first smart database for agri-food products: a pilot study

SmartAgrifoodDB is an intuitive integrated database that sprang from the need to provide information and indicators on agri-food and its sustainability. Our search of the literature showed a lack of such databases designed to collect and publish information on agri-food supply chains. However, stakeholders require that: i) information on origin and the supply chain from production to distribution be traceable and accessible to consumers; ii) the plethora of information stored in hard copy archives be transformed into digital format. The agri-food web is in its infancy, and *SmartAgriFoodDB* is the first pilot study to address the Italian market. In promoting a major sector of the national economy, it enhances the agri-food sector and the transparency of final products.

8.1 *SmartAgrifoodDB, the first RDBMS in the agri-food sector*

To develop good software, it is essential to do correct requirements analysis. A glance at the main literature showed that the data in question was difficult to manage, being scanty, approximate, dated, heterogeneous, redundant and above all unstructured. The lack of a single integrated recipient for the information on agri-food products such as olive oil-oil (1), viticulture (2,3,4), dairy and cereals (5,6) guided the first steps of our project towards a "Relational DataBase Management System" (RDBMS), structured in tables with relationships organized in data sets.

SmartAgriFoodDB is a dynamic web-oriented RDBMS, representing an innovation in the agri-food sector, since its relational architecture accepts all information on agri-food products with the following characteristics:

- relational: data is related and shared at many levels, i.e. within and between supply chains;

- scalable: maintaining performance as the amount of data stored/archived increases/decreases;
- consistent: data meaningfully and effectively usable in business applications;
- safe: the database must be designed in such a way as to prevent damage to software and hardware;
- intact: the database must be capable of guaranteeing data conservation without loss;
- cloud: the systems allow the database to exploit the cloud computing paradigm.

Implementing a tool of this kind means separately developing its two sides (usually denoted as *back-end* and *front-end*) that are later interfaced. The *back-end* or *back-office* is implemented first. At different levels it includes all the data structures contained in the project and all the specific functions for their management. In practice, the *back-office* is everything that the user cannot see but which creates outputs in response to his dynamic requests. Conversely, the *front-end* is the part visible to the user, namely all the information retrieved from the database, suitably structured by the programmer and displayed as output for the user.

9. Concluding remarks

In this paper we present an innovative method for integrating new technological and methodological systems of statistical indicators of traceability, quality and safety of agri-food chains in Italy by means of a step-by-step procedure. The method is supported by an analysis of the literature. The purpose of the integrated databases is to provide support for citizens, institutions, firms and policy makers. The level of analysis ranges from national, to regional and if possible local. It will contain specific case studies at local level or for specific food chains. A strength of the proposed method is that it can be readily extended to international level.

References

1. Ahumada O., Villalobos J.R. (2009). Application of planning models in the agri-food supply chain: A review. Eur J Oper Res, 196, 1–20. https://doi.org/10.1016/j.ejor.2008.02.014.
2. Altamore, L., Bacarella, S., Columba, P., Chironi, S., & Ingrassia, M. (2017). The Italian consumers' preferences for pasta: Does environment matter? Chemical Engineering Transactions, 58, 859–864. https://doi.org/10.3303/CET1758144
3. Anderson, K. and G. Puga (2021), Database of South Australian Winegrape Vine Area, Crush, Price, and Per Hectare Yield and Value of Production, by Region and Variety, 2001 to 2021, Wine Economics Research Centre, University of Adelaide, December. https://economics.adelaide.edu.au/wine-economics/databases
4. Annunziata, A.; Vecchio, R. Consumer perception of functional foods: A conjoint analysis with probiotics. Food Qual. Prefer. 2013, 28, 348–355.
5. Aprile, M. C., Caputo, V., & Nayga, R. M. (2012). Consumers' valuation of food quality labels: The case of the European geographic indication and organic farming labels. International Journal of Consumer Studies, 36(2), 158–165. https://doi.org/10.1111/j.1470-6431.2011.01092.x
6. Ares, G., Dauber, C., Fernandez, E., Gimenez, A., & Varela, P. (2014). Penalty analysis based on CATA questions to identify drivers of liking and directions for product reformulation. Food Quality and Preference, 32, 65–76. https://doi.org/10.1016/j.foodqual.2013.05.014
7. Aschemann-Witzel, J., Ares, G., Thøgerse, J. Monteleone, E. (2019), A sense of sustainability? – How sensory consumer science can contribute to sustainable development of the food sector, Trends in Food Science & Technology 90, 180–186.
8. Aschemann-Witzel, J., Otterbring, T., De Hooge, I. E., Normann, A., Rohm, H., Almli, V. L., et al. (2020). Consumer Associations about Other Buyers of Suboptimal Food – and what it Means for Food Waste Avoidance Actions. Food Qual. and Prefer. 80, 103808. doi:10.1016/j.foodqual.2019.103808
9. Asioli, D., Boecker, A., & Canavari, M. (2014). On the linkages between traceability levels and expected and actual traceability costs and benefits in the Italian fishery supply chain. Food Control, 46, 10-17.
10. Asioli, D., T. Næs, A. Øvrum, V.L. Almli. Comparison of rating-based and choice-based conjoint analysis models. A case study based on preferences for iced coffee in Norway. Food Quality and Preference, 48 (2016), pp. 174-184, 10.1016/j.foodqual.2015.09.007
11. Banterle, A., Stranieri, S., & Baldi, L. (2006). Voluntary traceability and transaction costs: an empirical analysis in the Italian meat processing supply chain (No. 737-2016-50864).
12. Barge, P., Gay, P., Merlino, V., & Tortia, C. (2013). Radio frequency identification technologies for livestock management and meat supply chain traceability. Canadian Journal of Animal Science, 93(1), 23-33.
13. Baudino, C., Giuggioli, N. R., Briano, R., Massaglia, S., & Peano, C. (2017). Integrated methodologies (SWOT, TOWS, LCA) for improving production chains and environmental sustainability of kiwifruit and baby kiwi in Italy. Sustainability, 9(9), 1621.
14. Bazzani, C., Caputo, V., Nayga, R. M., & Canavari, M. (2017). Revisiting consumers' valuation for local versus organic food using a non-hypothetical choice experiment: Does personality matter? Food Quality and Preference, 62, 144–154. https://doi.org/10.1016/j.foodqual.2017.06.019
15. Bazzani, C., Capitello, R., Ricci, E. C., Scarpa, R., & Begalli, D. (2020). Nutritional knowledge and health consciousness: Do they affect consumer wine choices? evidence from a survey in Italy. Nutrients, *12*(1), 84. https://doi.org/10.3390/nu12010084
16. Besnard F., Maietta O.W., D'Alessio M. (2006), "Le motivazioni all'acquisto dei prodotti del Commercio Equo e Solidale: un'analisi comparata sui consumatori delle botteghe del mondo in Emilia Romagna e in Campania", Economia agro-alimentare, 2, pp. 131-170.

17. Blanc, S., Massaglia, S., Brun, F., Peano, C., Mosso, A., & Giuggioli, N. R. (2019). Use of bio-based plastics in the fruit supply chain: An integrated approach to assess environmental, economic, and social sustainability. Sustainability, 11(9), 2475.
18. Blasi, E., Monotti, C., Ruini, L., Landi, C., Avolio, G., & Meriggi, P. (2015). Eco-innovation as a driver in the agri-food value chain: An empirical study on durum wheat in Italy. Journal on Chain and Network Science, 15(1), 1–15. https://doi.org/10.3920/JCNS2014.x014
19. Blei, M., Andrew, Y., Jordan, M.I. (2003). Latent Dirichlet Allocation. Journal of Machine Learning Research 3, 993-1022.
20. Canavari, M., & Coderoni, S. (2020). Consumer stated preferences for dairy products with carbon footprint labels in Italy. *Agricultural and Food Economics*, *8*(1), 1–16. https://doi.org/10.1186/s40100-019-0149-1
21. Caporale, G., Monteleone, E. (2004), Influence of information about manufacturing process on beer acceptability, Food Quality and Preference, 15, 3.
22. Carlucci, D., De Devitiis, B., Nardone, G., & Santeramo, F. G. (2017). Certification labels versus convenience formats: What drives the market in aquaculture products? *Marine Resource Economics*, *32*(3), 295–310. https://doi.org/10.1086/692091
23. Cocco, L., & Mannaro, K. (2021, March). Blockchain in agri-food traceability systems: A model proposal for a typical Italian food product. In 2021 IEEE International Conference on Software Analysis, Evolution and Reengineering (SANER) (pp. 669-678). IEEE.
24. Corrao S., (2000). *Il Focus Group*, Franco Angeli, 2000.
25. Cortese, D., Rainero, C., & Cantino, V. (2020). Stakeholders' social dialogue about responsibility and sustainability in the food sector. *British Food Journal*.
26. Cosmina, M., Gallenti, G., Marangon, F., & Troiano, S. (2016). Reprint of "Attitudes towards honey among Italian consumers: A choice experiment approach." *Appetite*, *106*, 110–116. https://doi.org/10.1016/j.appet.2016.08.005
27. Crovato, S., Mascarello, G., Marcolin, S., Pinto, A., & Ravarotto, L. (2019). From purchase to consumption of bivalve molluscs: A qualitative study on consumers' practices and risk perceptions. *Food Control*, *96*(June 2018), 410–420. https://doi.org/10.1016/j.foodcont.2018.09.040
28. De Magistris, T., Del Giudice, T., & Verneau, F. (2015). The Effect of Information on Willingness to Pay for Canned Tuna Fish with Different Corporate Social Responsibility (CSR) Certification: A Pilot Study. *Journal of Consumer Affairs*, *49*(2), 457–471. https://doi.org/10.1111/joca.12046
29. Delarue, J. 2015. The use of rapid sensory methods in R&D and research: an introduction. In: Julien Delarue, Ben Lawlor and Michel Rogeaux eds. Rapid Sensory Profiling Techniques and Related Methods. 3-25. Elsevier. Amsterdam.
30. De Devitiis B., D'Alessio M., Maietta O.W. (2008), "A comparative analysis of the purchase motivations of Fair-Trade products: the impact of social capital", 12th Congress of the European Association of Agricultural Economists, pp. 14. defra (ed.) (2002), The strategy for sustainable farming and food, defra Publication, London, UK.
31. Del Borghi, A., Strazza, C., Magrassi, F., Taramasso, A. C., & Gallo, M. (2018). Life Cycle Assessment for eco-design of product–package systems in the food industry—The case of legumes. Sustainable Production and Consumption, 13, 24-36.
32. Dinnella, C; Pierguidi, L; Spinelli, S; Borgogno, M; Toschi, TG; Predieri, S; Lavezzi, G; Trapani, F; Tura, M; Magli, M; Bendini, A; Monteleone, E. Remote testing: Sensory test during Covid-19 pandemic and beyond. (2021) Food Quality and Preference, 96, 104437
32. Fitzsimmons, J., & Cicia, G. (2018). Different tubers for different consumers: Heterogeneity in human values and willingness to pay for social outcomes of potato credence attributes. *International Journal on Food System Dynamics*, *9*(4), 354–374. https://doi.org/10.18461/ijfsd.v9i4.946
33. Gallenti, G., Troiano, S., Marangon, F., Bogoni, P., Campisi, B., & Cosmina, M. (2019). Environmentally sustainable versus aesthetic values motivating millennials' preferences for

wine purchasing: evidence from an experimental analysis in Italy. Agricultural and Food Economics, 7(1). https://doi.org/10.1186/s40100-019-0132-x

34. Galli, F., F. Bartolini, G. Brunori, L. Colombo, O. Gava, S. Grando, A. Marescotti. 2015. Sustainability assessment of food supply chains: An application to local and global bread in Italy. Agricultural and Food Economics 3 (1): 749. https:// doi. org/10. 1186/ s40100- 015- 0039-0.
35. Gallo, A., Accorsi, R., Goh, A., Hsiao, H., & Manzini, R. (2021). A traceability-support system to control safety and sustainability indicators in food distribution. Food Control, 124, 107866.
36. Guido, R., Mirabelli, G., Palermo, E., & Solina, V. (2020). A framework for food traceability: case study–Italian extra-virgin olive oil supply chain. International Journal of Industrial Engineering and Management, 11(1), 50.
37. Hwang J, Lee S, Jo M, Cho W, Moon J. The Effect of Sustainability-Related Information on the Sensory Evaluation and Purchase Behavior towards Salami Products. Food Sci Anim Resour. 2021 Jan;41(1):95-109. doi: 10.5851/kosfa.2020.e83. Epub 2021 Jan 1. PMID: 33506220; PMCID: PMC7810397.
38. Ingrassia, M., Chironi, S., Grasso, G. Lo, Gristina, L., Francesca, N., Bacarella, S., … Altamore, L. (2022). Is Environmental Sustainability Also "Economically Efficient"? The Case of the "SOStain" Certification for Sicilian Sparkling Wines. *Sustainability (Switzerland)*, *14*(12). https://doi.org/10.3390/su14127359
39. Janssen, M., & Hamm, U. (2012). Product labelling in the market for organic food: Consumer preferences and willingness-to-pay for different organic certification logos. Food Quality and Preference, 25(1), 9–22. https://doi.org/10.1016/j.foodqual.2011.12.004
40. Kleine-Kalmer, R.; Profeta, A.; Daum, D.; Enneking, U. Pre-Launch Exploration of Consumer Willingness to Purchase Selenium- and Iodine-Biofortified Apples—A Discrete Choice Analysis of Possible Market Settings. Nutrients 2021, 13, 1625. https://doi.org/10.3390/nu13051625
41. Laureati, M,, Jabes, D., Russo, V. , Pagliarini, E. (2013), Sustainability and organic production: How information influences consumer's expectation and preference for yogurt, Food Quality and Preference, 30, 1.
42. Latino, M. E., Menegoli, M., Lazoi, M., & Corallo, A. (2022). Voluntary traceability in food supply chain: a framework leading its implementation in Agriculture 4.0. Technological Forecasting and Social Change, 178, 121564.
43. Lerro, M., Caracciolo, F., Vecchio, R., & Cembalo, L. (2018). Consumer's Side of Corporate Social Responsibility: A Nonhypothetical Study. Journal of Consumer Affairs, 52(3), 689–710. https://doi.org/10.1111/joca.12182
44. Mania, I., Delgado, A. M., Barone, C., & Parisi, S. (2018). The ExTra tool—A practical example of extended food traceability for cheese productions. In Traceability in the Dairy Industry in Europe (pp. 29-66). Springer, Cham.
45. Mauracher, C., Tempesta, T., & Vecchiato, D. (2013). Consumer preferences regarding the introduction of new organic products. The case of the Mediterranean sea bass (Dicentrarchus labrax) in Italy. Appetite, 63, 84–91. https://doi.org/10.1016/j.appet.2012.12.009
46. Mazzocchi, C., Ruggeri, G., & Corsi, S. (2019). Consumers' preferences for biodiversity in vineyards: A choice experiment on wine. Wine Economics and Policy, 8(2), 155–164. https://doi.org/10.1016/j.wep.2019.09.002.
47. Mehrabi, S.; Perez-Mesa, J.C.; Giagnocavo, C. (2022). The Role of Consumer-Citizens and Connectedness to Nature in the Sustainable Transition to Agroecological Food Systems: The Mediation of Innovative Business Models and a Multi-Level Perspective. Agriculture, 12, 203. https://doi.org/10.3390/agriculture12020203.
48. Menozzi, D., Nguyen, T. T., Sogari, G., Taskov, D., Lucas, S., Castro-Rial, J. L. S., & Mora, C. (2020). Consumers' preferences and willingness to pay for fish products with health and environmental labels: Evidence from five european countries. Nutrients, 12(9), 1–22. https://doi.org/10.3390/nu12092650
49. Merlino, V. M., D. Borra, V. Girgenti, A. Dal Vecchio, and S. Massaglia. "Beef meat preferences of consumers from Northwest Italy: Analysis of choice attributes." Meat science 143 (2018): 119-128.

50. Milc J, Sala A, Bergamaschi S, Pecchioni N. A genotypic and phenotypic information source for marker-assisted selection of cereals: the CEREALAB database. Database (Oxford). 2011 Jan 18;2011:baq038. doi: 10.1093/database/baq038. PMID: 21247929; PMCID: PMC3025694.
51. Morgan, D. L. (1996). *Focus groups as qualitative research Morgan, David L. 1996. Thousand Oaks, CA: Sage Publications.* (Vol. 16). Sage publications.
52. Morgan, D. L. (2018). Living Within Blurry Boundaries: The Value of Distinguishing Between Qualitative and Quantitative Research. *Journal of Mixed Methods Research*, *12*(3), 268–279. https://doi.org/10.1177/1558689816686433
53. Moro, D., Veneziani, M., Sckokai, P., & Castellari, E. (2015). Consumer Willingness to Pay for Catechin-enriched Yogurt: Evidence from a Stated Choice Experiment. Agribusiness, 31(2), 243–258. https://doi.org/10.1002/agr
54. Moser, R., & Raffaelli, R. (2012). Consumer preferences for sustainable production methods in apple purchasing behaviour: A non-hypothetical choice experiment. International Journal of Consumer Studies, 36(2), 141–148. https://doi.org/10.1111/j.1470-6431.2011.01083.x
55. Napolitano, F., Braghieri, A., Piasentier, E., Favotto, S., Naspetti, S., & Zanoli, R. (2010). Effect of information about organic production on beef liking and consumer willingness to pay. Food Quality and Preference, 21(2), 207–212. https://doi.org/10.1016/j.foodqual.2009.08.007
56. Napolitano, F., Caporale, G., Carlucci, A., Monteleone, E. (2007) Effect of information about animal welfare and product nutritional properties on acceptability of meat from Podolian cattle, Food Quality and Preference, 18,2.
57. Penco, L., Serravalle, F., Profumo, G., & Viassone, M. (2021). Mobile augmented reality as an internationalization tool in the "Made In Italy" food and beverage industry. Journal of Management and Governance, 25(4), 1179-1209.
58. Piracci, G., Boncinelli, F., & Casini, L. (2022). Wine consumers' demand for social sustainability labeling: Evidence for the fair labor claim. Applied Economic Perspectives and Policy, 1–20. https://doi.org/10.1002/aepp.13260
59. Pomarici, E., Asioli, D., Vecchio, R., & Næs, T. (2018). Young consumers' preferences for water-saving wines: An experimental study. Wine Economics and Policy, 7(1), 65–76. https://doi.org/10.1016/j.wep.2018.02.002
60. Porto, S. M., Arcidiacono, C., Anguzza, U., & Cascone, G. (2014). Development of an information system for the traceability of citrus-plant nursery chain related to the Italian National Service for Voluntary Certification. Agricultural Engineering International: CIGR Journal, 16(2), 208-216.
61. Predieri S, Sotis G, Rodinò P et al (2018) Older adults involvement in developing satisfactory pasta sauces with healthy ingredients. Br Food J 120:804–814
62. Proserpio C, Fia G, Bucalossi G, Zanoni B, Spinelli S, Dinnella C, Monteleone E, Pagliarini E. Winemaking Byproducts as Source of Antioxidant Components: Consumers' Acceptance and Expectations of Phenol-Enriched Plant-Based Food. Antioxidants. 2020; 9(8):661. https://doi.org/10.3390/antiox9080661
63. Qian, J., Ruiz-Garcia, L., Fan, B., Villalba, J. I. R., McCarthy, U., Zhang, B., ... & Wu, W. (2020). Food traceability system from governmental, corporate, and consumer perspectives in the European Union and China: A comparative review. Trends in Food Science & Technology, 99, 402-412.
64. Rotaris, L., & Danielis, R. (2011). Willingness to pay for fair trade coffee: A conjoint analysis experiment with Italian consumers. Journal of Agricultural and Food Industrial Organization, 9(1). https://doi.org/10.2202/1542-0485.1305
65. Ruggeri, G., Corsi, S., & Nayga, R. M. (2021). Eliciting willingness to pay for fairtrade products with information. Food Quality and Preference, 87, 104066. https://doi.org/10.1016/j.foodqual.2020.104066
66. Sacchi, G. (2018). The Ethics and Politics of Food Purchasing Choices in Italian Consumers' Collective Action. *Journal of Agricultural and Environmental Ethics*, *31*(1), 73–91. https://doi.org/10.1007/s10806-018-9710-2

67. Scarpa, R., Thiene, M., & Marangon, F. (2007). The value of collective reputation for environmentally-friendly production methods: The case of val di gresta. Journal of Agricultural and Food Industrial Organization, 5(1). https://doi.org/10.2202/1542-0485.1149
68. Scozzafava, G., Gerini, F., Boncinelli, F., Contini, C., Marone, E., & Casini, L. (2020). Organic milk preference: is it a matter of information? Appetite, 144. https://doi.org/10.1016/j.appet.2019.104477
69. Seninde, D.R.; Chambers, E., IV. Comparing the Rate-All-That-Apply and Rate-All-Statements Question Formats across Five Countries. Foods 2021, 10, 702. https://doi.org/10.3390/foods10040702
70. Stasi, A., Bimbo, F., Viscecchia, R., & Seccia, A. (2014). Italian consumers' preferences regarding dealcoholized wine, information and price. Wine Economics and Policy, 3(1), 54–61. https://doi.org/10.1016/j.wep.2014.05.002
71. Stranieri, S., Cavaliere, A., & Banterle, A. (2018). The determinants of voluntary traceability standards. The case of the wine sector. Wine Economics and Policy, 7(1), 45-53.
72. Tempesta, T., & Vecchiato, D. (2013). An analysis of the territorial factors affecting milk purchase in Italy. Food Quality and Preference, 27(1), 35–43. https://doi.org/10.1016/j.foodqual.2012.06.005
73. Tessitore, S., Iraldo, F., Apicella, A. A., & Tarabella, A. T. (2020). The link between food traceability and food labels in the perception of young consumers in Italy. International Journal on Food System Dynamics, 11(5), 425-440.
74. Tessitore, S., Iraldo, F., Apicella, A., & Tarabella, A. (2022). Food traceability as driver for the competitiveness in Italian food service companies. Journal of Foodservice Business Research, 25(1), 57-84.
75. TOLOMEO (2013). Filiere agroalimentari tra innovazione e tradizione, Rapporto Finale
76. Urbano, O., Perles, A., Pedraza, C., Rubio-Arraez, S., Castelló, M. L., Ortola, M. D., & Mercado, R. (2020). Cost-effective implementation of a temperature traceability system based on smart RFID Tags and IoT services. Sensors, 20(4), 1163.
77. Vass, C., Rigby, D., and Payne, K. (2017), "The Role of Qualitative Research Methods in Discrete Choice Experiments: A Systematic Review and Survey of Authors". Medical Decision Making. Vol. 37, pp. 298-313
78. Vecchio, R. (2013). Determinants of willingness-to-pay for sustainable wine: Evidence from experimental auctions. Wine Economics and Policy, 2(2), 85–92. https://doi.org/10.1016/j.wep.2013.11.002
79. Vecchio, R., Van Loo, E. J., & Annunziata, A. (2016). Consumers' willingness to pay for conventional, organic and functional yogurt: Evidence from experimental auctions. International Journal of Consumer Studies, 40(3), 368–378. https://doi.org/10.1111/ijcs.12264
80. Vecchio, R. (2011). Italian and United States Farmers' Markets: Similarities, Differences and Potential Developments. Journal of Food Products Marketing, 17(2-3), 386-406. https://doi.org/10.1080/10454446.2011.548751
81. Verain, C.D.M., Snoek, H.M., Onwezen, M.C., Reinders, M.J., Bouwman, E.P. (2021), Sustainable food choice motives: The development and cross-country validation of the Sustainable Food Choice Questionnaire (SUS-FCQ), Food Quality and Preference, 93, 104267.
82. Vidal, L.; Ares, G.; Hedderley, D.I.; Meyners, M.; Jaeger, S.R. Comparison of rate-all-that-apply (RATA) and check-all-that-apply (CATA) questions across seven consumer studies. Food Qual. Prefer. 2018, 67, 49–58.
83. Vigneau, E., Cariou, V., Giacalone, D., Berget, I., & Llobell, F. (2022). Combining hedonic information and CATA description for consumer segmentation. Food Quality and Preference, 95, 104358. https://doi.org/10.1016/j.foodqual.2021.104358

Annex. Table 1

Nome database	Fonte	Anno	Serie storica	Frequenza di rilevamento	Dettaglio territoriale	Tipo di rilevazione	Ambito di pertinenza	Tipologia dati	Obiettivo PAC
7° Censimento dell'agricoltura	ISTAT	2020	1961-2020	10 Anni	Comunale	Universale	Agricoltura	Superfici, Allevamenti, Impresa, Ambientali, Sociali	1,2,3,5,7, 8
RICA	CREA	2020	2008-2020	Annuale	Nazionale/Regionale	Campionaria	Agricoltura	Superfici, Allevamenti, Impresa, Input, Produzioni, Commercio, Ambientali, Sociali	1,2,3,5,7, 8
REA	ISTAT	2016	n.d.-2018	Annuale	Nazionale/Regionale	Campionaria	Agricoltura	Superfici, Allevamenti, Impresa, Input, Produzioni, Commercio, Ambientali, Sociali	1,2,3,5,7, 8
Coltivazioni e allevamenti	ISTAT	2022	n.d.-2022	Annuale/Mensile	Provinciale	Campionaria -Stime- Universale	Agricoltura	Superfici, Allevamenti, Impresa, Input, Produzioni	1,2,3,8,9
Prodotti di qualità e agriturismo	ISTAT	2017	2014-2017	Annuale	Provinciale	Universale	Agricoltura e agroindustria	Impresa, Produzioni, Sociali	2,3,6,8,9
Mezzi di produzione	ISTAT	2021	2003-2021	Annuale	Provinciale	Universale	Agricoltura	Input	4,5
ASIA	ISTAT	2020	1996-2020	Annuale	Regionale	Universale	Agroindustria	Impresa, Sociali	2,8
ASIA agricoltura	ISTAT	2018	2017-2018	Annuale	Regionale	Universale	Agricoltura	Impresa, Sociali	2,8
Prezzi	Camera di Commercio	2022	2020-2022	Settimanale /Mensile	Provinciale	Campionaria	Agricoltura e agroindustria	Commercio	1,2,3
Prezzi dei prodotti agricoli	ISTAT	2022	2017-2022	Mensile	Nazionale	Campionaria	Agricoltura	Commercio	1,2,3
Spese per Consumi delle Famiglie	ISTAT	2021	1997-2021	Annuale	Regionale	Campionaria	Agricoltura e agroindustria	Consumi	9
IRI	IRI	2022	n.d.-2022	Mensile	Regione	Universale	Agricoltura e agroindustria	Consumi	9
Nielsen	Nielsen	2022	n.d.-2022	Mensile	Regione	Universale	Agricoltura e agroindustria	Consumi	9

Coeweb	ISTAT	2022	1991-2022	Mensile	Provinciale	Universale	Agricoltura e agroindustria	Commercio	2,3
BES	ISTAT	2022	2013-2022	Annuale	Provinciale	Campionaria	Sostenibilità	Ambientali, Sociali	3,6,8
Indagine multiscopo sulle famiglie "Aspetti della vita quotidiana"	ISTAT	2022	1993-2022	Annuale	Nazionale/Regionale	Campionaria	Sociale	Sociali	8
Annuario dei dati Ambientali	ISPRA	2021	n.d.-2021	Variabile	Variabile	Campionaria	Ambiente	Ambientali	4,5,6
Banca Dati Monitoraggio sul valore tecnologico-qualitativo delle varietà di frumento coltivate in Italia: anni 1963-2014	MIPAAF	2014	1963-2014	Annuale	Provinciale	Campionaria	Agricoltura	Produzioni	2,10
Registro Nazionale degli stabilimenti produttori di uova da cova e pulcini	MIPAAF	2022			Provinciale	Universale	Allevamento	Produzioni	9
Registro nazionale delle varietà di vite	MIPAAF	2022			Nazionale	Universale	Agricoltura	Biologici	
Repertori regionali agrobiodiversità	Regioni	2022		Annuale	Regionale	Universale	Agricoltura/ allevamento	Biologici	6,9,19
Anagrafe nazionale biodiversità	MIPAAF	2022		Annuale	Regionale	Universale	Agricoltura/ allevamento	Biologici	6,9,19
Impronta Carbonica Aziende Agricole Italiane	CREA	2013			Nazionale/Regionale	Campionaria	Sostenibilità	Ambientali/Consumi	4,5,6,9,10
Database consumo di suolo in Italia	SNPA	2022	2006-2022	Annuale	Regionale/Comunale	Universale	Agroindustria	Ambientali/Superfici	4,5,6,10
Banca dati del germoplasma	CREA	2021			Nazionale	Universale	Agricoltura	Biologici	5,6,9
Banca dati degli agrofarmaci	Image Line	2022			Nazionale	Universale	Agricoltura	Ambientale	5,6,9,10
Banca dati oli monovarietali italiani	ASSAM	2022	2006-2022	Annuale	Regionale	Campionaria	Agricoltura	Biologici/Produzione	2,3,9,10
BANCA DATI ISOTOPICA PRIVATISTICA dei vini italiani	Fondazione Edmund Mach e Unione Italiana Vini	2022		Annuale	Locale	Campionaria	Agricoltura	Biologici/Produzione	2,3,9,10