SWITCH

Switching European food systems for a just, healthy and sustainable dietary transition through knowledge and innovation

SmartCounters first report on system evaluation

D6.9

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Abbreviations and acronyms

NIR	Near-Infrared
HW	Hardware
SW	Software
POS	Point of Sale
API	Application Programming Interface
CSV	Comma-Separated Values
SQL	Structured Query Language
KPIs	Key Performance Indicators
CO2	Carbon Dioxide
IoT	Internet of Things
REST	Representational State Transfer

Executive Summary

The primary objective of Task 6.4 within Work Package 6 of the SWITCH project is to enhance the monitoring and analysis of various aspects of the food supply chain by implementing SmartCounters. These advanced platforms utilize new digital and wireless technologies for real-time data collection and transmission from all actors involved in the supply chain, including producers, processors, markets, canteens, restaurants, and consumers.

The SmartCounter is an innovative platform that combines sophisticated software and modular hardware components to facilitate data acquisition and processing within food hubs. It leverages blockchain technology for secure data storage and accessibility, ensuring transparency and traceability across the food supply chain. The core of the platform is represented by the data acquisition software components, including web forms, bulk uploads, and Application Programming Interface (API) integration modules. This software suite enables seamless digital and automatic data collection from various stakeholders such as producers, restaurateurs, canteens, end consumers, and markets.

Algorithms integrated into the software are used to correlate data and calculate complex Key Performance Indicators (KPIs). These algorithms process various data points to derive meaningful insights, such as efficiency metrics, sustainability scores, and quality indicators. By correlating different sets of data, the software can identify trends and patterns, enabling stakeholders to make informed decisions based on comprehensive performance metrics. Furthermore, the software enhances the quality and safety of food products by providing accurate and timely data analysis.

The platform also includes highly effective data processing and visualization components such as dashboards for data visualization, a landing page for user interaction, QR codes for easy access to information, and blockchain certificates to ensure data authenticity and integrity.

In addition to its comprehensive software capabilities, the SmartCounter also offers an optional modular hardware kit, resembling a "fruit crate" commonly found in local markets. This kit includes hardware components such as a tablet, printer, and connectivity router, which can be selected based on specific needs. This modular approach provides users with the flexibility to tailor their SmartCounter setup according to their requirements, optimizing the configuration based on the tasks and environments in which they operate. The SmartCounter is an out-of-the-box solution that is easy to use without the need for complex installation or configuration processes. Both the hardware and software components can be pre-configured and ready to use, ensuring that the system can be quickly set up and deployed. The entire

system can be customized to meet the specific needs of different food hubs, including adjusting the hardware configuration, software applications, and connectivity options to match operational requirements and environmental conditions.

The SmartCounter employs multiple data acquisition methods, including manual entry via web forms, bulk uploads, and API integration. This ensures that the platform meets the diverse needs of users, enhancing operational efficiency and ensuring the accuracy and timeliness of the data collected. The collected data encompasses sustainability metrics, nutritional information, and purchase data, all of which are crucial for comprehensive analysis.

The integration of blockchain technology represents a pivotal step towards enhancing data security, transparency, and traceability. By establishing a decentralized and immutable ledger, blockchain ensures the integrity and authenticity of data related to the food supply chain. The SmartCounter uses the postiChain platform, integrated with Polygon public blockchain technology, to track, tokenize[1], and notarize[2] data. Additionally, the collected data is transmitted to the Data Lake for comprehensive storage and analysis. This approach fosters trust and accountability among stakeholders, including consumers, producers, and regulatory bodies.

The implementation of SmartCounters in designated food hubs marks a significant advancement in data acquisition, elaboration and transmission. The application of this technology is designed collaborating closely with each Food Hub to customize the SmartCounter according to their specific activities and use cases (detailed in D5.2). This customization ensures that the platform can effectively capture raw data from various activities, transform it into meaningful insights, and calculate relevant KPIs. By providing a clear and accurate picture of performance across different stages of the food supply chain, the SmartCounter helps stakeholders make informed decisions and drive continuous improvement.

Overall, the SmartCounter platform, with its advanced software capabilities and optional hardware components, offers a user-friendly solution for data gathering and analysis in food hub environments. Its architecture ensures efficient data processing, robust security, and adaptability to various operational requirements. This collaborative effort benefits individual food hubs and aligns with the SWITCH project's goals of fostering a healthier and more sustainable food system.

[1] Tokenization is like creating a digital placeholder or a unique identifier for sensitive information. Imagine you have a secret message, and you replace each word with a code that only you and the receiver understand. This way, the actual message stays hidden and secure.

[2] Notarization is like getting a document officially stamped and signed to prove it is genuine. In the digital world, it means verifying and recording information in a secure and unchangeable way, ensuring its authenticity and integrity.

1. Introduction

This deliverable, titled "SmartCounter First Report on System Evaluation" is produced in the framework of Task 6.4 within Work Package (WP) 6 of the project. Task 6.4, titled "Online food diet data transmission technologies - SmartCounter," involves collaboration among several partners including BC3, BAUMHAUS, AGROCAM, RISE, INRAE, KUTXA, LAORE, BCC, and FFI. This task spans from Month 1 to Month 48 and encompasses Deliverables D6.9 and D6.10 (expected in M30).

The primary objective of Task 6.4 is to implement new digital technologies, developed and tested by partner POSTI, for the acquisition, elaboration and transmission of food diet data through SmartCounter. This will enable the analysis of consumers' dietary habits and the evaluation of dietary shifts in the Hubs' experiments.

A total of 90 SmartCounter will be available for deployment across regional Hubs to collect real-time data, which will be transmitted to the DataLake server. The data collected will be accessible through advanced dashboards, enabling real-time monitoring of the sustainability performances of food actors and providing this information to consumers.

1.1. Purpose of the document

The purpose of this document is to provide a comprehensive overview of the SmartCounter, detailing its software and hardware components [chapter 2] and explaining how the SmartCounter facilitates efficient data collection, processing, and analysis, enhancing the traceability, quality, and safety of food products [chapter 3], ultimately illustrating its application within Food Hub environments [chapter 4].

2. The SmartCounter: A Comprehensive Software and Hardware Platform

The SmartCounter is an advanced platform that combines both software and hardware to acquire and process data related to various activities within food hubs. At its core, the SmartCounter is a powerful software solution designed to facilitate data collection from diverse food sources, utilizing blockchain technology for secure storage and accessibility by different stakeholders. The heart of the platform is represented by the data acquisition software components, including web forms, bulk uploads, and api integration modules. This software suite enables seamless digital and automatic data collection from various entities such as producers, restaurateurs, canteens, end consumers, and markets.

The software system of the SmartCounter is designed to handle large volumes of data efficiently, ensuring high levels of accuracy and reliability. Efficiency in this context means that the software can process and manage extensive datasets quickly and with minimal computational resources, achieved through optimized data structures, parallel processing, and high-performance computing techniques. To ensure high levels of accuracy and reliability, the software employs rigorous data validation protocols, error-checking mechanisms, and redundant data storage solutions. For example, the system cross-verifies data entries using multiple sources and employs checksum algorithms to maintain data integrity, consistently producing precise and correct results.

Algorithms integrated into the software are used to correlate data and calculate complex Key Performance Indicators (KPIs) for each Food Hubs' activity (KPIs are listed in the D5.2). These algorithms process various data points to derive meaningful insights, such as efficiency metrics, sustainability scores, and quality indicators. By correlating different sets of data, the software can identify trends and patterns, enabling stakeholders to make informed decisions based on comprehensive performance metrics.

Valuable insights derived from the data analysis inform decision-making processes. For instance, by calculating complex KPIs, the software helps producers understand and improve efficiency, sustainability, and quality. Identifying trends and correlations in the data enables stakeholders to adjust their offerings and detect inefficiencies in the supply chain, leading to process improvements and optimized operations.

Additionally, in subsequent releases, the SmartCounter will be equipped with robust security features to protect data integrity and confidentiality.

The platform also includes highly effective data processing and visualization components such as dashboards for data visualization, a landing page for user

interaction, QR codes for easy access to information, and blockchain certificates to ensure data authenticity and integrity.

In addition to its comprehensive software capabilities, the SmartCounter also offers an optional modular hardware kit, resembling a "fruit crate" commonly found in local markets. This kit includes hardware components such as a tablet, printer, and connectivity router, which can be selected based on specific needs. This modular approach provides users with the flexibility to tailor their SmartCounter setup according to their requirements, optimizing the configuration based on the tasks and environments in which they operate. These hardware components are designed to ensure reliable performance and seamless operation in diverse settings streamlining operations within food hubs. The SmartCounter is an out-of-the-box solution that is easy to use without the need for complex installation or configuration processes. It provides immediate access to comprehensive data acquisition and processing capabilities. The system can be quickly initiated by simply pressing start, providing immediate access to comprehensive data acquisition and processing capabilities.

The SmartCounter consists of the following software and optional hardware components (see also Appendix 1 for more details):

Software Components

- Data Acquisition Modules (web forms, bulk uploads, API integration)
- Dashboards for data visualization
- Landing page
- QR code
- Blockchain certificate

Hardware Components

- Digital cash register
- Printer
- Tablet
- Wi-Fi router

Figure 1. Components of the SmartCounter

This combination of advanced software capabilities and optional hardware components makes the SmartCounter a versatile and user-friendly solution for data gathering and analysis in food hub environments. What sets the SmartCounter apart from other existing solutions in the market is its simplicity of use, which translates to a low operational impact. This means that operators spend minimal time collecting data, making the process highly efficient.

As such the SmartCounter can be presented as different integrated Solutions

- Ready-to-Use Configuration: Both the hardware and software components of the SmartCounter are pre-configured and ready to use. This means that upon deployment, the system can be quickly set up without the need for complex installation or configuration processes.
- Portable Container: The SmartCounter system, including the tablet, printer, and connectivity router, can be provided in a portable container. This container ensures that all components are securely housed and easily transportable, allowing for quick setup and operation in various locations.
- Customization for Specific Requirements: The entire SmartCounter system can be customized to meet the specific needs of different Food Hubs. This includes adjusting the hardware configuration, software applications, and connectivity options to match the operational requirements and environmental conditions of each location.

In the context of SWITCH, where Food Hubs need to undertake actions that must be measured to understand their effects on sustainability and nutritional indicators, the SmartCounter is particularly advantageous. It allows even small, less digitalized entities to easily acquire raw data and automatically calculate KPIs without a high operational burden. This ensures that all stakeholders, regardless of their digital maturity, can participate in data collection and analysis, facilitating the measurement and improvement of sustainability and nutritional outcomes.

3. The SmartCounter Process

Accurate data collection and operational traceability enable food providers and restaurants to track the quality and safety of their products. This also provides consumers with transparent and reliable information about the origin and composition of the foods they consume. Enhanced traceability systems not only improve food safety, but also build consumer trust by offering insights into the entire food production process. Additionally, these systems facilitate compliance with regulatory requirements and support sustainability initiatives by tracking resource use and waste management.

As the food systems continue to evolve, the integration of advanced technologies for data capture and analysis becomes increasingly important. By understanding these processes, stakeholders can better appreciate the critical role of data in fostering a safer, more transparent, and sustainable food supply chain.

The following diagram outlines the key steps involved and a step-by-step practical application of the SmartCounter system is summarized in the Appendix 2 together with a Q&A guidelines in its use.

Each step plays a crucial role in ensuring that data is accurately captured, managed, and used to enhance the quality, safety, and transparency of food products.

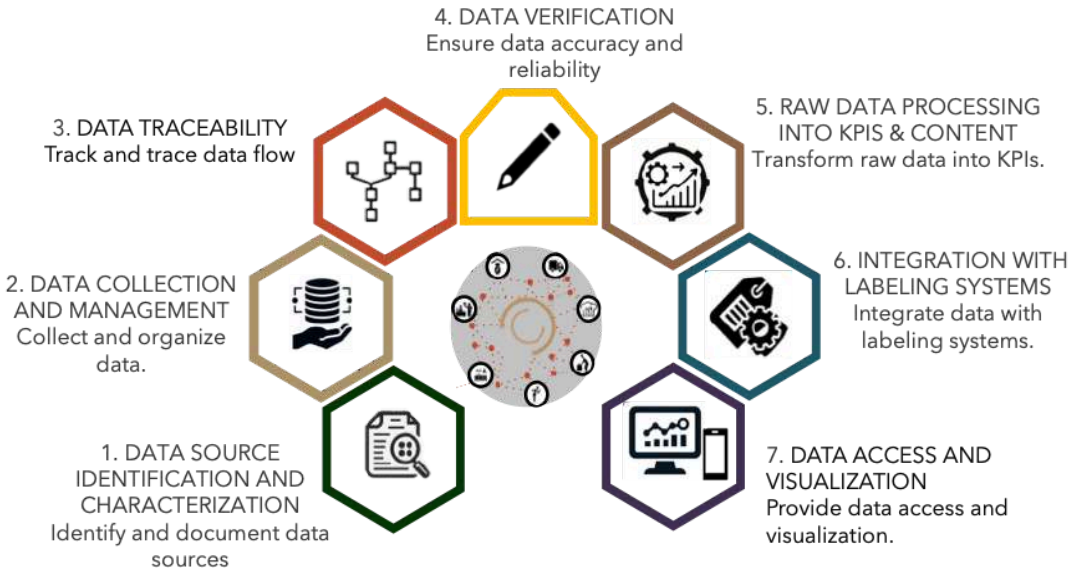


Figure 2. SmartCounter process

The diagram highlights the following steps:

- Data Source Identification and Characterization: Identify and document all relevant data sources to ensure comprehensive data collection and accurate analysis (see par 3.4).
- Data Collection and Management: Gather and organize data from the identified sources to ensure that it is easily accessible and usable for further processing (see par 3.5).
- Data Traceability: Track and trace the flow of data from its source to its final use using blockchain technology to ensure transparency, accountability, and data integrity throughout the entire process (see par 3.6).
- Data Verification: Ensure the accuracy, reliability, and integrity of the collected data by implementing rigorous verification processes.
- Raw Data Processing into KPIs & Content: Transform raw data into meaningful KPIs to provide actionable insights for environmental labeling.
- Integrate processed data with labeling systems, including the capability to generate labels with QR codes.
- Data Access and Visualization: Provide stakeholders with easy access to data and meaningful visualizations to facilitate informed decision-making and enhance transparency.

3.1. Comprehensive data integration & management architecture

Tracking the flow of data within the system is crucial to ensure the efficient collection, analysis, and transmission of essential information related to sustainability and the behavior of various stakeholders. The SmartCounter can facilitate the importation of various types of data, including sustainability metrics of the production chain (e.g. provenience, farm name, farm geolocalization, producer type, etc..), detailed product information (variety, carbon and water footprint, harvest date, transformation date, etc..), macro and micro-nutritional data (Carbs%, Fats%, water content%, brix°, etc.) coming e.g. from the MyFreshFood technology (under development under Task 6.5), and purchase data (price, customer type, order number, etc.).

The following diagram illustrates the comprehensive data integration and management architecture, highlighting the advanced aggregation module and the pathways for secure storage and flexible analysis.

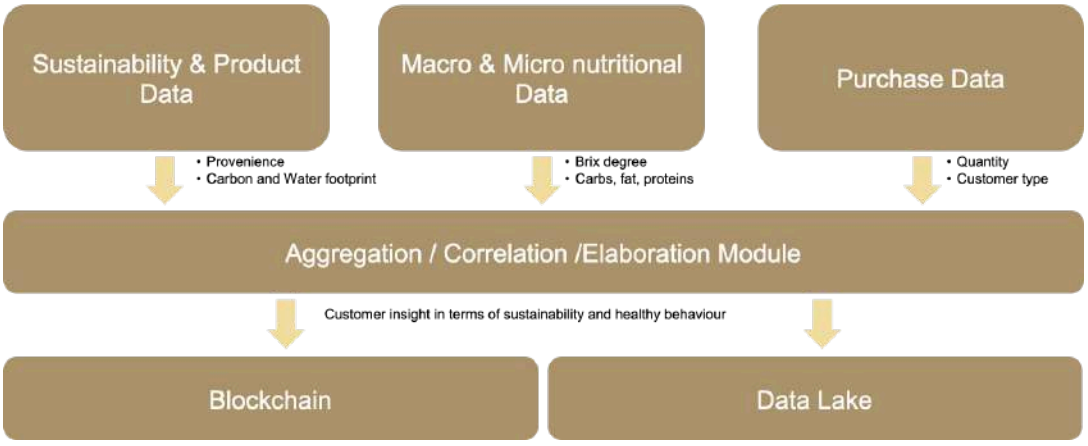


Figure 3. The comprehensive data integration and management architecture

These diverse data types converge in an advanced aggregation, correlation, and elaboration module.

The process of data flow within the system can be broken down into several key steps:

- Aggregation & Correlation: the collected data is aggregated, correlated, and processed in a central module.
- Blockchain Registration: once processed, the data is transcribed onto the blockchain, serving as an immutable and secure ledger for project transactions and critical information. This ensures the integrity and security of the data, allowing stakeholders to access verified, accurate, and transparent information.

- Data Lake Storage: whether the data is registered on the blockchain or not, it is transferred to the Data Lake. In the Data Lake, the data is stored, organized, and made available for further analysis and utilization. The Data Lake serves as a central repository where all collected data, regardless of its registration on the blockchain, is consolidated (see D6.2).

This comprehensive approach to data integration and management enhances the ability to make informed decisions. By ensuring transparency, verifiability, and security, blockchain technology empowers stakeholders to uphold the highest standards of quality and integrity in their operations. The combination of blockchain and Data Lake storage provides a robust framework for managing vast amounts of data while maintaining flexibility for in-depth analysis.

3.2 The platform

The SmartCounter platform is designed with a robust architecture that seamlessly integrates software components to ensure efficient data collection, processing, and presentation, highly customizable and flexible ro be adapted to the specific needs of each Food Hub and their activities (detailed in D5.2).

The SmartCounter platform's modular design allows for high flexibility and adaptability. Each component can be tailored to meet the specific requirements of different food hubs, ensuring that the platform enhances data collection, traceability, and overall efficiency in diverse operational environments (further information in Appendix 1).

The following diagram illustrates the architecture and components of the SmartCounter platform (further information in Appendix 1):

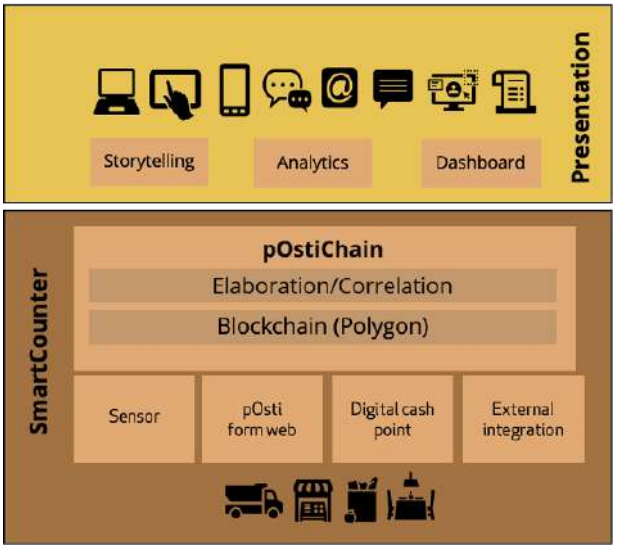


Figure 4. Architecture and components of the SmartCounter platform

3.3 Data source identification and characterization

To address the challenges encounterable according to the specific needs of the different Food Hubs, the platform is customized for the data collection form designed to acquire data from the different Food Hubs and their diverse activities (detailed in D5.2). This form is structured to capture specific data requirements, ensuring that the collected information meets the needs of each Hubs' activity. We built a data model with specific fields for the characterization of data (see Appendix 3), such as the data owner and source, the method of data acquisition, and the frequency of acquisition. It also indicates whether the data should be aggregated, includes space for additional notes, and links the data to relevant KPIs. This comprehensive format ensures that all necessary information is captured in a consistent and structured manner. Possible valorizations for each field are considered to ensure the data's relevance and utility.

This structured approach to data collection is crucial for generating actionable insights and achieving the overarching goals of enhancing the efficiency, sustainability By ensuring accurate and comprehensive data collection, the web-based form supports the effective calculation of project KPIs and fosters continuous improvement in the food system.

3.4 Data collection and management

Effective data acquisition is crucial for the operation of agri-food supply chains. To address the diverse needs and technological capabilities of users (Hub leaders, Consitum partners, etc.) the SmartCounter employs three primary modes of data acquisition: Manual Entry via Web Forms, Bulk Uploads, and API Integration. Each method offers unique advantages and caters to different operational requirements.

- Manual Entry via Web Forms: This method allows users to input data directly into the platform through online forms. While straightforward, it can be time-consuming and susceptible to human errors. This mode is most suitable for small-scale data input or when other methods are not feasible.

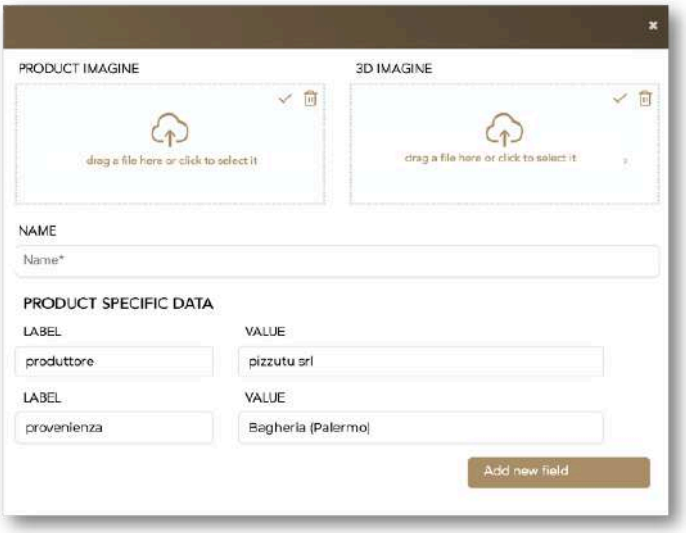


Figure 5. Manual Entry via Web Forms

- Bulk Uploads: This mode involves uploading large amounts of data from external files (like CSV or Excel spreadsheets) directly to the platform. This is typically done through file uploads or file transfer protocols (e.g., SFTP). Bulk uploads offer efficiency for managing large datasets, but the data often requires pre-processing to ensure compatibility with the platform.

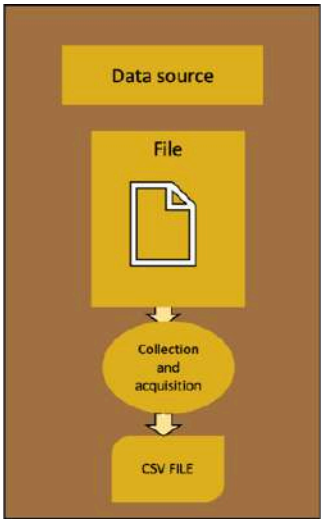


Figure 6. Bulk Uploads

- API Integration: This approach leverages APIs to establish connections between the platform and diverse external data sources. API integration enables the automatic and real-time transfer of data, streamlining the process and reducing manual effort. This is highlighted as the most adaptable and potentially universal

method for data acquisition, as it can connect to various sources regardless of their specific data formats.

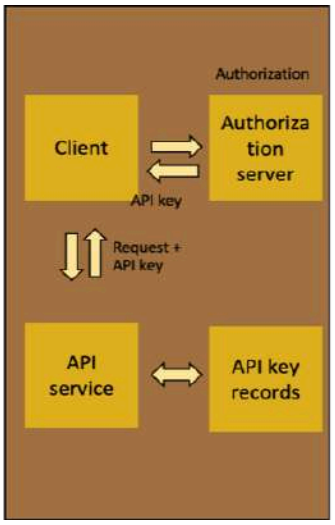


Figure 7. API Integration

The illustration explains how a system connects and communicates with an API. It starts with the client, which could be any application or program that needs to use the API service. The client first logs in to an identity server to verify its identity and get a special key.

The identity server checks the client's login details and, if everything is correct, gives the client an authentication key. The client then uses this key to make secure requests to the API service. This process ensures that only authorized clients can access the API, making interactions secure and efficient. In the data collection phase, the SmartCounter adapts to different user needs by allowing data entry through web forms, bulk uploads, and API connections. This flexibility improves both the efficiency and accuracy of the data gathered. (see Appendix 4 for more details).

3.4.1 Key stakeholders for data acquisition

The data acquisition process involves several key stakeholders, such as restaurateurs and producers, who play vital roles in implementing and benefiting from the SmartCounter system. For example, restaurateurs utilize the SmartCounter to gather and input essential data related to their establishments. They can input detailed business information, menu offerings, and ingredient sourcing. This ensures transparency and accountability in their operations. The SmartCounter platform

allows restaurateurs to track ingredient quality coupling for example the MyFreshFood technology (under development under Task 6.5) which assesses through the NIR (Near-Infrared) technology the ripeness and other organoleptic characteristics. The system can also integrate with the restaurant management software to capture sales data, customer interactions, and analytics, providing a comprehensive overview of business activities.

Also producers contribute critical data about agricultural production and the agri-food supply chain. From the beginning of cultivation, producers track vital information such as the origin, variety, and yield of crops. This data is crucial for ensuring comprehensive traceability throughout the supply chain. The SmartCounter system supports producers by capturing real-time data on raw materials. For instance, as batches of fruits and vegetables are prepared for market, SmartCounters can also be coupled with the MyFreshFood technology (under development under Task 6.5) equipped with NIR to assess the quality and readiness of the produce. This ensures that only the best products reach consumers, maintaining high standards of quality and safety.

3.5 Data Traceability with blockchain technology

Incorporating blockchain technology into the project represents a pivotal step towards enhancing data security, transparency, and traceability. Following the data collection phase, blockchain integration establishes a decentralized and immutable ledger that securely records every transaction and interaction within the system. This integration ensures the integrity and authenticity of data related to food diet monitoring, freshness indicators, and other crucial aspects of the platform.

For the SmartCounter, blockchain technology provides several advantages. By using blockchain, users are empowered with greater control over their data while ensuring privacy and confidentiality. Each user maintains ownership of their information, granting permission for access and sharing based on predetermined criteria. This transparent approach fosters trust and accountability among all stakeholders involved, including consumers, producers, and regulatory bodies.

The identified data will be tracked, tokenized, and notarized on the blockchain using the postiChain platform, made available by pOsti and integrated with Polygon, a public blockchain technology. postiChain is a set of integrated applications based on a common core for designing and deploying enterprise applications using blockchain. For this project, postiChain Traceability, a leading global market solution for food traceability with blockchain, will be used. The requests and data provided by different stakeholders are generated and automatically transferred to the notarization platform. pOsti has developed an interface to automate the extraction and transfer of relevant data from various databases. Simultaneously, the frequency for data extraction and

transfer can be defined (e.g., every time a new user is registered). Product contents will be diversified into various formats (audio, images, video, etc.), and based on the collected and tracked data, they can be made available to consumers, supply chain actors, and other targets.

In conclusion, blockchain-enabled information capture and traceability revolutionize the way data is collected and utilized across the food system. By ensuring transparency, verifiability, and security, blockchain technology empowers stakeholders to make informed decisions and uphold the highest standards of quality and integrity in their operations.

3.6 Integration with the DataLake

The integration of SmartCounters with the Data Lake plays a pivotal role in leveraging new digital technologies to gather comprehensive dietary habits data and evaluate dietary shifts within the experimental Hubs. The integration of SmartCounters with the Data Lake is structured to facilitate the efficient flow of data from the wireless sensors to the centralized repository for comprehensive analysis and evaluation. This integration encompasses the establishment of robust communication channels, data ingestion protocols, and synchronization mechanisms to ensure the smooth transfer of dietary habits data. In particular the integration is facilitated through industry-standard communication protocol RESTful APIs. This type of API enables communication between the SmartCounters and the centralized repository (DataLake), ensuring efficient data transfer and management.

The API system allows SmartCounters to send data to the Data Lake efficiently and securely. SmartCounters collect real-time data from sensors, digital cash points, and manual entries. This data is sent to the Data Lake in a simple and readable format. Security is ensured through an authentication system, primarily using openID, but in some cases, a special key provided during setup is used. Data is encrypted during transmission to maintain privacy and security. The Data Lake receives and verifies the data from the SmartCounters, then organizes it into a structured format for further use. The processed data is stored in the Data Lake, which uses scalable storage solutions. Additional information, such as timestamps and data types, is also stored to ensure comprehensive data management (see Appendix 5 for more details).

4. Application of SmartCounters in Food Hubs

The process to define the application of the SmartCounters within the six Food Hubs, highlighted several issues that emerged regarding the standardization of data collection protocols across the various Food Hubs, given the diverse nature of their activities and the specific requirements of their action plans (detailed in D5.2). Through several one-to-one meetings with each Food Hub, it was discussed how data acquisition and collection can be optimized through SmartCounters for monitoring the single specific activities (presented in D5.2).

Although raw data is valuable, its immediate utility is limited without complete processing and interpretation. This step is crucial for generating indicators that are meaningful and consistent with the project KPIs. Therefore, the SmartCounter is also be able to process raw Data into specific indicators to be used as basis for the assessment of meaningful KPIs (listed in D5.2) so to evaluate the effect of each Hubs' activities on the dietary habits of consumers and evaluate dietary shifts in the Hubs' experiments.

This phase highlighted the complexity of creating a one-size-fits-all solution for all Food Hubs, as each Hub operates under different regional, cultural, and logistical constraints. A significant challenge identified is the integration of various data sources and ensuring the SmartCounters' ability to collect, analyze, and process data from existing systems used by the stakeholders involved, and finally to flow into the SWITCH Data Lake. As such, the SmartCounter acts as a tool to facilitate the acquisition, collection, analysis, recording, measurement, and processing of data from the different Food Hubs and individual activities, allowing to quantify the benefits of each activity in relation to the project KPIs. For example, we have integrated Agroecology survey (implemented by WP3, see D3.2) and psychosocial survey (implemented by WP4, see D4.2) into the SmartCounter, for all stakeholders involved in specific activities to create an easily measurable checklist. This integration allows to collect a wide range of demographic information, including gender, age, housing situation, salary, employment status, and education level of all subjects involved, both authenticated (such as producers and restaurateurs involved in specific activities) and non-authenticated (consumers or end-users of the services and programs). In this way, we ensured capturing a comprehensive view of the behaviors, preferences, and challenges of the stakeholders, translatable into tangible results in line with specific project KPIs.

This same approach can be applied to every activity conducted during the project's course. Using APIs and standardized protocols, SmartCounters facilitate the automatic or semi-automatic acquisition of data from existing management systems or databases. The flexibility offered by adaptable configuration options allows

customizing SmartCounters to work with different technological platforms and operating systems used by Food Hubs, thus reducing implementation complexity.

Regarding training and support, it was thought to organize webinars with stakeholders involved in the project. Additionally, detailed manuals will be included for efficient use, helping stakeholders quickly familiarize themselves with the new technology. Addressing resistance to change is crucial for the adoption of SmartCounters. Actively involving stakeholders in the implementation process, listening to their concerns, and adapting the technology based on their feedback can significantly reduce resistance. Clearly demonstrating the benefits of SmartCounters, such as operational efficiency and improved data quality, further incentivizes stakeholders to abandon traditional methods. To ensure data quality and completeness, SmartCounters can automate data collection, thereby reducing human error and improving consistency and accuracy. Integrated data validation and cleaning tools ensure that collected data is complete and accurate, while specific training on maintaining high data quality standards supports this process. Finally, to ensure data privacy and security, SmartCounters can use advanced encryption techniques to protect data both in transit and at rest, ensuring that only authorized users can access sensitive data.

4.1 Assessment with Food Hubs

The application of SmartCounters in various possible scenarios raised important reflections concerning potential entry barriers for their use in restaurants, companies, and all places where they need to be employed for data collection, measurement, and processing, in particular:

- In the context of the Cagliari Food Hub, for the activity "La Buona Tavola," which aims to enable primary school students and their parents to appreciate, access, and consume typical, local, sustainable, and healthy foods while reducing household waste, SmartCounters can play a fundamental role. SmartCounters will facilitate the collection and analysis of data, providing a detailed view of operations and helping to make informed decisions to continuously improve the quality of meals offered. For instance, they can monitor the increase in the use of certified products (such as PDO-IGP, SQNPI, SQNZ, CAM) in school canteens and households, evaluating the effectiveness of promoted guidelines or the increase in the use of plant-based products. These two indicators will not only support Laore's mission to promote sustainability and health but also provide concrete evidence of the positive impact of initiatives within the canteens. Data collection and analysis will help raise further awareness of sustainability and improve connectivity among

supply chain actors, ensuring broader access to healthy and sustainable foods. Moreover, SmartCounters play a crucial role in fostering the involvement of local producers and increasing the visibility of their high-quality products within the specific context.

- In the context of the Basque food hub located in San Sebastian, one of the main barriers identified is technological integration with existing systems, for example in "Activity 5: BCC Inn Canteens". SmartCounters can be designed to seamlessly integrate with the current technological systems used in BCC Inn canteens, facilitating the automatic acquisition of data regarding the adoption of vegetarian, vegan, and vegetable-based options, reducing dishes made with animal-origin products, and involving suppliers within the activity. SmartCounters can support the activity by measuring consumer feedback data, their satisfaction levels, and the adoption of new dietary options, helping to demonstrate the benefits of more sustainable and healthy diets on end consumers. This feedback allows for continuous adaptation of the menu and procurement strategies to enhance the acceptance and attractiveness of the proposed food choices.
- In the context of activities at the Montpellier Food Hub, several challenges and barriers have quickly become evident, such as the need to integrate specific sustainability criteria into local food networks and manage the behavioral impact assessment of users through existing platforms like BOCAL. Another challenge that has emerged is the introduction and evaluation of the Ici.c.Local label at outdoor markets, where limited access to stable energy sources and the internet can complicate data collection and the implementation of new initiatives. To address these challenges, SmartCounters represent an effective solution. For data collection from the BOCAL platform, SmartCounters can automate the collection of existing management data within the system, facilitating the import and analysis of existing data to create an accurate database. Additionally, they can support the creation of specific data collection modules based on identified KPIs, ensuring continuous and detailed monitoring. For the activity related to promoting the Ici.c.Local label within markets, SmartCounters can be customized to automatically import identified data, such as the number of labeled products available at each market, and administer questionnaires to consumers to assess the impact on their food choices. Furthermore, they can enrich product information with specific data such as packaging type, sensory and nutritional characteristics, and the origin of raw materials, providing a detailed view that supports the evaluation of label effectiveness and the involvement of producers in the activity. Lastly, for Activity 5 concerning the metropolitan food supply strategy, SmartCounters can be used to collect data during training sessions on best practices for food

stores and to monitor sales of products promoted through such training. They can also support the collection of qualitative feedback from retailers and consumers involved in awareness campaigns for the Food Index for Good (FIG), enhancing understanding of initiative impacts and facilitating the adaptation of future strategies.

- In the context of the Gothenburg Food Hub in Sweden, various barriers and challenges have been identified to improve sustainability and food health in the region. Despite economic prosperity, there are socio-economic and health disparities that need to be addressed. The Food Hub focuses on increasing the consumption of whole foods, vegetables, legumes, and sustainable seafood. The main barriers encountered in the use of SmartCounters concern the sourcing of data from different sources, the difficulty of integrating this information into a single system, and involving the various stakeholders in activities. SmartCounters can meet these specific needs. For example, for the "Seafood in Public School Meals" initiative, which aims to develop practical skills and knowledge of sustainable seafood consumption among Swedish children, this activity includes training courses for catering staff, workshops with chefs and producers, and integrating seafood into the learning process through dedicated sessions with students. Students will be involved as "Foodinfluencers," learning to prepare and promote seafood dishes. For this specific activity, SmartCounters can automate the collection and analysis of data related to seafood consumption in schools. They can be employed to monitor the increase in seafood consumption and collect feedback from both students and school staff involved in the activity, providing an accurate and detailed database to evaluate the initiative's impact. Additionally, they can help integrate and synchronize data from different sources.
- In the context of the Berlin-Brandenburg Food Hub, the major difficulty lies in integrating data from different sources. Information can come from local food initiatives, small producers, projects along the food chain, and food policy strategies, each with its own data collection systems. For example, in procurement activity, a significant barrier is collecting accurate data on local and sustainable sourcing. SmartCounters can automate data collection on sourcing and monitor the quantity and quality of local products distributed in LebensMittelPunkte (LMP). This helps track the origin of products and ensure that sustainability goals are met. Regarding cooking activity, a challenge is monitoring the effectiveness of training programs and cooking workshops. Using SmartCounters, it is possible to collect data on participation in cooking courses and evaluate the impact of training sessions on preparing healthy and sustainable meals. Additionally, they can track participant feedback to continually improve the programs. In the context of changing eating behavior,

a barrier is evaluating the effectiveness of efforts to change eating habits. SmartCounters can collect data on food consumption and preferences of participants in community events. This data can be analyzed to identify changes in eating behaviors and measure the effectiveness of initiatives.

In conclusion, SmartCounters can be effectively employed to overcome all these barriers. By integrating seamlessly with existing systems, automating data collection, and providing detailed analysis, SmartCounters address the challenges of technological compatibility, data quality, and comprehensive monitoring. They facilitate the collection of demographic information and consumer feedback, support the evaluation of sustainability initiatives like Ici.c.Local, and enhance the effectiveness of metropolitan food supply strategies. Through customization and real-time data processing, SmartCounters not only improve operational efficiency but also provide valuable insights that drive informed decision-making and continuous improvement. Ultimately, their deployment within the Food Hubs ensures a more sustainable, healthy, and connected food network, benefiting all stakeholders involved.

4.2 First piloting activity implementation

In the Rome Food Hub, we have delved deeper into the data collection model engaging with various stakeholders such as Spesabus, Biolà, and Zolle in the Activity 1 (see D5.2 for more details in this activity).

A first pilot of SmartCounter platform customization entailed specifically to facilitate data acquisition tailored to the needs of the stakeholders involved in the Spesabus service (Figure 8). This ensures that the platform can effectively capture raw data from various activities associated with Spesabus and process it for calculating the project's KPIs and ensuring that the information is relevant and actionable for each stakeholder group.

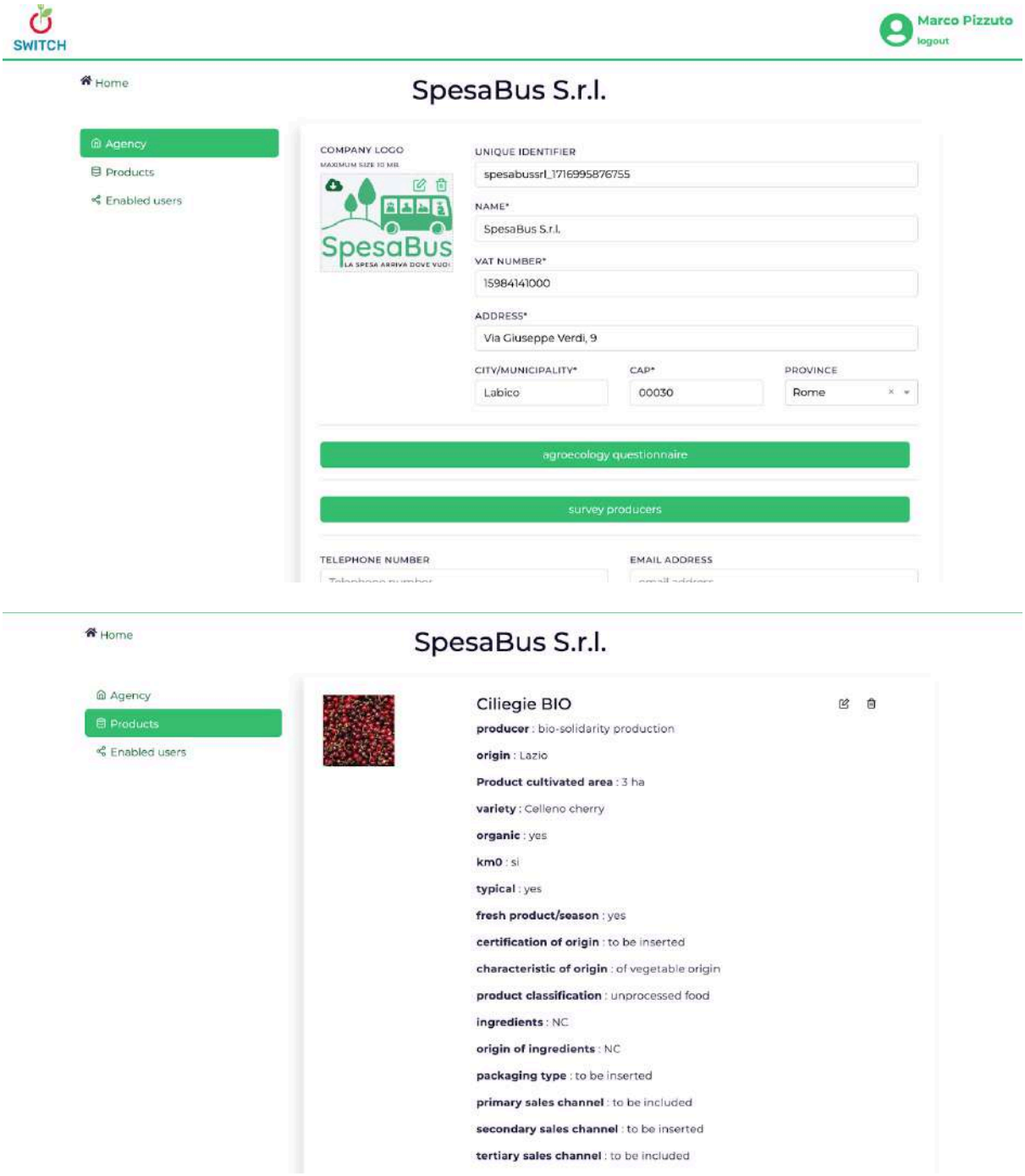


Figure 8. A pilot of SmartCounter platform customization

5. Future steps

As demonstrated in the initial piloting activity of the Rome Food Hub, the SmartCounter platform will be meticulously customized to cater to the specific needs of each activity within every Food Hub. This tailored approach ensures that each unique action can be developed and implemented in a timely manner, aligning

seamlessly with the predefined settings and objectives outlined in the Food Hubs' Action Plans (as detailed in D5.2), thus guaranteeing a coherent and efficient progression of activities across all Food Hubs, ultimately fostering a more structured and successful execution of the overall project goals.

Appendix 1 - Description of the SmartCounter architecture and its components

The SmartCounter is composed by:

a) Data Acquisition Layer

A web-based application designed for flexible and efficient data collection allows manual data entry via web forms, bulk uploads from CSV/Excel files, and API-based data collection. The form web adapts to various data input needs, making it easy for users to provide information through a user-friendly interface.

Technical Specifications: Representational State Transfer (REST) services are built using Java and as Quarkus framework and Pyton. The web application used by users is built using Angular.

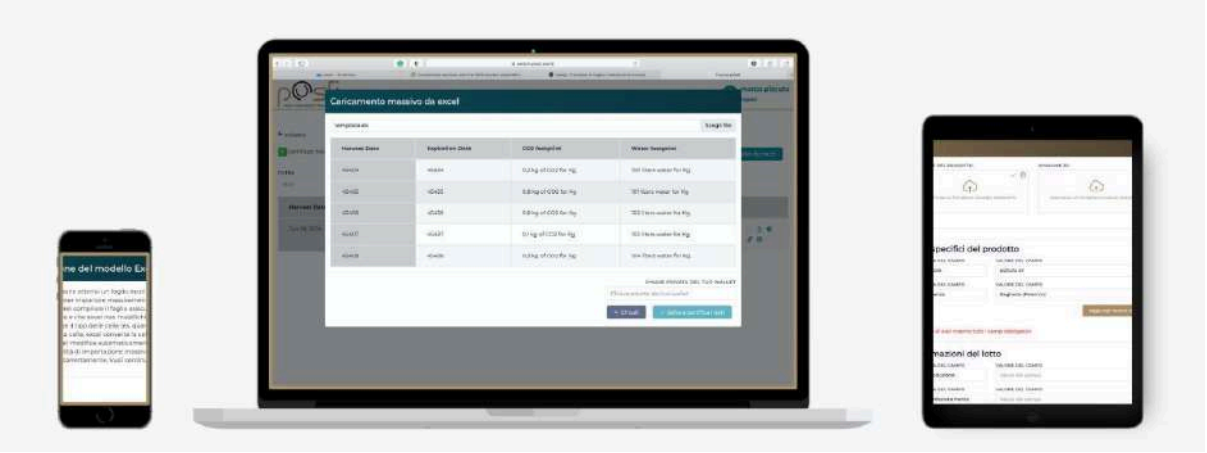


Figure 4. Data Acquisition Layer

Sensor Integration Module: Integrates with various IoT sensors to collect real-time environmental data. It supports automatic data collection and transmission to the central processing unit, enhancing the accuracy and timeliness of data gathered from the field.

Technical Specifications: Supports MQTT and HTTP for data transmission, and is compatible with standard sensors measuring temperature, humidity, CO2 levels, etc.

Digital Cash Point: Integrates with the platform to record sales transactions and manage inventory. It provides real-time data on sales and inventory, contributing to comprehensive data collection from commercial activities within Food Hubs.

Technical Specifications: Connects with point-of-sale systems to capture transaction data, recording sales data, customer interactions, and financial transactions.

External Integration: Facilitates connectivity with other external systems and devices, allowing the platform to incorporate additional data sources for a more comprehensive

dataset. This module enhances the breadth and depth of data collected by integrating with various third-party systems.

Technical Specifications: Utilizes RESTful APIs for seamless data exchange, ensuring compatibility with multiple external systems.

b) Data Processing Layer

Elaboration/Correlation Module: Processes and correlates collected data to generate insights. It uses advanced algorithms to analyze data, calculate complex Key Performance Indicators (KPIs), and identify trends and patterns. This module ensures that the data collected is transformed into valuable, actionable insights for stakeholders.
Technical Specifications: Implemented in Python and R, using Pandas and NumPy for data manipulation, Scikit-learn for machine learning, and TensorFlow for deep learning.

Blockchain (Polygon): Ensures data authenticity and integrity through a decentralized ledger. It records transactions and data interactions immutably, providing transparency and security. The blockchain component is crucial for maintaining the trustworthiness of data within the platform.
Technical Specifications: Built on the Polygon blockchain, utilizing smart contracts written in Solidity.

c) Data Presentation Layer

Dashboard: Provides an interactive interface for monitoring key metrics and making informed decisions. The dashboard displays real-time data, KPIs, and insights in a user-friendly format, enabling stakeholders to quickly grasp essential information.
Technical Specifications: Built using React and Angular for the frontend and various technologies for data visualization.

Analytics: Offers deep insights through sophisticated data analysis. It provides advanced analytics capabilities, including predictive modeling and trend analysis, helping stakeholders understand complex data and make informed decisions.
Technical Specifications: Utilizes tools like Tableau and Power BI for comprehensive data analysis.

Storytelling: Translates data into compelling stories and visual representations, making it easier for stakeholders to understand and act upon the information. This component enhances engagement and comprehension through narrative-driven data visualizations.
Technical Specifications: Integrates with platforms like Tableau Story and Microsoft Power BI for creating narrative-driven visualizations.

On the hardware side, the SmartCounter includes three main components: a tablet, a printer, and a connectivity router, each carefully integrated to ensure reliable performance and seamless operation in diverse settings. However, these hardware elements are optional and

can be customized based on the specific requirements of the food hub, providing flexibility and adaptability to different operational environments.

Tablet: The primary purpose of the tablet is to serve as the device from which users can access the digital cash register. Beyond this, the tablet can also function as the interface for the SmartCounter, allowing users to utilize the form web for data entry and view dashboards where available. Depending on the needs of the food hub, the tablet can be customized with different software applications tailored to specific operational requirements.

Printer: The printer is used to generate receipts and QR codes, which can be used in conjunction with the tablet and the digital cash register software. It provides physical copies of transaction records, enhancing transparency and accountability. QR codes printed on receipts can also facilitate easy access to additional information or services. The printer can be configured to meet the specific printing needs of the food hub, including different receipt formats and QR code functionalities.

Connectivity Router: The connectivity router provides internet access, particularly in locations where Wi-Fi is not readily available. It ensures that the SmartCounter system remains connected, enabling real-time data transmission and access to cloud-based services. This is crucial for the seamless operation of the SmartCounter, especially in remote or temporary setups. The router can be tailored to support various connectivity options (e.g., 4G/5G, Ethernet), ensuring robust and reliable internet access in different operational environments.

Appendix 2 - How To Smart Counter

Here is how the SmartCounter system can be applied in practice:

Data Input and Tracking: Restaurateurs and producers begin by inputting initial data into the SmartCounter system. This includes detailed information on business operations, agricultural practices, and ingredient sourcing.

Real-Time Data Collection: The SmartCounter collects data in real-time from multiple sources within the food hub. This includes sensors, processors, and communication modules that capture information on ingredient supplies, sales, and customer interactions. Producers track key data points from the start of cultivation, ensuring that all relevant information is documented and traceable.

Integration and Analysis: The SmartCounter platform integrates data from various sources, providing a unified view of operations. This integration helps in analyzing consumer behavior, market trends, and operational efficiency. The SW Digital Cash Point component enhances data capture by collecting sales data and customer information, offering insights into consumer preferences and purchasing patterns.

Traceability and Reporting: Data collected through the SmartCounter system is used to generate comprehensive reports that trace the entire production and supply chain. These reports include details such as origin, variety, yield, ripeness, and organoleptic characteristics of produce. Restaurateurs and producers can access these reports to ensure compliance with quality standards and regulatory requirements.

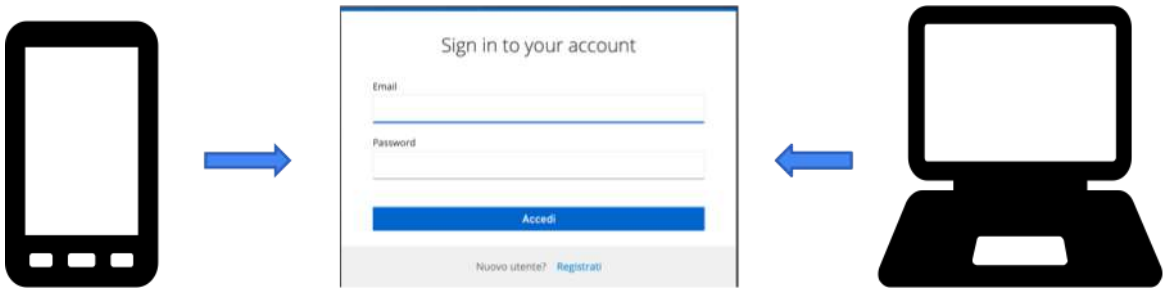
Enhanced Customer Transparency: At the market, the SmartCounter system generates a "talking" receipt that consolidates all gathered information about a product's journey and characteristics. This receipt provides customers with detailed insights into the origin and quality of their purchases. In restaurants, blockchain technology records essential company information and ingredient details, ensuring transparency in culinary offerings.

By implementing the SmartCounter system, key stakeholders like restaurateurs and producers can enhance the accuracy, reliability, and transparency of their data. This comprehensive approach not only improves operational efficiency but also builds consumer trust by providing detailed, traceable information about the food they consume.

Q&A Guideline:

Q1. How do I access it?

A1. Through links: https://switchproject.posti.world/ The link can be accessed through a browser from every mobile device or PC.



Q2. Registration and Login

A2. The first time you access the platform, you need to register.

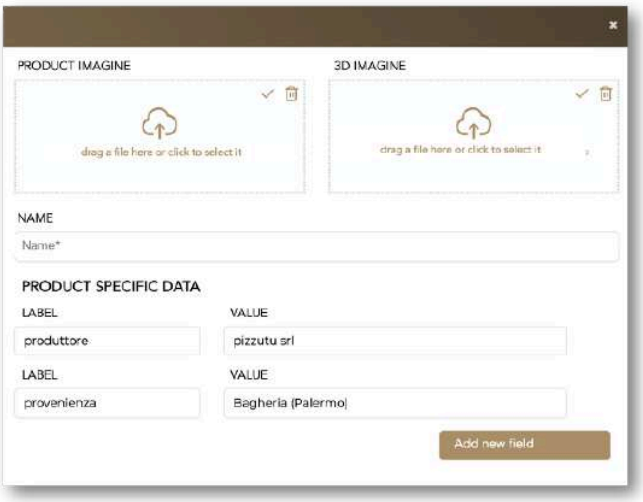
- Step 1.Click on the “Register” link under the “Sign In” button to access the registration page.
- Step 2.Fill in all the required fields on the registration page with your first name, last name, email and password.
- Step 3.After entering all registration details, click the “Register” button to complete the registration. Next, return to the login page at switch.posti.world.

Q3. How do I enter the data?

A3. Through a web form

- Step 1: Product Details Enter producer's name and "CSA Das Gemuse Synikat" under "Name" and "Field Value" respectively, then add provenance and farmer details. Use "Add New Field" for additional info.
- Step 2: Lot Information Record harvest and expiration dates, CO2, and water footprints. Add more details if needed using "Add New Field to Lot".

- Step 3: Finalize and Save Choose to cancel changes, save, or save and certify the data in blockchain. Remember, customization is available to suit your product and needs.



Q4. How do I enter the data?

A4. Uploading an excel/csv file

- Step 1: Excel File Preparation Ensure Excel cells remain text format to avoid automatic conversion. This file serves as a template for bulk data upload.
- Step 2: Fill in Template Use the provided Excel template with columns for Harvest Date, Expiration Date, CO2 footprint, and Water footprint. Input data for each product or lot.
- Step 3: Upload and Process Save the completed Excel template, then select it to upload. The web app processes and imports the data.

Q5. How do I visualize the results?

A5. Through a dashboard. Visualizing data through dashboards serves to monitor performance in real-time, facilitate effective communication of complex information, enable in-depth analysis, support decision-making, and track progress towards goals

Elenco Pecorino Romano casearia - Pecorino Romano

5 Pecorino Romano trovati

+ nuovo

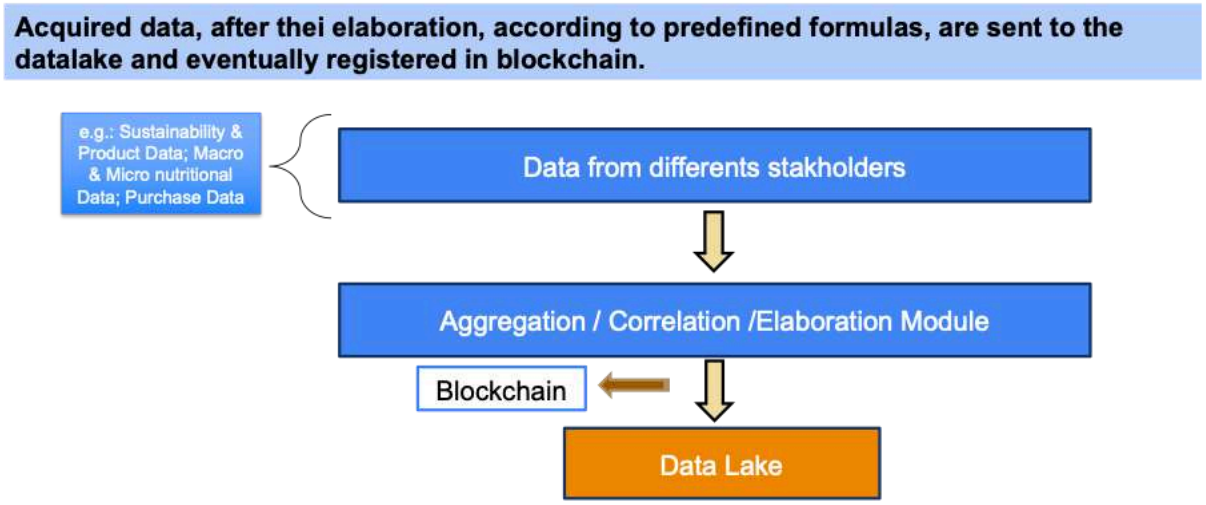
prodotto	Lotto	Stagionatura	Sconto disponibile	
	28/09/2022			
Pecorino Romano DOP	30/05/2018	30/05/2018	Sconto del 10% per due anni sullo shop DOL	
Pecorino Romano DOP	30/05/2018	30/05/2018	Sconto del 10% di due anni sullo shop DOL	
Pecorino Romano DOP	30/05/2018		Sconto del 10% per due anni sullo shop DOL	
Pecorino Romano DOP	30/05/2018		Sconto del 10 percento sullo shop DOL per due anni	

Q6. How do I visualize the results?

A6. Through a landing page. Through the landing page we can build an effective storytelling for the end user viewing the data. To the storytelling we can add multimedia files (photos, videos) and relevant content.

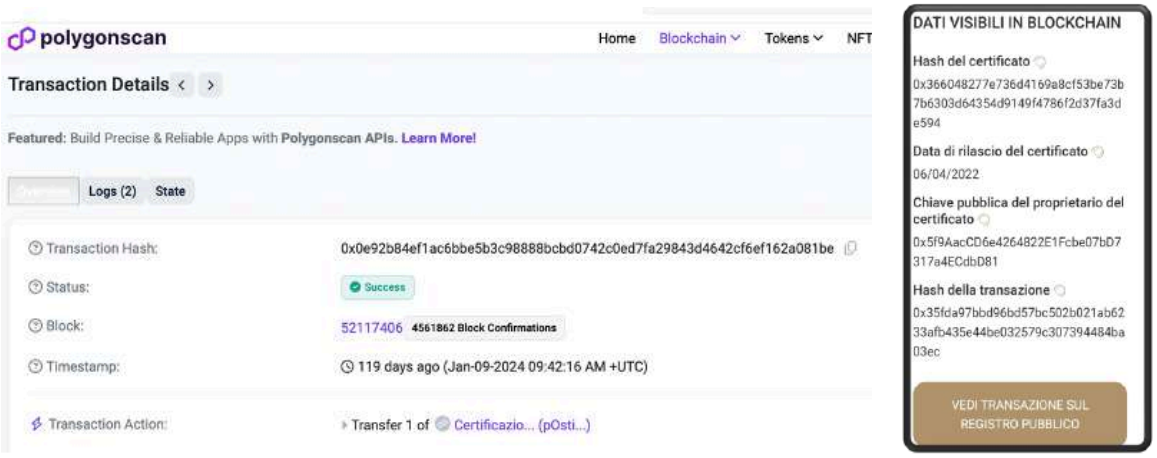
Q7. Where does the generated data of the counter go?

A7. Acquired data, after their elaboration, according to predefined formulas, are sent to the DataLake and eventually registered in blockchain.



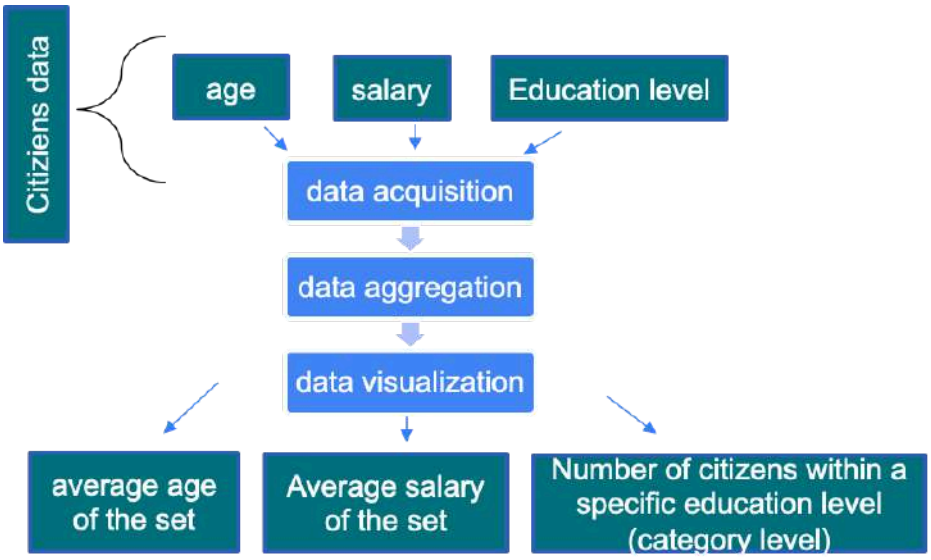
Q8. Is the blockchain notarization free?

A8. Yes. Only the notarization data in blockchain has, for each transaction, a cost that is only a few thousandths of a euro.



Q9. What is the level of security of data privacy?

A9. Data collected may be processed in different ways depending on the nature of the data and specific privacy needs. This may include encrypting sensitive data to ensure the security and confidentiality of the information. In addition, data can be aggregated to obtain a broader and more general view of trends without compromising user privacy (as in the example in the image opposite).


Citiziens data
age
salary
Education level
data acquisition
data aggregation
data visualization
average age of the set
Average salary of the set
Number of citizens within a specific education level (category level)

Appendix 3 - Characterization of data

- Field Name: Descriptive name of the data field.
- Description: Brief description of the data field.
- Agroecology Questionnaire (Reference Area): Thematic area of the agroecology questionnaire.
- Data Type:
  - Option 1: Static (not change over time)
  - Option 2: Variable (change over time)
  - Option 3: Dynamic (change each time)
- Data Category: Category of the data.
- Blockchain (Indicates if the data should be registered on the blockchain):
  - Option 1: Yes (to be registered in blockchain)
  - Option 2: No (not to be registered in blockchain)
- Plain Data (Indicates if the data is visible to various users):
  - Option 1: Yes (data visible to various users)
  - Option 2: No (data not visible to various users)
- Encrypted: Indicates if the data is encrypted:
  - Option 1: Yes
  - Option 2: No
- Data Owner: Entity that owns the data.
- Data Source: Source from where the data is collected.
- Acquisition Mode (Method of data acquisition):
  - Option 1: Manual (through form)
  - Option 2: Massive data loading (through files in CSV format for bulk data)
  - Option 3: API (REST)
  - Option 4: Web Service
  - Option 5: Calculated (data calculated from raw data)
- Acquisition Frequency (Frequency of data acquisition):
  - Option 1: One-time
  - Option 2: On-off
  - Option 3: Variable
- To Aggregate (Indicates if the data should be aggregated):
  - Option 1: Yes
  - Option 2: No
- Data type:
  - Option 1: Raw Data
  - Option 2: Aggregate Data
- Note: Additional notes or comments.
- KPI Related (Relevant KPIs linked to the data):

- Option 1: Behavior change towards health and sustainability (40% improvement over baseline)
- Option 2: Improvement on environmental targets (70% improvement over baseline)
- Option 3: Increase in connectivity among stakeholders (50% improvement over baseline)
- Option 4: Increase share of sustainable and healthy local products in the HUB areas (minimum 30%)
- Option 5: Increased visibility of sustainable farming systems in the HUBs by 70%
- Option 6: Increased interest in consumers in H&S products in the HUBS (50% engagement)
- Option 7: Final increased share of at least 30% of local and sustainable fish products
- Option 8: Increase labeling of sustainability (+30%) used by fishing and aquaculture companies in the HUB areas
- Option 9: Increase share of local and sustainable food products in local retailers (minimum +20%)
- Option 10: Increase consumer awareness on sustainable fish options (+70% in test groups)
- Option 11: Engage one group of 50 people per vulnerable category in each Hub
- Option 12: Identify and engage 20 isolated small producers in each Hub

- Notes: Additional notes.

Appendix 4 - The process of API integration

The process of API integration, highlighting the steps involved in authorizing and handling API requests between the client and the API service.

- Client Authorization:

The process begins with the client, which could be any application or system that needs to interact with the API service.

The client sends a login request to the identity server in order to authenticate itself and obtains the session token that will be used to invoke API service.

- Identity Server:

The identity server is a server implementing the OpenID protocol.

Upon receiving a request from the client, the identity server verifies the client's credentials and issues an authentication token if the client is authorized.

- Request Handling:

Once the client obtains the authentication token, it includes this key in the requests sent to the API service. The authentication token is used by the service API to authenticate the client and ensure that it has the necessary permissions to access the requested resources.

This API integration process ensures secure and controlled access to the API service, allowing clients to interact with the system efficiently while maintaining data security and integrity.

Focusing on the data acquisition phase highlights the versatile and adaptable capabilities of the SmartCounter. By utilizing methods such as Manual Entry via Web Forms, Bulk Uploads, and API Integration, the platform ensures that the diverse needs of users are met, enhancing operational efficiency and ensuring the accuracy and timeliness of the data collected.

Appendix 5 - RESTfulAPI Design

The REST (Representational State Transfer) API is designed to handle requests and responses between the SmartCounters and the Data Lake. It follows standard HTTP methods such as GET, POST, PUT, and DELETE to manage data operations.

Data Transmission:
- SmartCounters: collect real-time data from various sources, such as wireless sensors, digital cash points, and manual entries.
- API Requests: The SmartCounters send this collected data as HTTP requests to the Data Lake's API endpoints. Each request includes relevant data in JSON format, which is lightweight and easy to parse.

Authentication and Security:
- The authentication will be made by using well known protocols like openID. Only for specific cases for which it is impossible to use openID, can an authentication approach be used with an API Key. In this case, the API key is provided during the initial setup and must be included in all requests to validate the sender.
- Encryption: Data transmitted via the API is encrypted using SSL/TLS protocols to maintain data integrity and confidentiality.

Data Reception and Processing:
- API Endpoints: The Data Lake's backend services include specific API endpoints designed to receive data from the SmartCounters. These endpoints handle the incoming data, validate it, and process it as needed.
- Data Parsing: The received data in JSON format is parsed and transformed into a structured format suitable for further processing.

Storage in Data Lake:
- Data Ingestion: Once the data is processed, it is ingested into the Data Lake using API calls. The Data Lake, built on scalable storage solutions like Amazon S3, uses these APIs to receive and store large volumes of data efficiently.
- Metadata Management: Along with the raw data, metadata such as timestamps and data types are also stored to ensure comprehensive data management and traceability.