PININ: increasing customer awareness through an innovative IoT and blockchain-based high quality food product tracking system

PININ: increasing customer awareness through an innovative IoT and blockchain-based high quality food product tracking system

Federica Cena
Department of Computer Science
University of Turin
Turin, Italy
federica.cena@unito.it

Claudio Schifanella
Department of Computer Science
University of Turin
Turin, Italy
claudio.schifanella@unito.it

Cristina Tortia
DISAFA
University of Turin
Turin, Italy
cristina.tortia@unito.it

Valeria Maritano
DISAFA
University of Turin
Turin, Italy
valeria.maritano@unito.it

Oscar Bruschi
Interlogic
Turin, Italy
oscar.bruschi@interlogicsrl.it

Valentina Cobetto
Enhancers
Turin, Italy
valentina.cobetto@enhancers.it

Serena Ambrosini
Alten Italia SPA
Turin, Italy
serena.ambrosini@alten.it

***Abstract*—The PININ project (PIemuNt chèINa) aims to increase the quality and perception of high-quality agri-food products through the use of innovative technologies that allow to optimize and reduce the quality certification and traceability costs, as well as improve the access to traceability information by the final user. It also allows to facilitate the controls in the food chain to certify sustainability starting from cattle breeding in alpine past. The PININ project focuses its effort in the definition and implementation of a comprehensive agri-food traceability system specifically designed for high-quality food products involving all different phases, up to the distribution and consumption. To reach these goals, the project develops a complex platform mixing blockchain and internet of things, augmented reality and interactive maps. They allow the creation of an innovative food product tracking system along the entire supply chain, from raw materials to consumer, and to introduce innovative services for the consumer and the stakeholder. Within the PININ platform, one of the most important tool is represented by a mobile app for customers providing information regarding the whole products production chain, as well as places of sales and consumption like restaurants. In this paper, we present the results on evaluation of the app with final users, in order to test the usability and usefulness of the solution.**

***Index Terms*—Traceability, blockchain, crowdmapping, supply chain, internet-of-things**

I. Introduction

The PININ project (PIemuNt chèINa) aims to increase the quality and perception of high-quality agri-food products through the use of innovative technologies that allow to optimize and reduce the quality certification and traceability costs [1], as well as improve the access to traceability information by the final user. Moreover, the project aims at facilitating the controls in the food chain to certify sustainability starting from cattle breeding in alpine past. To reach these goals, the project exploits different technologies such as blockchain, artificial intelligence, internet of things (IoT), augmented reality, interactive maps. They allow the creation of an innovative food product tracking system along the entire supply chain, from raw materials to consumer, and to introduce innovative services for the consumer and the stakeholder.

The PININ project builds a distributed and decentralized infrastructure based on blockchain [2], [3] that allows IoT-level traceability and is scalable throughout the supply chain. The blockchain allows traceability at different levels of physical aggregation of the product (item-level, packages or lots), and the level of detail of the information flow: expiring date, production methods, certifications, details on ethics, sustainability, requirements related to ethnic and religious group, nutritional information, composition and presence of allergens, etc., as well other information that can also be used in marketing strategies and against counterfeiting. The other building block is IoT, that is use for monitoring the positions of the cattle through intelligent collars.

The methodology of the project will be tested in various use cases: i) Food traceability and smart labeling, ii) Traceability in the provision of European funds for breeding, iii) Anti-counterfeiting of bottled products (wine and spirits), iv) Search for food products with fake brands on E-commerce sites. In this paper, we focus on the first use case, describing the solution we developed by means of IoT and blockchain technologies for cattle monitoring, cheese and meat traceability, and its evaluation with users .

The paper is organized as follows: Section II describes related work, Section III illustrates the architecture and the front-end app. Finally, Section IV shows the results of our experiments and Section V concludes the paper.

This work is supported by the POR-FESR2014-2020-Piattaforma Bioeconomia – Regione Piemonte

II. Related work

Given the complex nature of food supply chains, farm to fork traceability is both critical and difficult for companies to accomplish. Basically, traditional traceability systems motivation is to respect mandatory requirements to withdraw rapidly dangerous food lots in case of recalls. Indeed, an efficient tracking system is a prerequisite for implementing other extended features in food supply chain information systems. The lack and transparency and traceability in food supply chains is caused by multiple reasons like lack of digitalization, lack of standardization of processes and lack of trust, that affect the perception of food quality by customers [4], [5]. This is especially true in areas characterized by small and localized productions of very typical and unique food product, like in the Piedmont region and, more in general, in Italy.

In this scenario, blockchain, together with IoT and artificial intelligence, is gaining momentum in the proposal of different supply chain traceability systems [6], [7].

In [8], ProductChain, a scalable permissioned blockchain framework that stores and makes public to consumers products traceability information is presented. It is maintained by a consortium of stakeholders including government and regulatory entities. ProductChain proposes the use of a three-tier shared architecture based on a transaction vocabulary and different access control mechanisms that ensures reliability and availability of collected data for end users. AgriBlockIoT project [8] proposes a fully decentralized, blockchain-based traceability solution for agri-Food supply chain management, able to integrate IoT devices producing and consuming digital data along the supply chain, from the farm to the fork.

The PININ project implements a specific IoT support for cow pasture monitoring based on the communication among two collar types, one bearing a Bluetooth Low Energy (BLE) sensor and the other carrying a GPS/4G module. A similar systems was proposed by Maroto-Molina et al., to monitor herd position using the LPWAN communication mode [9], and in [10], [11]. In [12], the authors proposes the first paper integrating blockchain and the LoRaWAN network to build an open, reliable, decentralized and tamper-proof system, which provides the mechanism to verify that a transaction data existed at a given time in the network. Instead, [13] proposes a solution to allow low-power IoT sensors to access a blockchain-based infrastructure through an IoT gateway as a blockchain node, proposing an event-based messaging mechanism for low-power IoT devices.

Shahid et al. [14] propose a complete solution for blockchain-based agri-food supply chains leveraging the characteristics of blockchain technology and smart contracts. It is based on a blockchain-based Ethereum network where transactions are written to the blockchain and external data are stored into IPFS, the Interplanetary File Storage system to ensure immutability and reliability.

Baralla et al. [15] present a blockchain oriented platform, especially focused on the management of the cold chain, to guarantee the origin and provenance of food items in a Smart Tourism Region context. Smart contracts are used to guarantee trust, transparency, efficiency while data are gathered by different IoT devices.

Marchesi et al. [16] propose a general-purpose approach for the blockchain-based agri-food supply chain management, proposing a system that can be confgured for most agri-food productions. They provide apps that interact with smart contracts, providing information to customers.

Finally, Marchese et al. [17] propose a framework based on Hyperledger Fabric through a complete model of a blockchain-based agri-food supply chain traceability system.

The main contribution of this work with respect to these state-of-the-art work is the innovative applications of IoT technology and blockchain for providing information to users about *niche* local food product, and not product for mass distribution, as well as the complete solution for the supply chain, both for stake-holders and for customers. In details, in this paper we demonstrate the effectiveness of the PININ app that customers can use to know the history of different products, like high quality diary products and organic pork meat.

III. Traceability of food with innovative services for consumers

One of the goals of the PININ project is to improve the dialogue between producers, consumers, wholesalers and retailers and food administration activities such as restaurants. To reach this goal, it was necessary to develop an IT platform for the traceability of livestock in the pastures based on blockchain and IoT technologies.

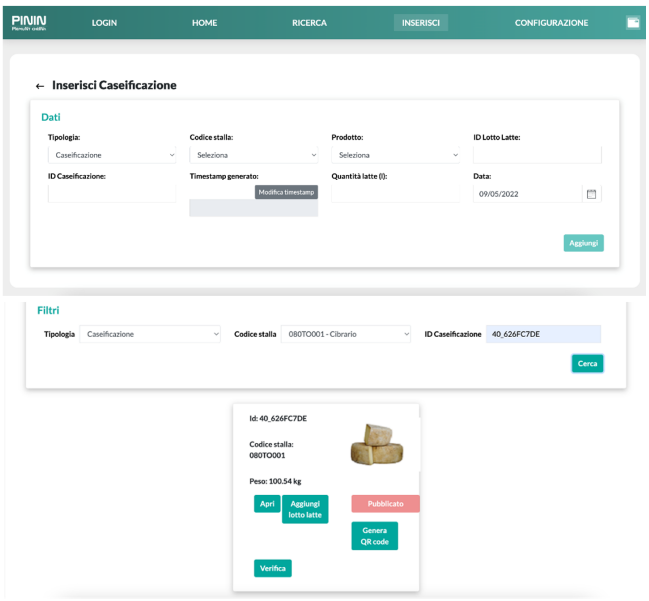

Fig. 1. The PININ dAPP provided to breeders and producers

A. System architecture

In this section we explore the characteristics of the PININ system architecture. It is based on a modular approach that can

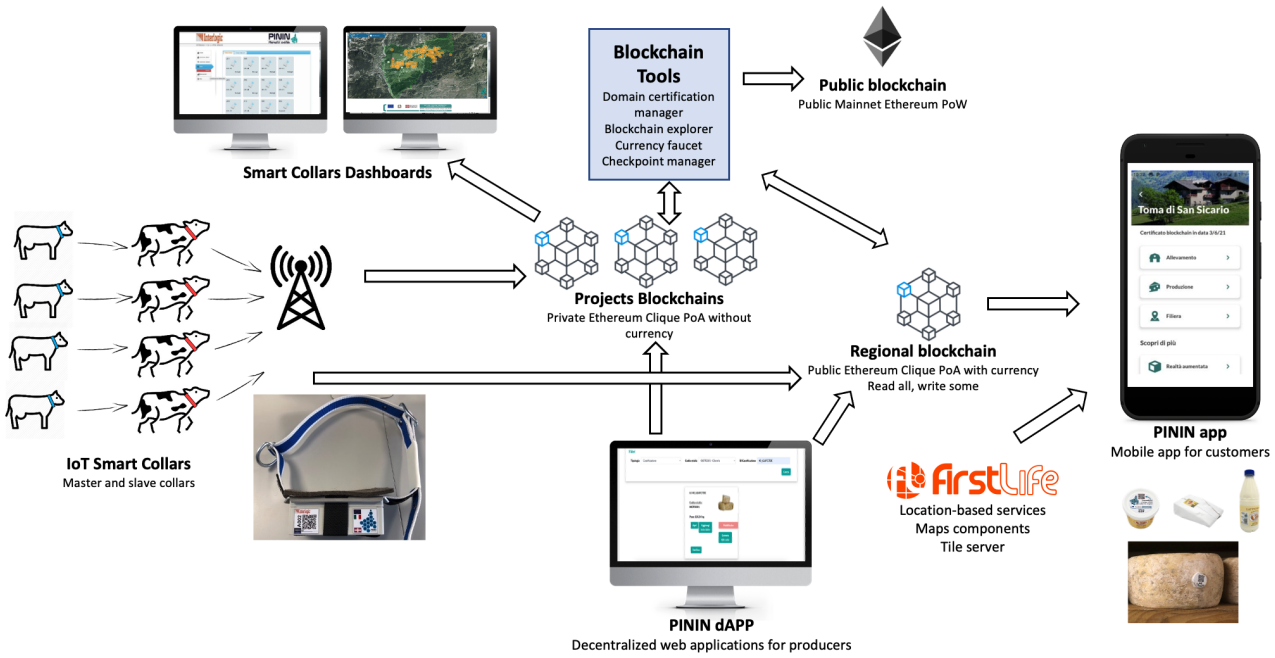

Fig. 2. The PININ system architecture

be adapted and configured to support different agrifood chains. Although in this work we focus on the production chain of dairy products, the ecosystem developed within the PININ project has also been successfully tested in the breeding, production and sale of meat from organic pigs.

Figure 2 depicts the main components of the PININ environment: it is based on IoT, mobile network, blockchain, mobile and web applications, implementing and supporting both data ingestion from breeders and producers (the consortium members) as well as data retrieval from final users.

Starting from the IoT layer, we designed and developed different types of smart collars which, when worn by cows, allowed the tracking of their position while grazing. To save cost in implementing pasture monitoring on a large number of cows, we implemented two collar types, one slave bearing only a Bluetooth Low Energy (BLE) sensor and the other, the master, carrying a GPS/4G module. Thanks to the integrated GPS module, a battery and a cellular transmission module, the master collars are able to sample the position of each cow throughout the day and to periodically send the collected data to the software module responsible for their storage and certification. Positions of slave collars are acquired by master collars leveraging proximity. A map-based interactive dashboard based on the location services offered by the FirstLife [18] platform is available to breeders and public authorities to monitor the positions of the cows over time.

The blockchain module is responsible for the certification of the collected data, and it is based on the Ethereum technology. This module is made up of two different blockchains: the freely accessible Regional public blockchain is an open PoA blockchain maintained by a set of local enterprises, academic institutions and public administrations, and contains all certified data that the consortium members intends to make public to the end users. On the other side, for each specific production chain, a private Consortium PoA blockchain, maintained by the consortium members, is used to certify all consortium-wide private data that can be used for example during auditing from authorities. Finally, the integrity and certification of all information are also strengthen by the implementation of a checkpointing strategy into the Ethereum main net, reducing at the same time transaction costs. We developed a set of smart contracts responsible of storing, indexing and providing collected data.

Breeders, producers, shopkeepers and customers can interact with the blockchain layer by using two different applications designed and developed within the PININ project. The first one is a decentralized application (dApp) offering to all stakeholders of the production chain the possibility of collecting data and certify them into the regional and consortium blockchains (see Figure 1). Considering the production chain of dairy products, the breeder can associate all cow positions to all milk batches obtained after the milking, while the dairyman can link the latter to all cheese wheels produced and monitors all the maturing phase.

The latter application, the one evaluated in this paper, is the PININ application: a mobile application, freely available for Android and iOS devices, specifically developed to provide the end users the possibility of obtaining certified information about the origin of the products (see Section III-B).

B. The Pinin app

We designed and developed a mobile app to provide users with different type of information related to products: certified data about the supply chain and raw materials in the blockchain, information about the product's networks of places, as well as information inserted by stakeholder and other users. It can be accessed in different modalities: geolocated by means of a map, vocally by means of a chatbot, using augmented reality. In details, such mobile app allows the final user to:

- discover the entire production chain of a product (derived from the certificated data in Blockchain), by scanning graphic elements (QR-code or similar) present in the package or at the point of sale
- through geo-localized services on a map, explore the territory in search of the places of production and sale of food products subject to certification
- leave a comment on a single product or on the experience of visiting a place of production or sale
- indicate the preferred products and places, which will be used to personalize the results provided by advanced services on chatbots
- use and populate the geolocalized platform of historical and experiential information linked to the methods of production and use of products
- explore the certificated data present in Blockchain and complementary information with the aid of augmented reality techniques
- explore such information also by means of a personalized chatbot, that is able to provide results related to user's preferred products.

The user can choose if to login the app, in order to have the possibility to save her preferred items and to speed up the connection time.

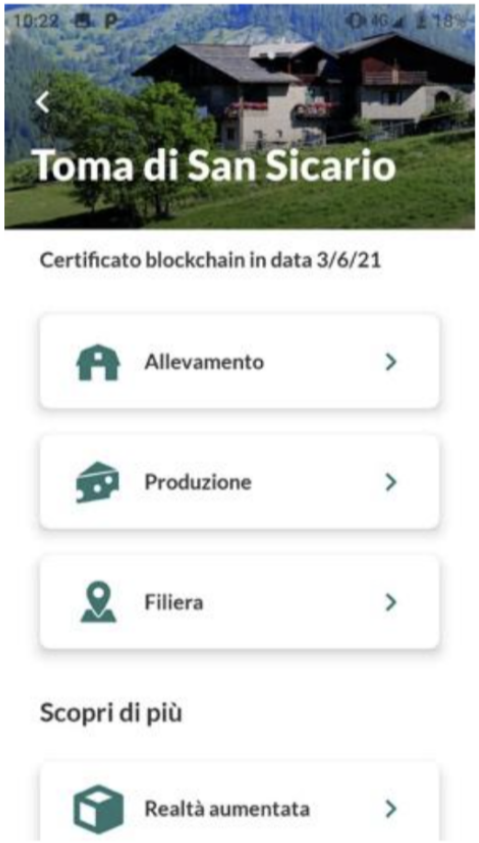

Fig. 3. The PININ app

IV. Evaluation of PININ app

For its evaluation, the PININ app was tested in the field with real users on two different occasions, with the following objectives:

- to test the usability of the solution
- to test the usefulness of the solution

Users had to try the app and then answer a questionnaire. The test experience lasted an average of 10 minutes per person.

A. Experimental Setting

The app was tested in the field with real users in two moments, on 30 April 2022 at the local producers' market in Turin, Italy and on 12 May 2022 at the Computer Science Department of the University of the same city. In total, 35 persons have been involved, and in particular:

- 16 users (customers) at the market (9 males, 7 females)
- 19 users (students, researchers, professors) at the Department of Computer Science (5 females, 13 males)

No monetary or other incentive was provided as a reward for the participation to the study. People have been informed that the data are processed anonymously only for scientific purposes in accordance with European current legislation.

B. Market

The experimentation took place at the Porta Palazzo market at the stall of one of the producers who joined the project. After a brief introduction to the project, users tried the PININ app on a mobile phone provided by the experimenters. In particular, they were asked to frame the QR code of a cheese, without having to log in to simplify the interaction. After that, they browsed the information offered by the app on the supply chain, and the various features (reviews, search for a shop that sells and a restaurant that uses them on a map, augmented reality, reviews). After the experience of using the app, people were interviewed with the questions in the questionnaire and the answers were reported by the researchers (for practical reasons, since there were no conditions for asking them to fill in directly). The sample was selected by asking people who were present on the market and had made a purchase at the supplier's shop.

C. Department of Computer Science

The members of the IT department of the University of Turin (70 members) were invited by means of an email. People who decided to voluntarily participate in the trial were invited

Fig. 4. The PININ app

to a room, where they took part in the test one at a time. In the room, a wheel of cheese was available to be tasted freely. The cheese had a QR code on it that could be framed by a telephone offered by the experimenters. After a brief introduction to the project and a more specific one on the use case being tested, users then tried the PININ app. In particular, they were asked to frame the QR code of the cheese, without the need to log in. After browsing the information offered by the app on the supply chain, and the various features (reviews, search for a shop that sells and a restaurant that uses them on a map, augmented reality), people were invited to fill out a paper questionnaire. 18 people participated, 16 of whom completed the final questionnaire in all its parts, and 1 only in the second part. The questionnaire was completed autonomously by the people who voluntarily joined the trial.

1) Questionnaire: The questionnaire consisted of two parts: a first section (with 10 questions) relating to the level of usability of the app, using a standard SUS closed-ended test, and a second section (with : 11 questions) developed by the researchers on the general utility of the proposed solution (*if it is useful, if you would use it, why? which features are more useful and which less, what the app has helped you with, if it finds it useful to have a reference in the blockchain, if with the app it would buy more local products*).

D. Results

We report here the results of the experimentation separately for the two different settings, given the different experimental conditions.

E. Market

Only eight people said that the app is useful (because "*It is important / interesting to know the origin of what you eat*" (6 subjects), "*It guarantees me the authenticity of the product*" (2)), while the same number has alleged that it was not (because "*The trust in the producer counts more* (2)", "*It takes too long when I shop* (5)", "*I trust the external specification* (1)". Only 3 people said who would use the app in the future. The functionality considered most useful was *tracking* (6 preferences), followed by *QR code*, *the map*, and *the possibility of finding shops and restaurants* (1 preference each). The app in particular was considered useful because it helps to see where the animal was raised (8 preferences) and to discover the origin of the things I eat (5 preferences) and to know the place of the pasture (3 preferences.) The augmented reality functionality was considered less useful. Blockchain technology was known by a minority of subjects (6 out of 16), and consequently almost all (12/16) said they did not find this information useful. Almost all people declared that they already trust the information that is provided on the typicality of the examples (14/16) and therefore with this type of app they would not see their way of buying change in favor of local products (10 out of 16). Despite this, about half of the people expressed their interest in having a system that guarantees you greater reliability of the information on the label.

The following are the most interesting free comments left by the users:

- the possibility of finding shops where to buy the product is useless, since we are already buying it in a shop.
- Useful as a principle idea but I would not use it because it is not very practical at the point of sale (4)
- Useful for products of which I do not know the manufacturer (2),
- a guarantee system for information on the label is useful but in another context, such as the large-scale distribution, not in the market of local producers (2)
- Useful for making a choice among heterogeneous products(1)
- Real-time use of the app is not comfortable, it is better to use it at home after the purchase (1)
- Information that is in the app is more useful for practitioners than for an end user who needs other information presented in a different way, maybe using augmented reality service on the product (1)
- I would not use it for daily shopping but only for the purchase of special value products from time to time (1)

F. Department of Computer Science

All the subjects declared that the app is useful (because "It is important / interesting to know the origin of what

you eat" (5), "it easily provides me with various types of information, including production process and supply chain productive (5) "," It guarantees me the authenticity / quality / guarantee of the product "(4)) and that he would use the app in the future. The features considered most useful were *tracking* and *finding shops and restaurants* (13 preferences each). The app in particular was considered useful because it helps to see where the animal was raised (8 preferences) and to discover the origin of the things I eat (5 preferences) and to know the place of the pasture (3 preferences.) Also for this target, augmented reality was considered as the least useful feature, while grazing-level tracking was deemed too detailed for some. In this context, blockchain technology was known to almost everyone (except two), and consequently almost all (12/16) said they found this information useful. Almost all of the people declared that they already have confidence in the information that is provided on the typicality of the examples (13/19) and that they would be interested to have a system that guarantees you greater reliability of the information on the label. This would make it possible to encourage the purchase of local products (16 out of 19).

These are the most relevant comments:

- Information on pasture, milk batch does not necessarily help to understand the quality of the product (1)
- I would only need it in specific cases, not on a daily basis (1)
- Better to have the farmer who tells me instead of technology (1)
- it would be useful to show pairings with local wines or cured meats
- the app should suggest products that I have told myself I like (1)
- use collars to monitor other parameters (cow health and well-being, tracking in case of death) 1
- the app is also used to support local producers 1

G. Usability results

The 16 users in the market for contingent conditions were omitted the closed questions, which were answered only by the subjects in the IT department. Table I presents the average rating for question (the maximum value is 5):

The standard approach to scoring the SUS is to convert raw item scores to adjusted scores: for the odd-numbered items (the positive-tone items), it is needed to subtract 1 from the raw score; for the even-numbered items (the negative-tone items), it is needed to subtract the raw score from 5. The sum of the adjusted scores then should be multiplied by 2.5 to get the standard SUS score (Lewis, 2018). SUS yields a number (ranging from 0 to 100) representing a composite measure of the overall usability of the system being studied but does not tell what the problems are. Our app measures 55,95. The average value of an SUS questionnaire calculated on over 500 applications is 68. It means that if the SUS score we have collected is 56, if it is lower it is be worse than the average, and thus some works needs to be done to improve the interaction.

Questions	**average rating**
I think I'd like to use this system frequently	3,74519
I found the complex system without needing it	1,49038
I found the system very simple to use	4,33173
I needed to learn a lot of processes before I was able to get the most out of the system	1,42307
I found the various system features well integrated	4,16826
I found inconsistencies between the various features of the system	1,89903
I think most people could learn how to use the system easily	3,90865
I found the system very cumbersome to use	2,07211
I was was very familiar with the system during use	3,92788
I needed to learn a lot of processes before I was able to get the most out of the system	1,41826

TABLE I
THE USABILITY TEST'S ANSWERS

H. Discussion

The results of the experimentation are very different depending on the target. While people in the market are more skeptical about the actual usefulness of the app, at the "neutral" place of the department people have shown to be more interested and convinced of the usefulness of the system in all cases (19/19). The explanation could be that the app is useful in a context where the user do not know the product or there is a choice to be made, not where the user already knows the product and the choice has already been made. For example, at the local producers market in Porta Palazzo, people always buy on a trust basis from the same producers with whom they build a relationship of familiarity and sometimes friendship that lasts over the years. In addition, the banquets are all single-producer. Instead, in a different context, for example a shop in which different types of cheese were presented, the certainty of the origin could affect the final decision, as it was said by the people themselves during the test. This was also confirmed in the context of the IT department, where people were invited to taste a cheese they knew nothing about and it was therefore certainly interesting to have additional information on its provenance. In general, we can say that the most appreciated feature by all users, regardless of the context, was the possibility of tracking, even if not everyone is interested in such a deep level of detail. Some have pointed out that the app could be useful for some purchases, but not in everyday life; others that the app could be useful to practitioners (cooks, chefs, etc). Some people have pointed out that using the app is impractical during the purchase, but it would be better afterwards: in this sense, the functionality that allows you to save the history of scanned products at the point of sale, available only for registered users, is of sure interest. Other very popular features, especially in the neutral context of the department, was the possibility of finding shops where to buy the product, which is obviously less useful on the market point of sale. The least appreciated feature was that of augmented reality because it was considered less useful, in both contexts. The possibility of seeing the blockchain code

was most appreciated, as was to be expected, by users of the IT department, given the technical background. To conclude, we can say that the app could be seen as a digital surrogate for establishing the relationship of trust between producer and consumer in contexts where there are more products and the degree of interaction between consumer and seller is less present.

V. Conclusion

In this paper we present PININ project and in particular the app for giving traceability information to final users. Other aspects have been developed during the projects, like the traceability in the provision of European funds for breeding, anti-counterfeiting of bottled products (wine and spirits), and search for food products with fake brands on E-commerce sites. However they are out of the scope of the paper. The main goal of the project was to increase the quality and perception of high-quality agri-food products through the use of innovative technologies, and according to our evaluation we can see that this goal - with the limitation of context of use seen above- has been reached.

The main limitations of the solution are related to some usability issues, that are emerged from the user tests. At the same time, we need to test with a wider sample of users in a different context of purchase.

As future work we plan to test the platform to the other use cases, such as cattle monitoring and anti-counterfeiting. We are working to extending the map-based representation of the information, in order to allow more efficient information filtering such as in [19].

References

[1] Fabrizio Dabbene, Paolo Gay, and Cristina Tortia. Traceability issues in food supply chain management: A review. *Biosystems engineering*, 120:65–80, 2014.

[2] Kristoffer Francisco and David Swanson. The supply chain has no clothes: Technology adoption of blockchain for supply chain transparency. *Logistics*, 2(1):2, 2018.

[3] Guoqing Zhao, Shaofeng Liu, Carmen Lopez, Haiyan Lu, Sebastian Elgueta, Huilan Chen, and Biljana Mileva Boshkoska. Blockchain technology in agri-food value chain management: A synthesis of applications, challenges and future research directions. *Computers in Industry*, 109:83–99, 2019.

[4] Petter Olsen and Melania Borit. The components of a food traceability system. *Trends in Food Science Technology*, 77:143–149, 2018.

[5] Dong Li, Xiaojun Wang, Hing Kai Chan, and Riccardo Manzini. Sustainable food supply chain management. *International Journal of Production Economics*, 152:1–8, 2014. Sustainable Food Supply Chain Management.

[6] Francesca Antonucci, Simone Figorilli, Corrado Costa, Federico Pallottino, Luciano Raso, and Paolo Menesatti. A review on blockchain applications in the agri-food sector. *Journal of the Science of Food and Agriculture*, 99(14):6129–6138, 2019.

[7] Guoqing Zhao, Shaofeng Liu, Carmen Lopez, Haiyan Lu, Sebastian Elgueta, Huilan Chen, and Biljana Mileva Boshkoska. Blockchain technology in agri-food value chain management: A synthesis of applications, challenges and future research directions. *Computers in Industry*, 109:83–99, 2019.

[8] Sidra Malik, Salil S. Kanhere, and Raja Jurdak. Productchain: Scalable blockchain framework to support provenance in supply chains. In *2018 IEEE 17th International Symposium on Network Computing and Applications (NCA)*, pages 1–10, 2018.

[9] Francisco Maroto-Molina, Jorge Navarro-García, Karen Príncipe-Aguirre, Ignacio Gómez-Maqueda, José E. Guerrero-Ginel, Ana Garrido-Varo, and Dolores C. Pérez-Marín. A low-cost iot-based system to monitor the location of a whole herd. *Sensors*, 19(10), 2019.

[10] Rui Guedes, Paulo Pedreiras, Luís Nóbrega, and Pedro Gonçalves. Towards a low-cost localization system for small ruminants. *Computers and Electronics in Agriculture*, 185:106172, 2021.

[11] A. Buerkert and E. Schlecht. Performance of three gps collars to monitor goats' grazing itineraries on mountain pastures. *Computers and Electronics in Agriculture*, 65(1):85–92, 2009.

[12] Jun Lin, Zhiqi Shen, Chunyan Miao, and Siyuan Liu. Using blockchain to build trusted lorawan sharing server. 2017.

[13] Kazım Rıfat Özyılmaz and Arda Yurdakul. Integrating low-power iot devices to a blockchain-based infrastructure: Work-in-progress. In *Proceedings of the Thirteenth ACM International Conference on Embedded Software 2017 Companion*, EMSOFT '17, New York, NY, USA, 2017. Association for Computing Machinery.

[14] Affaf Shahid, Ahmad S. Almogren, Nadeem Javaid, Fahad Ahmad Al-Zahrani, Mansour A. Al Zuair, and Masoom Alam. Blockchain-based agri-food supply chain: A complete solution. *IEEE Access*, 8:69230–69243, 2020.

[15] Gavina Baralla, Andrea Pinna, Roberto Tonelli, Michele Marchesi, and Simona Ibba. Ensuring transparency and traceability of food local products: A blockchain application to a smart tourism region. *Concurrency and Computation: Practice and Experience*, 33, 2021.

[16] Lodovica Marchesi, Katiuscia Mannaro, and Raffaele Porcu. Automatic generation of blockchain agri-food traceability systems. *2021 IEEE/ACM 4th International Workshop on Emerging Trends in Software Engineering for Blockchain (WETSEB)*, pages 41–48, 2021.

[17] Angelo Marchese and Orazio Tomarchio. A blockchain-based system for agri-food supply chain traceability management. *SN Comput. Sci.*, 3:279, 2022.

[18] Guido Boella, Alessia Calafiore, Elena Grassi, Amon Rapp, Luigi Sanasi, and Claudio Schifanella. Firstlife: Combining social networking and vgi to create an urban coordination and collaboration platform. *IEEE Access*, 7:63230–63246, 2019.

[19] Noemi Mauro, Liliana Ardissono, and Maurizio Lucenteforte. Faceted search of heterogeneous geographic information for dynamic map projection. *Information Processing & Management*, 57(4):102257, 2020.