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### EDITED BY

Manjeet Singh Nain,  
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### REVIEWED BY

Dilshad Sarwar,  
Northeastern University London, United  
Kingdom  
Matilde Reitano,  
University of Catania, Italy

### \*CORRESPONDENCE

Marzia Ingrassia  
✉ marzia.ingrassia@unipa.it

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# Consumer preferences and marketing model for certified blockchain products based on Sicilian ancient grains: authenticity, health, and ecosystem services

Marzia Ingrassia<sup>1\*</sup>, Simona Bacarella<sup>1</sup>, Stefania Chironi<sup>1</sup>,  
Sandro Galluzzo<sup>1</sup> and Giuseppe Russo<sup>2</sup>

<sup>1</sup>Department of Agriculture, Food and Forestry Sciences, Università degli Studi di Palermo, Palermo, Italy, <sup>2</sup>Consorzio di Ricerca Gian Pietro Ballatore, Assoro, Italy

**Introduction:** Sicilian ancient grains have a dual value, as they contribute to biodiversity and are beneficial to human health thanks to their natural resistance to diseases and mycotoxins. In addition, they offer unique sensory characteristics that are appreciated by consumers around the world. The exploitation of these local resources may represent a promising alternative for agriculture in southern Italy. Currently, the absence of a local smart traceability system limits their potential. This study is part of a 3-year regional research project that aims to enhance Sicilian ancient grains through the implementation of blockchain technology along the supply chain to add value to the products by certifying authenticity, food safety, quality, and transparency. The aim is to obtain information on consumer preferences, awareness, and willingness to pay for products made from ancient Sicilian grains certified with blockchain technology, as well as the opinions of experienced entrepreneurs, to design a marketing and communication strategy to promote this supply chain.

**Methods:** Sample surveys were conducted on Sicilian consumers, and focus groups were held with both consumers and experts.

**Results:** An integrated multi-channel marketing and communication model has been proposed as the most effective for this niche supply chain.

**Discussion:** The findings fill a gap in the literature because it is the first study of its kind for this supply chain, and the proposed model is applicable not only to the enterprises of this supply chain but also to other high-value niche product supply chains worldwide.

### KEYWORDS

consumer behavior, product positioning, quality certifications, small and micro farms innovation, sustainable food systems

## Highlights

- Valorization, conservation, and promotion of Sicilian ancient grains (SAG).
- Blockchain technology (BT) for the supply chain certification.
- Consumer's willingness to pay and appreciation.
- Marketing and communication models for SAG-based BT-certified products.
- Replicability of methodology for other niche agri-food product supply chains.

## 1 Introduction

Blockchain is a distributed transaction ledger technology maintained across multiple nodes by a group of participants in a peer-to-peer network. Each new block must be verified through peer consensus mechanisms, and modifying a record requires modifying all subsequent records. Blockchain technology (BT) is very interesting, as it is an innovative disruptive technology that is traceable, immutable, and transparent (Zhang et al., 2023). Blockchain technology (BT) has found applications in a variety of sectors, going well beyond cryptocurrencies such as Bitcoin, revolutionizing the interactions between participants because it ensures trust among them. Nowadays, BT extends to logistics, Industry 4.0, supply chain, finance, document management, decentralized information systems, social networks, IoT, healthcare sector, agri-food sector (Kim et al., 2024), and many others (Osservatori Digital Innovation della School of Management del Politecnico di Milano, 2025). Furthermore, global interest in blockchain is growing in various scientific disciplines, as demonstrated by the numerous international conferences, workshops, and seminars dedicated to blockchain, which are improving its performance thanks to the contribution of artificial intelligence (Ameyaw and de Vries, 2021; Chinnici et al., 2025; Kamble et al., 2025).

BT has found a place in the agri-food sector (Kim et al., 2024) as it can provide transparent information on food products. Recent studies showed that BT can be utilized in agriculture, mostly for food safety, through the traceability of provenance, farming, usage in crop certification, insurance, etc. (Malisic et al., 2023). Most cases of BT application in the agricultural and food sectors relate to food traceability since it has the potential to facilitate transparent information and empower food supply chains. The blockchain platform can contribute to sustainable agriculture and the development of new sustainable food systems (Ellahi et al., 2024). The current food supply chains involve multiple stakeholders, and the use of blockchain technology involves many participants such as farmers, engineers, IT experts, wine producers, and buyers to perform all activities (Agnusdei et al., 2022).

The Sicilian wheat landraces and historical varieties, mainly cultivated at the beginning of the 19th century, defined as “*conservation varieties*,” are commonly known as “Sicilian ancient grains” (SAG), and are local populations and varieties of wheat that retain the agronomic characteristics of pre-green revolution grains. Although these ancient grains are an asset of Sicilian biodiversity and represent sustainability in food production, they are currently at risk of extinction. Although SAG could be a valid alternative to modern wheat cultivars, this supply chain is structurally weak and not solidly organized. Ancient Sicilian grains have various quality characteristics that are appreciated by producers, scientists, and even consumers (Ruisi et al., 2021). For this reason, strengthening this supply chain with the inclusion of products such as pasta, bread, pizza, and other baked goods derived from these ancient grains is of great interest to researchers, producers, processors, pasta factories, artisan workshops, bakeries, pizzerias, bakeries with pizzerias, retail outlets, and even large-scale organized distribution.

The Università degli Studi di Palermo (University of Palermo, Sicily, Southern Italy), along with the Gian Pietro Ballatore Research Consortium (Sicily, Southern Italy) and the Regional Consortium for Applied Research and Experimentation Co. Re. R. A. S. (Sicily, Southern Italy), together with other private partners (entrepreneurs of the supply chain), have carried out a research project funded by the

European Union (under the Common Agricultural Policy through the Sicilian Rural Development Plan 2014–2020), entitled “Organization of a Nutraceutical Supply Chain System for Wheat and Pseudo cereals of High Commercial Interest”. This project, carried out from 2021 to 2024, also known as the ‘SFINGE project’, aimed “to fill the organizational gap in the Sicilian cereal supply chain which is unable to exploit the value of wheat and pseudo cereals of high commercial interest and to promote cereal production and cereal-based products from environmentally protected areas”.

This innovative project involved the implementation of a quality system organized using blockchain technology (BT) to certify the supply chain of Sicilian ancient grains, from seed to flour, at a regional level. This blockchain system had a public institution responsible for certification (rather than several individual peers), i.e., responsible for checking all individual blocks in the chain, for their validation and final closure: the Gian Pietro Ballatore Research Consortium (one of the main partners of the project).

At this time, there is no consumer guarantee system to certify the traceability of the entire SAG supply chain; therefore, it appeared interesting to extend the application of blockchain technology. This extension would allow entrepreneurs to produce and commercialize products made from Sicilian ancient grains, such as pasta, bread, pizza, and baked goods, with an additional value given by the traceability certification with blockchain (Giunta et al., 2020). It is reasonable to assume that the application of blockchain technology along the supply chain could be appreciated by consumers, increasing the perceived value of these products. In fact, a robust traceability certification like blockchain might help to mitigate potential consumer skepticism toward recurring issues such as food quality, authenticity, wholesomeness, safety, security, freshness, and traceability (Sun et al., 2022; Malisic et al., 2023).

This study, carried out between 2021 and 2024, is part of the SFINGE Project with the aim of developing a marketing and communication model to position in the market these products (such ‘new products’)—i.e., pasta, bread, pizza, and baked goods—made using SAG and certified with BT.

It consisted of PHASE 1 “Consumer studies” (Analysis 1 and Analysis 2), and PHASE 2 “Focus Groups with experts (Analysis 3), and design of marketing and communication model/strategy (Analysis 4). More specifically, the objectives of each analysis are specified as follows.

- PHASE 1: Consumer studies (AN1 and AN2)

Analysis 1 “Sampling survey methodology” (AN1) and Analysis 2 “Focus Groups with consumers” (AN2).

- i Objective 1 (O1): Obtain information on consumers’ preferences, purchasing behaviors, motivations, and willingness to pay for products derived from SAG (e.g., pasta, bread, pizza, and baked goods) certified with blockchain technology, as well as their knowledge about blockchain certification.

- PHASE 2: Focus Groups with experts (AN3), and design of marketing and communication model/strategy (AN4)

Analysis 3: “Focus Groups with experts” (AN3).

- i Objective 2 (O2): Obtain information from experts (entrepreneurs and other qualified subjects, i.e., partners of the SFINGE project and other qualified parties such as wheat producers, mills, pasta factories, and industrial bakery manufacturers, who have implemented or are willing to implement the blockchain certification from seed to flour at the regional level) about aims and motivations to define vision and mission, as well as about strengths, weaknesses, opportunities, and threats of producing products with Sicilian ancient grains certified with blockchain technology.

Analysis 4: “SWOT Analysis, “PEST Analysis”, *market analysis, analysis of competitors, analysis of the dimensions of communication by the “AGIL methodology” (AN4)*, combined with the results of “Consumer studies” (AN1 and AN2) and of “Focus Groups with experts” (AN3).

- i Objective 3 (O3): Design a marketing and communication model/strategy for branding, positioning, commercializing, and communicating the value of “new products” (i.e., SAG products with BT certification).

## 2 Sicilian ancient landraces: quality characteristics and value

Italy is Europe’s leading producer of durum wheat and the second largest producer worldwide, with 1.24 million hectares of cultivated area and 3.8 million tons of durum wheat. Italy is also the world’s leading producer and exporter of pasta (Altamore et al., 2018), using mainly Italian durum wheat.

The Sicily region (southern Italy) is the second-largest Italian producer of durum wheat, accounting for 21% of Italy’s total production, after Apulia (southern Italy), which accounts for 28% (Petrontino et al., 2024). The average area cultivated with durum wheat in the 3-year period 2022–2024 is equal to 274,205 hectares, with a downward trend over the last 10 years (290,000 ha in 2015), and it constitutes 96% of the total cereal production, according to the Italian General Census of Agriculture 2020 (Altamore et al., 2024; ISTAT, 2025).

Nowadays, landrace diversity is considered essential to reduce genetic erosion and preserve biodiversity; therefore, there has been increasing interest in wheat landraces and historical varieties cultivated at the beginning of the 19th century, defined as “conservation varieties” (Russo, 2018).

The word “ancient grains” refers to local populations and varieties of wheat that maintain the agronomic characteristics of pre-green revolution grains. These ancient varieties are grown on a few thousand hectares, ranging between 2,000 and 3,000 hectares (Gian Pietro Ballatore Consortium, Cereal Supply Chain Observatory, 2025). According to the National Agricultural Information System (SIAN, 2025), there are currently 29 Sicilian “conservation” varieties, including varieties of durum and soft wheat (Stazione Consorziale Sperimentale di Granicoltura per la Sicilia, n.d.). The varieties of Sicilian ancient durum wheat (SAG) include 19 varieties: *Biancuccia*, *Bidi* (synonym *Margherito*), *Bivona*, *Capeiti 8*, *Castiglione glabro*, *Ciciredda*, *Faricello*, *Francesca*, *Gioia*, *Martinella*, *Paola*, *Perciasacchi*, *Russello*, *Sammartinara*, *Scavuzza*, *Scorsonera*, *Timilia reste bianche*,

*Timilia a reste nere*, and *Tripolino*, among which the best known are *Perciasacchi*, *Russello* and *Timilia reste nere*. These varieties have been included in the specific section for conservation varieties of the National Register of Agricultural and Vegetable Species held by the Ministry of Agriculture, Food and Forestry Policies (MiPAAF), with the Decree of 17 December 2010, concerning “Implementing provisions of Legislative Decree No. 49/2009” on the procedures for admission (European Union, Eur-Lex, 2009, 2023, 2024) for local conservation and enactment of rules for the registration, certification, and marketing of seed material of these varieties. Today, in Sicily, the preservation of germplasm is supported by research institutions such as the “Caltagirone Experimental Station for Cereal Crops”, “CREA-ACM”, “Gian Pietro Ballatore Research Consortium”, universities, which have specific know-how and germplasm collections. The registration of conservation varieties in the register of local conservation varieties is free of charge and is carried out at the request of public bodies, scientific institutions, organizations, and individual farmers (Gian Pietro Ballatore Consortium, Cereal Supply Chain Observatory, 2025; Russo, 2018).

From a nutritional point of view, these ancient populations have a higher gluten content than modern varieties (Palombieri et al., 2024). In fact, the gluten content of wheat depends on its protein content, since gluten is the most significant component. The average protein concentration of ancient varieties is generally higher than that of modern varieties, i.e., 14.5%, while the average value for modern varieties is 12.1% (Paciulli et al., 2021).

In contrast, SAG has a lower gluten index than modern varieties; however, the gluten index does not measure the quantity of gluten but rather some of its characteristics, particularly tenacity (Saia et al., 2015; Badagliacca et al., 2025; Russo, 2018; Cammerata et al., 2021).

These characteristics, which reveal different nutritional properties, imply different attitudes toward processing. The weak gluten index of the ancient landraces makes these varieties less suitable for some processing methods, such as the cooking stability of pasta during the traditional Italian cooking process (Ministero del Turismo, Repubblica Italiana, 2025), as pasta made with SAG becomes overcooked more quickly than common pasta. However, it has a higher aromatic complexity.

As is well known, people affected by immune reactions to gluten intake, known as celiac disease, cannot tolerate even trace amounts of gluten. Therefore, for these people, there would be no difference in the intake of products made from ancient grains compared to modern ones. Moreover, there is no evidence that gluten in modern cultivars is more harmful than that in ancient varieties (Saia et al., 2015). So far, there are no solid studies showing no intolerance to SAG in terms of gluten sensitivity. There is scientific evidence that confirms that ancient grains contain gluten that is not free of the toxic fragments involved in the processes of gluten sensitivity or intolerance (Russo et al., 2014). However, the low tenacity discovered by rheological gluten analyses in SAG has encouraged operators in the cereal supply chain to consider the ease of human enzymes to metabolize these foods in the digestive process (Saia et al., 2015).

Finally, regarding nutrients, the concentration of microelements, in particular iron, zinc, and manganese, was found to be higher in Sicilian ancient populations, showing significant differences compared to modern varieties (Gian Pietro Ballatore Consortium, Cereal Supply Chain Observatory, 2025; Badagliacca et al., 2025). These elements are necessary for healthy human metabolism, so it is beneficial that these products contain higher quantities of them than modern grains.

Sicilian ancient grains have qualities not directly related to their organoleptic characteristics. Native crops help preserve local biodiversity, which is essential for food system sustainability (Pandolfo et al., 2021). The large number of ancient local populations is an important source of biodiversity due to the presence of a gene pool with a broader base, which can allow greater plasticity in adapting to different environmental conditions and a lower need for inputs for cultivation, also adapting to eco-compatible production techniques (Badagliacca et al., 2025; Russo, 2018; Zhang et al., 2024). Therefore, SAG are a valuable source of biodiversity and germplasm of great scientific interest due to their unique qualities in terms of taste, health, and nutrition (Ruisi et al., 2021; Gallo et al., 2010).

In relation to food safety, a survey carried out by the “Gian Pietro Ballatore” Research Consortium between 2006 and 2008, as part of the national “MICOCER” (mycotoxins and cereals) project, coordinated by the Lombardy region, showed that Sicilian durum wheat production is less exposed to the risk of mycotoxin contamination than other Italian wheat productions. Mycotoxins are natural products of the secondary metabolism of molds that have toxic effects on humans and animals. Mycotoxins are particularly dangerous to human health as they cannot be eliminated through digestion or heat treatments used during food preparation and preservation (Armeli et al., 2025). However, the wheat supply chain can be exposed to various contaminants that may affect wheat quality, food safety, and human health.

In recent years, public institutions have been strongly committed to maintaining and promoting food safety through their regulatory activities, not least in the wake of repeated food scandals affecting many countries. In 2002, the European Union (EU) established the European Food Safety Authority (EFSA) to control and assess the risks of dietary exposure to mycotoxins, with Commission Regulation (EU) No. 2023/915 of 25 April 2023, as amended by Commission Regulation (EU) No. 2024/1038 of 9 April 2024, and to ensure a high level of consumer protection and to restore and maintain confidence in the EU food production and/or distribution system.

Thanks to the region's soil and climate conditions, durum wheat cultivated in Sicily boasts hygienic and sanitary conditions that protect consumers from the risk of mycotoxins and other pathogens. The supply chain of Sicilian ancient grains is shorter than that of modern wheat; this implies further advantages in terms of sanitary quality and hygiene due to the short time raw materials spend in storage and the lower risk of biological oxidation and pathogen attack on the seeds.

Another positive characteristic is that conservation varieties are more resistant to weeds and thus help to decrease production losses. Moreover, their taller size also aids in biomass production, which negatively affects product yield. Regarding phenological characteristics, the Sicilian conservation varieties have a longer biological cycle than modern varieties (a later heading date), and literature has shown less susceptibility to brown rust infection and plant diseases (Pandolfo et al., 2021; Paciulli et al., 2021).

Agriculture contributes significantly to greenhouse gas emissions due to land use, fertilizers, and livestock production, but it is also a victim of climate change caused by global pollution. High temperatures and drought have led to changes in crops, unstable yields, and increased resource use. Over the years, modern wheat cultivars have replaced ancient varieties to increase economic efficiency. In this scenario, conservation varieties, with a biological stability that guarantees a satisfactory minimum yield even in poor, infertile, or drought-stricken environments, sometimes exceeding that of modern varieties, may be a possible alternative. The opportunity to cultivate SAG, with

their high resistance to adversity and high aptitude to produce with few inputs, may be a viable alternative for future Sicilian agriculture, which is still technologically backward and has an agricultural system very different from that of large agro-industrial companies in northern Europe or the rest of the world (Altamore et al., 2024).

Regarding the sustainability of food systems, the production of typical/local products, often products with quality certifications such as PDO and PGI, which are the pride of “Made in Italy” (Ricci et al., 2019), helps local micro-producers maintain their competitiveness in the domestic and international market. Therefore, the production and promotion of local quality products are crucial aspects for local small and medium-sized enterprises (Ingrassia et al., 2023). Moreover, such agricultural niche products, which are strongly linked to the territory, are a distinguishing and qualifying feature of entire regions, becoming one of their main attractions for tourists (Ingrassia et al., 2023; Zhang et al., 2025) and helping the local population remain in rural areas and preserve their culture and local socio-cultural traditions. International market dynamics, including price fluctuations and declines, cause sales difficulties for farmers. This is particularly evident in productive areas such as Sicily, which are not yet at the forefront of technology and produce limited quantities of wheat compared to other European and non-European territories. In this current geopolitical and economic global context of increasingly significant challenges for farmers, growing high-quality wheat is becoming complex and unsustainable, both economically and environmentally.

Furthermore, the permanence of people and their economic activities in rural areas contributes to maintaining the agricultural landscape of rural territories in proximity to urban areas (Ingrassia et al., 2023). These territories and landscapes represent the culture of populations that have based their traditions on agricultural activities for centuries—an “agricultural culture” or “agri-culture” (Saltini, 2010; Russo, 2009)—that is the culture of people who pass down production methods and high-quality products. In addition, this type of agriculture provides valuable ecosystem services to the inhabitants of nearby urban areas (Bellia et al., 2021; Prestia and Scavone, 2018; Marchese and Anselmo, 2001). Maintaining native crops adapted to the local climate and soil and able to grow even in extreme agronomic conditions is essential for the resilience of agriculture and the survival of these endangered rural ecosystems.

As regards the consumer, some of these varieties are going to be more often used to make pasta, bread, pizza, and bakery products, and today there is a growing number of bakeries, pasta factories, and pizzerias that produce products derived from SAG because consumers are showing increasing interest in these products (Cuoco et al., 2022). This interest is linked both to the perception that these grains are healthier and of higher quality and to their association with more traditional and sustainable agricultural practices. In fact, consumers are nowadays increasingly attentive to the origin of products, health, quality, and respect for the ecosystem. However, some critical issues arise to guarantee customers about the real genetic identity and traceability of these products. Typical products may be perceived by consumers as more natural and respectful of the ecosystem (Ingrassia et al., 2023) because they are associated with more artisanal activities and have a lower environmental impact than industrial products, as well as using raw materials and production techniques that are more respectful of the natural balance in terms of the use of additives, preservatives, chemical contaminants, etc. (Ingrassia et al., 2023). Moreover, the possibility of obtaining a “safer” flour, given the grains' genetic predisposition to adversity resistance, creates a significant added value for

products made from these grains. The consumer today is increasingly demanding when it comes to food safety and product origin (Joya et al., 2025). A strong appeal of products made with Sicilian ancient grains might encourage entrepreneurs to their adoption and cultivation. To promote the commercialization of these products, a certification that ensures traceability, authenticity, and food safety could help both consumers and wheat producers of the Sicilian ancient grains (Alam et al., 2025). Blockchain certification can be an extraordinary attribute of quality to support agriculture and the Sicilian ancient grains chain toward more sustainable and sophisticated traceability systems that certify product authenticity and provide greater safety for consumers (Oh et al., 2025; Guo et al., 2025).

### 3 Materials and methods

#### 3.1 Analysis 1: “Sampling survey methodology” (AN1)

For Analysis 1, the “Sampling survey” methodology was used. The statistical population of residents in Sicily in 2022 was chosen as the starting point, which, according to the latest ISTAT census, is equal to  $N = 4,814,016$  (ISTAT, 2022). This initial population was stratified by the following socio-economic characteristics: gender, age group, educational qualification, and annual family income. Some reflections were made aimed at obtaining a sample composition that was suitable for results not influenced by any socio-economic variable (characteristics of respondents). Therefore, for this study, we wanted a sample with a similar number of males and females, as well as in terms of income ranges. The average income in Italy is around €23,000–24,000 gross per annum for the general average of taxpayers (ISTAT, 2022), with significant differences between categories: employees around €23,000, self-employed workers around €64,600 gross (but with significant disparities), and pensioners above €19,700. Other ISTAT data for households (2023) indicate a median net household income of around €33,800 per year, but half of households earn less than €27,000, highlighting significant inequality. Considering that in Sicily the total number of employed persons (public plus private) was 1,181,000, of which 300,000 were public employees and 811,000 were private employees and self-employed workers (ISTAT, 2022), it was decided to divide residents according to income and to select for this study an equal number of respondents belonging to the two main income brackets, i.e., less than €25,000 and between €25,000 and €50,000.

Regarding age, a low priority was given to young people with a medium-high level of education, as they are likely to be more informed about blockchain and representative of future consumers.

The methodological choice to overrepresent young people and those with a high level of education in the final sample of 628 units deserves attention and should be discussed in more detail within the scope of the study, as it may overestimate the general interest in blockchain technology. Millennials (Generation Y) and Generation Z together represent approximately 75 to 80% of individual cryptocurrency holders in Italy, while Baby Boomers account for less than 1%. This group was oversampled in this study not to artificially inflate the perceived interest in blockchain technology, but because they represent the potential consumers of today and of the future.

Recent studies indicate that education level is one of the most significant factors in blockchain adoption (Castro and

Au-Yong-Oliveira, 2021). Lack of awareness and skepticism about ease of use remain the main obstacles for those without an academic or technical background. More educated users tend to perceive the advantages of blockchain in terms of transparency and immutability, factors that foster trust in the system (Kasumu and Agbarakwe, 2025).

Low incomes are closely linked to low levels of education, both in Italy and globally. Istat data for 2025/2026 show that there is a strong link between low income and low levels of education (ISTAT, 2024). The most recent data from 2025 and early 2026 confirm that education remain the main driver of social mobility and earning potential. Among young adults (aged 25–34), the unemployment rate for those without a diploma is 12.9%, compared to 6.9% for those who have completed secondary or higher education (ISTAT, 2025).

A slightly higher number of young adults with a high level of education in the sample reflects a group of consumers who are more likely to understand the value of BT, but there is a risk of failing to grasp the real barriers (technical and psychological) that hold back the less educated general population. However, since the prices of these new high-quality products will certainly be higher than those of common products at the beginning of their commercialization, a slightly higher number of young adults with medium-high income and education levels seem appropriate.

As is well known, the sample size depends on the parameter to be estimated or the hypothesis to be verified, the type of sampling (block or repeated), the variability of the population, the acceptable error, and the probability assigned to the confidence interval. To decide on the sample size, the percentage of error that is acceptable must be established. The degree of confidence to be attributed to the result must also be established. Since in this case the population is very large, it is possible to consider valid the probability conditions of  $p = q = 0.5$ ; therefore, a sample of  $n = 628$  units was considered suitable for this study with the following conditions:  $p = q = 0.5$ ,  $\epsilon = 4\%$ , and  $\text{Prob} = 95\%$ . From the initial database obtained at the end of 2024 (database of 3,192 cases), the cases with errors or blank records (no answers) were excluded. Using R statistical software, it was possible to extract from the clean database of 3,146 cases (completed questionnaires) a sub-sample of  $n = 628$  cases simultaneously (random bulk extraction), following the established rules: number of males = number of females, almost equal numbers for each age group with light priority for young people, average income of 37,000 euros, light priority for high education. The standard error (SE) measures the standard deviation of the sample distribution. With a sample of  $n = 620$ , the SE, which measures the accuracy of the sample estimate relative to the true value of the population, is equal to 1.99%. This methodology made it possible to draw inferences from the results obtained, and the stratification criteria applied increased the accuracy of the estimates.

##### 3.1.1 The questionnaire as a research tool

A questionnaire was specifically designed for this survey and then tested by a panel of qualified individuals with specific expertise on the subject to ensure consistency and coherence. Subsequently, a pre-test of the paper questionnaire was carried out using the “self-completion method with assisted administration” on a small sample of individuals randomly selected from the university campus, with the aim of verifying the clarity of the questions, the simplicity of the language used, and the suitability of the type of response for each question to simplify and speed up the response process for respondents. Following the test, an online version of the questionnaire was created using Google Drive

tools, and the link to the online version of the questionnaire was disseminated, from January 2022 to December 2024, via institutional emails and social media platforms (LinkedIn, Facebook, X (formerly Twitter), Instagram) belonging to the University of Palermo. Through these channels, and with the help of public institutions or authorities (the universities of Palermo and Catania, the Region of Sicily, the Chamber of Commerce, the Tax Office, the national social security institution, and professional associations), it was possible to obtain institutional email addresses. In the questionnaire format, it was stated whether respondents wished to participate in the study. If they answered positively, they were asked to declare their consent by selecting a prepared consent declaration inside the questionnaire. People who received the questionnaire via a link, if they wanted to participate in the research, had to complete the questionnaire independently (self-completion) and submit it via an option at the end of the questionnaire that led directly to a linked database.

The questionnaire was structured with closed and open-ended questions, with alternating or multiple answers, as well as filter and barrier questions. In particular, the questionnaire had two sections, the first containing questions on the socio-demographic characteristics of the sample and questions about products made from SAG, and their consumption at home and outside the home, motivations, and preferences for the consumption of pasta, bread, pizza, and other baked products made with SAG. The second part contained questions aimed at determining respondents' preferences for products made from SAG and certified with BT, information required, means of information, and consumers' willingness to pay for these products. Motivations and preferences were assessed using a preference scale. The score was assigned using a preference scale from 1 to 10, which was described as follows to facilitate understanding: 1–2 = not very preferred, 3–4 = slightly preferred, 5 = moderately preferred, 6 = sufficiently preferred, 7–8 = fairly to very preferred, 9–10 = extremely preferred. Respondents were asked to express their preference by assigning a score to each of the selected variables identified for the survey. Cronbach's alpha was used to verify the internal consistency of the questionnaires. For this study, an index value between 0.80 and 0.90 was accepted, indicating a good level of internal consistency (the coefficient varies between 0 and 1).

### 3.2 Analysis 2—"Focus Groups with consumers" (AN2) and Analysis 3—"Focus Groups with experts" (AN3)

Focus group (FG) methodology is a qualitative interview methodology often used for social research to collect qualitative information (Nyumba et al., 2018) and is based on literature for similar studies (Winter Falk et al., 1996; Osei et al., 2021; Altamore et al., 2018; Altamore et al., 2017). It is based on discussions among a group of people about a topic to be investigated in depth. The main objective of focus group methodology is to gather ideas, considerations, and suggestions from a group of individuals selected according to a well-defined target and invited to discuss freely and spontaneously on a specific research project (Hennink, 2007; Osei et al., 2021; Altamore et al., 2018; Altamore et al., 2017). It can be organized with consumers on a specific topic or product, or with experts (stakeholders or entrepreneurs) on issues of interest (Betts et al., 1996). Following the FG methodology, the discussion among participants is conducted by a moderator with experience in this type of methodology. The

moderator must introduce a series of topics to the selected small group of individuals in an informal and seemingly unstructured manner and facilitate discussion without influencing the opinions and relationships between participants, ensuring that the flow of information proceeds toward the objective of the discussion (Krueger, 1998; Hennink, 2007; Altamore et al., 2018; Altamore et al., 2017). The selected group of participants must consist of a minimum of 8 and a maximum of 13 people, who can be homogeneous or not in terms of social and economic characteristics depending on the aim of the study (Betts et al., 1996). The maximum duration of the session must not exceed 90 min (Betts et al., 1996), and in this study, the session lasted 60 min. The discussions were carried out at the research center of the Co. Re. R. A. S. (Consorzio Regionale per la Ricerca Applicata e la Sperimentazione, one of the main partners of the SFINGE project, see Introduction). Before each session began, participants were asked if they would like to take part in this study. If they answered affirmatively, they were asked to give their consent by signing a written consent form.

The participants' discussion was recorded by the authors and subsequently transcribed verbatim (Betts et al., 1996; Altamore et al., 2018; Altamore et al., 2017). The information obtained was analyzed in accordance with the methodology for analyzing these types of results (Hennink, 2007). This study involved the full transcription of audio/video recordings and the development of a shared opinion hypothesis among participants, identifying the relationship between discussions to explain the phenomenon under study. In addition, the content of the conversation was analyzed using NVivo v. 15 software (R Time Scientific Solutions) to quantify the frequency of certain terms or themes (where appropriate) and to describe opinions qualitatively. NVivo is qualitative data analysis software used to organize, analyze, and find logical patterns in large volumes of unstructured information. It is widely used in social sciences, marketing, and business intelligence (Ingrassia et al., 2022a). It is also particularly useful for managing and analyzing data that are not strictly numerical, such as texts, web and social media content, multimedia and files.

Vos Viewer software was also used for Analysis 3 "Focus Groups with Experts" to process the information obtained from the verbatim transcription of the focused group discussion (Chironi et al., 2020) and to obtain the co-occurrence Scientific Map (van Eck and Waltman, 2010; Kirby, 2023; Chinnici et al., 2025), which is a graphical representation that may highlight elements that do not emerge clearly from vast discussions and discover interconnections about the topics discussed that can be linked in a network (van Eck and Waltman, 2010; Bellia et al., 2022). In this case, it was used to create a conceptual map of links among the main topics discussed and highlight the main ideas on which to build the marketing model (in particular the Vision and the Mission).

For Analysis 2—"Focus Groups with consumers" (AN2), two sessions, each with eight different consumers, were carried out. When choosing the group, it is necessary to consider the variables that influence the purchasing choice and the product's consumption. On this basis, a heterogeneous sample of individuals, as described in the sampling methodology (Par. 3.1.), was chosen (Trost, 1986). Therefore, the participants were selected according to different consumer profiles previously identified by the research group based on predefined segmentation criteria from marketing literature (Keller and Kotler, 2009; Kotler et al., 2019; Peter et al., 2024) and previous works (Altamore et al., 2018). The four identified profiles differ in terms of age range and

TABLE 1 Profiles of participants selected for the focus groups based on socio-demographic characteristics, behaviors, and lifestyles.

Profiles	Socio-demographic characteristics	Consumption behaviors	Lifestyles
1. Four participants	Ages: 16–30 Gender: two males and two females Family unit: two singles and two cohabitants without children. Occupation: students; public and/or private employees or freelance professionals	Place of consumption: both outside and at home Frequency of consumption: daily	Two sedentary and two practicing sports
2. Four participants	Ages: 30–40 Gender: two males and two females Family unit: at least one single and at least one cohabiting with children. Occupation: public and/or private employees or freelance professionals	Place of consumption: both outside and at home, with at least one predominantly outside and one mainly in the home Frequency of consumption: at least one daily and one weekly	Two sedentary and two practicing sports
3. Four participants	Ages: 40–60 Gender: two males and two females Family unit: at least one single and at least two cohabiting with or without children. Occupation: public and/or private employees or freelance professionals	Place of consumption: both outside and inside the home and mostly outside the home Frequency of consumption: at least one daily	Two sedentary and two practicing sports
4. Four participants	Ages 60–70 Gender: two males and two females Family unit: at least one single and at least two cohabiting with or without children Occupation: at least two retired people and public and/or private employees or freelance professionals	Place of consumption: at least one outside of home (predominantly at home) Frequency of consumption: at least one daily	At least one practicing sport

other socio-demographic characteristics, consumption behaviors, and lifestyles (Table 1).

For Analysis 3—“Focus Groups with experts” (AN3), three sessions in two different times (six sessions in total) were carried out with the partners of the SFINGE project, i.e., farms, and other enterprises (wheat producers, mills, pasta factories), actively participating in trials, in the implementation of the integrated traceability system for cereals and pseudocereals in Sicily, and in the creation of experimental fields; the company involved in the configuration, adaptation and segregation of the centralized blockchain system for the traceability of personal and geographical information of participating companies; wheat producers, mills, pasta factories, industrial bakery manufacturers, who are willing to implement the blockchain certification (from seed to flour at the regional level) and other qualified persons like, including the scientific managers of the research bodies involved in various capacities in the project, the managers of the Department of Agriculture responsible for the Rural Development Program measure through which the project was funded, and a number of university researchers who are experts in marketing and ancient Sicilian grains from an agronomic perspective.

These sessions of focused groups’ discussions were carried out to discover vision, mission, strengths and weaknesses, opportunities and threats of experts in this sector (Objective 2).

In total 24 people participated in the sessions with experts (divided as eight people for each focused group). In particular, the first three sessions were organized in 2022, after one year of project, and the second three in 2024, at the end of the SFINGE project (after having implemented the blockchain certification from seed to flour at the regional level).

### 3.3 Analysis 4—“SWOT Analysis, “PEST Analysis”, market analysis, analysis of competitors, and analysis of the dimensions of communication by the “AGIL methodology” (AN4), combined with the results of “consumer studies” (AN1 and AN2) and “Focus Groups with experts” (AN3)

For the design of a marketing and communication model/strategy for branding, positioning, commercializing, and communicating the value of “new products” (i.e., SAG products with BT certification), results from Analyses 1, 2, and 3 were used as inputs. SWOT Analysis, PEST Analysis, market analysis, analysis of competitors, and analysis of the dimensions of communication by the AGIL methodology were carried out (Mancini et al., 2019; Schimmenti et al., 2021).

For identifying the communication dimensions of these ‘new products’, the AGIL model developed by Parsons (1965) was used, which includes the four ‘Dimensions of Communication’ (Parsons, 1965). Multidimensional methods are used for complex phenomena so that they can be broken down into simpler components and are generally applied to analyze communication (Ingrassia et al., 2018; Ingrassia et al., 2022b; Ingrassia et al., 2024). The basic assumption of the paradigm from which Parsons starts, in his functionalist interpretation of social systems, is that every system, to survive and develop, must be able to solve four classes of functional problems referred to by the four letters of the acronym: A = Adaptation (adaptive function); G = Goal attainment (achievement of goals); I = Integration (integrative function); L = Latent pattern maintenance (maintenance of the latent model). The authors’ elaboration of Parsons’ model developed for this study is shown graphically in Figure 2 (Ingrassia et al., 2018;

Ingrassia et al., 2022b; Ingrassia et al., 2024). These four dimensions are displayed in quadrants on a Cartesian axis and must be read counterclockwise, starting from the upper right quadrant of the adaptation dimension, which represents maximum “symbolic complexity” and maximum “contingency of action,” and ending with the latent patterns dimension, which represents minimum “symbolic complexity” and minimum “contingency of action” (Ingrassia et al., 2018; Ingrassia et al., 2022b; Ingrassia et al., 2024). The first quadrant is the dimension of adaptation (A), which refers to a key aspect of communication that involves the efficient use of resources and methods in the service of a compelling purpose. The goal is to adapt communication approaches to different social structures, such as the market, mass media, digital media, and institutions. The second quadrant is the dimension of goal attainment (G), a cognitive aspect of communication that operates based on the information distribution function and refers to the principle of achieving the desired goals of information dissemination. The third quadrant is the integrative function (I), which emphasizes the norms and values of the community in which communication takes place, as well as the principles and traditions shared by the community. The fourth quadrant is the latent patterns dimension (L), linked to communication as a means of expressing one’s identity, whether individual or collective; it should measure consistency with shared values and ideas.

Based on the methodology for AGIL analyses, the participants in all focus groups (both consumers and experts) were asked to rank the importance and appropriateness of the selected indicators identified using a 5-point importance scale: 1 - not important/completely inappropriate, 2 - slightly important/inappropriate, 3 - moderately important/appropriate, 4 - very important/appropriate, 5 - absolutely important/very appropriate. The indicators identified are social networks, TikTok, Instagram, X (formerly Twitter), mobile messaging apps, the Internet, school, academic degree, post-graduate degree, family and friends, work colleagues, other institutional sources, newspapers and magazines, radio, digital disclosure platforms, YouTube, PayTV, and other (Figure 1).

The effectiveness of each dimension was calculated as the sum of scores assigned to each dimension divided by the sum of scores assigned to all dimensions (Ingrassia et al., 2024).

$$\%DimEffect = \left( \frac{\text{Sum of score assigned to one dimension}}{\text{Sum of scores assigned to all dimensions}} \right) \times 100$$

## 4 Results

This section provides a description of the results with their interpretation. The section is divided by subheadings: 4.1. Results of Analysis 1: Consumer responses to questionnaires; 4.2. Results of Analysis 2: Focus Groups with consumers; 4.3. Results of Analysis 3: Focus Groups with experts; 4.4. Results of Analysis 4: Marketing and communication model.

### 4.1 Results of Analysis 1: consumer responses to questionnaires

Concerning the socio-demographic characteristics of the sample, including city of residence, gender, age, level and field of education, occupation, family composition, and average annual income, results are shown in Table 2.

Most of the respondents, 91.7%, are from Sicily, and the remaining people are residents in Sicily but from other regions or countries. Results regarding gender show that 50% of the total are male, 48.3% are female, and 1.7% of respondents did not specify.

Regarding the age of respondents, the highest percentage, equal to 36.7%, falls within the 27–39 age group, followed by the 40–49 age group (17.5%). The remaining respondents are equally distributed across the other age groups, except for those over 70 years old (2.5%). About educational qualifications, 48.3% stated that they had a first and/or second level university degree, while 33.3% had a high school

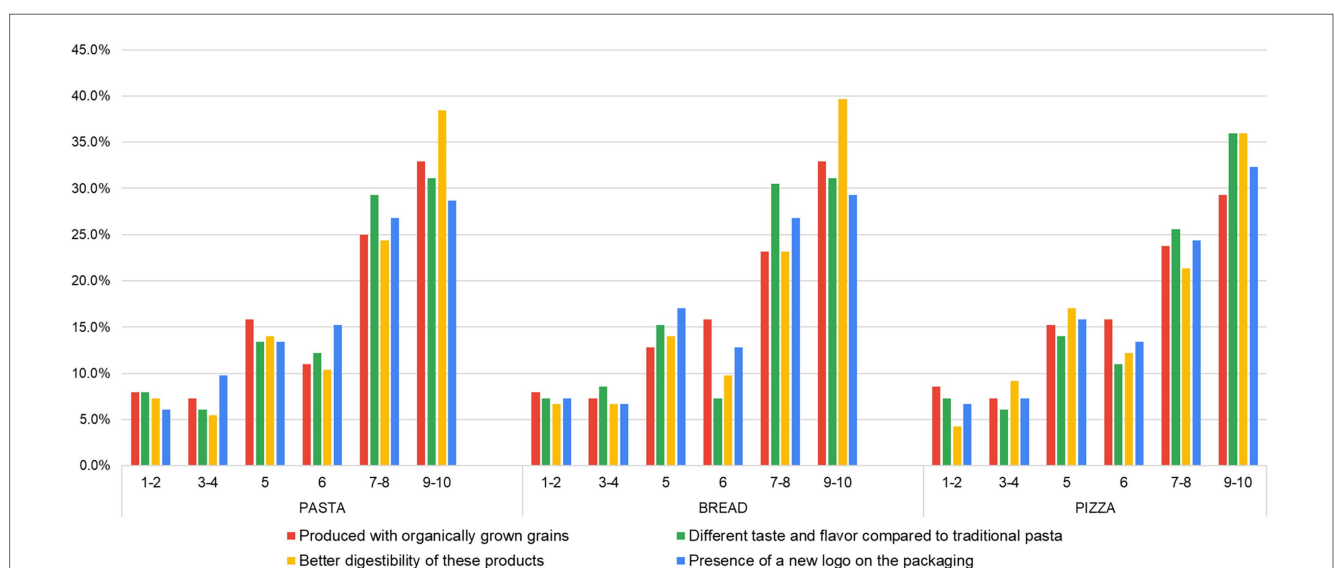
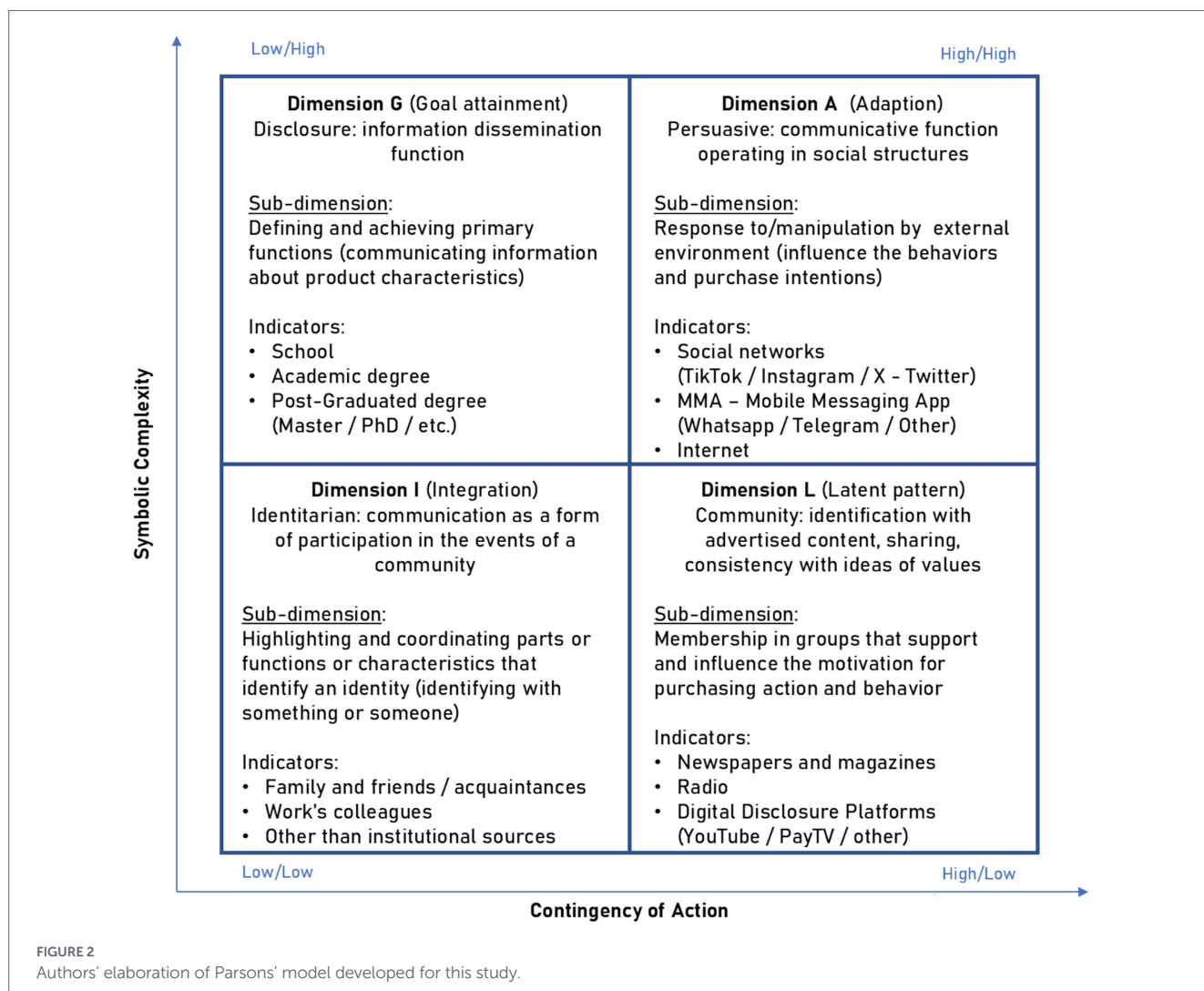


FIGURE 1 Consumer preferences for characteristics of pasta, bread, and pizza made with SAG considered during the purchasing phase. Information about other baked goods is not included in this paper due to space constraints. No noteworthy differences compared to those reported for pasta, bread, and pizza were found. The data are available on request.



diploma or less, and 16.8% had a master's degree/PhD or other qualification. Specifically, when asked to elaborate on the subject area of their studies, 44.2% of respondents said they had studied natural/earth/environmental/agricultural sciences, 20.8% economics/law, and 12.5% for both humanities/literature and mathematics/computer science. Lower percentages were recorded for other types of study. With regard to occupation (Table 2), 42.5% of the sample said they were employees, both in the public and private sectors, 15.0% were teachers/professors/researchers, 13.3% were entrepreneurs or freelancers, and 10.8% were students. A smaller percentage of respondents were employed in other occupations, while 15.0% were unemployed. The household consisted of three or four people in 57.5% of cases, two persons in 25.8% of cases, 10.8% lived alone, and 5.9% lived with more than four people. When asked about their average annual income, 44.5% said they had an average annual income of less than €25,000; 40.2% had an average annual income of between €25,000 and €50,000, while 15.3% said they earned more than €50,000 per year.

It was asked about consumers' information regarding SAG (Table 3). Almost all respondents said they had heard of ancient Sicilian cereals (91.1%). It is interesting to note that when asked what ancient grains are, respondents expressed conflicting opinions between the two answer options, giving greater prevalence to ancient varieties that enjoy qualitative characteristics such as greater nutrition and digestibility. Furthermore, as these products are strongly linked

to the territory and its traditions, it can be noted that the main source of information on these grains comes from places of consumption such as restaurants/pizzerias (20%), although the Internet and social networks together account for 21% of the total.

Regarding respondents' knowledge of the characteristics of products made with SAG (Table 3), results show that consumers have no correct knowledge about them. In fact, 68.2% of the respondents claim that they help against digestive disorders, and 74.7% claim they have superior health benefits compared to other types of grain. However, 89.2% of respondents say they purchase and consume SAG-based products.

Table 4 shows consumers' responses about the consumption and purchase of products made with SAG, with details of different age ranges and educational levels. Results show that no group of consumers declares they consume and purchase foods made with Sicilian ancient grains.

In general, all respondents are primarily interested in both consuming SAG outside the home and purchasing them for home consumption (56.5%), while 33.4% consume them only outside the home. The youngest consumers, ranging from 16 to 39 years old, are the most interested in both consuming outside the home and purchasing SAG products for home consumption. Among these, respondents with a degree (any level) show the greatest interest (25.6% of the total). These results also reflect the characteristics of the sample, which is composed

TABLE 2 Sample socio-demographic characteristics.

Variables	Variable character	Frequency (%)
Gender	Female	48.3
	Male	50
	Do not to answer	1.7
Age	16–26	15
	27–39	36.7
	40–49	17.5
	50–59	13.3
	60–69	15
	70 and up	2.5
Education	High school or less	33.3
	Master's degree (any level)	48.3
	Postgraduate studies	16.8
	Chemical analyst	0.8
	Eighth grade	0.8
Occupation	Student	10.8
	Employee (public/private)	42.5
	Researcher/teacher/professor	15
	Entrepreneur/freelancer	13.3
	Managers (public/private)	3.4
	Unemployed or inactive	15
Thematic area of studies	Economics/justice/political science/social sciences	20.8
	Natural/earth/environmental/agricultural sciences	44.2
	Architectural/engineering/art sciences	4
	Mathematics/physics/computer science	12.5
	Humanities/literature/linguistics	12.5
	Nursing science	3
	Languages	3
Number of cohabitants at home	Three- or four-person household	57.5
	Two-person households	25.8
	Living alone	10.8
	More than four persons	5.9
Range of income	Below €25,000	44.5
	From 25,000 to 50,000 euros	40.2
	Above 50,000 euros	15.3

of a slightly higher number of young people aged 16 to 39 (51.7%, Table 1). In general, the respondents most reluctant to consume this type of product (at home and outside the home) are those aged 60 and over, who are less inclined to try new consumption experiences and change their consumption habits.

Regarding preferences for pasta, bread, or pizza made with grains grown in Italy or Sicily, and preferences for SAG or quality certifications, Table 5 shows the results of the respondents' preferences for

products with grains grown in Italy, Sicily, and for SAG. Results highlight that consumers prefer products made with domestic wheat; for 43.6%, Italian wheat is extremely preferred, while for 56.7%, Sicilian wheat is extremely preferred. Regarding SAG, consumers show high appreciation for pasta, pizza, and bread, with a percentage of "Extremely preferred (10-9)" higher than 30%. About products with quality certifications such as Protected Denomination of Origin (PDO), Protected Geographical Indication (PGI), or organic certification (Ingrassia et al., 2022a; Altamore et al., 2017; Altamore et al., 2018), respondents show a positive preference (70% preference in the 5–10 range). On the other hand, they are very reluctant to consume these types of products enriched with functional components (Table 5).

In accordance with the literature (Altamore et al., 2018), the sensory appreciation of SAG by consumers is a very important finding because taste, smell, and visual appearance are some of the primary drivers of liking for food products. Consumers declared that the different tastes and aromas are noted mainly for pizza, and improved digestibility was noted for pasta and bread (data not shown). Results also highlight the misconception that these products are easier to digest than others made from modern hard grains (data not shown).

About consumers' knowledge of blockchain-certified SAG-based products, it emerged that as many as 70.7% of respondents were unaware of the existence of this type of certification for food products. Respondents were then asked, in the case of purchasing pasta, bread, and pizza made with SAG and certified with BT, what attributes would be most important to them when choosing these foods (Figure 3). The set consists of the following options: produced with organically grown grains, different taste and flavor compared to traditional pasta, better digestibility of these products, and presence of a new logo on the packaging. In general, all characteristics received the highest preferences (7–8 and 9–10) for all products, showing very good interest from respondents, but particularly high ratings were given to the improved digestibility characteristic and different taste/flavor (Figure 2).

Additionally, respondents were asked if they would prefer a public or private entity for SAG-based blockchain-certified products and which specific entity they would desire as a guarantor of the authenticity of the product and supply chain traceability to assure compliance with the rules of blockchain in the supply chain and to monitor the blockchain functioning (Table 6). Almost half of the sample believes that this role should be carried out by a public authority linked to agricultural issues, such as the Italian Ministry of Agriculture and Food Sovereignty (25.8%) or the Regional Department (23.3%). Some respondents (24.2%) think that a regional research consortium specialized in cereals could be the controller of blockchain certification for foods produced with SAG, and 14.2% believe that this role should be assigned to a private organization (Table 6). The most referred channel for communicating information about blockchain-certified SAG-based products is publicity through mass media (TV, radio, newspapers, and online) planned by public institutions.

Figure 3 shows the consumers' responses related to the best way of communication to convey information regarding food certified with blockchain technology, categorized by age group. Among the youngest respondents (16–26), the most preferred means of information is public institutions' social media (8.5%), followed by advertising by public institutions (region/ministry) through traditional media, such as TV and radio (6.7% of respondents). It is interesting to note that, in the 16–26 age group, respondents expressed no preference

TABLE 3 Consumers' knowledge about products made with Sicilian ancient grains.

Variables	Items	Preference rating (%)
Ever heard of ancient grains	To be familiar	91.1
	Not know	8.9
What ancient grains are	Ancient varieties of high quality, more nutritious, and easier to digest than today's varieties	59
	Ancient varieties of local production	41
Source of information about SAG	In a restaurant/pizzeria	20
	Through acquaintances	16
	On TV	12
	Through work colleagues	12
	On social networks	7
	On Internet	14
	At the bakery	4
	In specialist magazines	11
	Through a nutritionist	4
Knowledge of the nutritional characteristics of SAG	Yes	81
	No	10
	Not know	9
Knowledge about better digestibility and proven ability of SAG to help alleviate digestive disorders	Yes	68.2
	No	14.3
	Not know	17.5
Knowledge of the superior health benefits of SAG compared to other types of grain	Yes	74.7
	No	13.2
	Not know	12.1
Purchase or consumption of foods produced with SAC by respondents	Yes, consumed outside home but not purchased for consumption at home	33.4
	Yes, consumed outside home, purchased for consumption at home	55.8
	No, I do not consume or purchase them	10.8
Types of foods produced with SAG consumed by respondents	All products (pasta, bread, pizza, and baked goods in general)	52.5
	Pasta, bread, and pizza	22.1
	Pasta only	3.7
	Bread only	4.5
	Pasta and bread	6.4
	Pasta and pizza	3.6
	None	7.2

regarding information from schools, possibly because they have already received it. Similarly, the highest preference among people aged 27–39 is for traditional advertising by institutions, with 15% of respondents. In this age group, 5.5% of respondents claim that information from schools could be a good means of communication. In general, for the older age group (60 years old and above), institutional advertising was observed as the best way of communication, despite a lower percentage.

The final part of the survey focused on the willingness of respondents to pay a higher percentage of the price for blockchain-certified SAG-based products compared to the actual price of common pasta,

bread, and pizza (Table 7). The result is almost the same for both products, and the most significant finding is that more than 30% of respondents would pay from 5 to 15% more than the price of conventional products. On average, among the three products, 27.8% of respondents are not willing to pay more than 5%. Although referring to only a few respondents, the number of those who would pay 30% more for blockchain-certified pasta is higher than for the other products (6.7%).

These findings are in line with previous literature on consumers' WTP for pasta certified with blockchain technology (Petrontino et al., 2024).

TABLE 4 Consumption and purchase of products made with Sicilian ancient grains by age and level of education of respondents.

Age range	Education	No (%)	Yes (consumption and purchase)* (%)	Yes (only consumption)** (%)	Total (%)
16–26	Middle school/high school diploma	1.6	1	1	3.6
	Degree (any level)	2	6.6	2.6	11.2
	Master's degree/PhD	0	0	0	0
27–39	Middle school/high school diploma	1.5	6.5	2.2	10.2
	Degree (any level)	3	10.2	6.2	19.4
	Master's degree/PhD	0	4	2.3	6.3
40–49	Middle school/high school diploma	0	1.6	5	6.6
	Degree (any level)	0	3.6	2.7	6.3
	Master's degree/PhD	0	3.3	1.8	5.1
50–59	Middle school/high school diploma	0	3.3	3.2	6.5
	Degree (any level)	0	2.3	2.8	5.1
	Master's degree/PhD	1	1	0	2
60+	Middle school/high school diploma	0	5.3	2.6	7.9
	Degree (any level)	1	4.3	1	6.3
	Master's degree/PhD	0	3.5	0	3.5
Total (%)		10.1	56.5	33.4	100

\*Consumed outside home and purchased for consumption at home.

\*\*Consumed outside home but not purchased for consumption at home.

Consumers' willingness to pay was analyzed according to different income ranges (Figure 4). As expected, the results show that in the lowest income range, most respondents are willing to pay a higher price of up to 5% (16.6%); 11% are willing to spend even up to 15% more. In the middle-income range, between €25,000 and €50,000, most respondents (17.7% of the total sample) would be willing to pay 5–15% more than the average market price for the same products made from common wheat. In the income range above 50,000 euros, the highest percentage of respondents (6.3% of the total sample) would be willing to pay 15 to 30% more. For each income range, a low percentage of respondents appear willing to spend a markup above 30% of the standard price to buy food products made with SAG certified with BT.

In conclusion, the results of Analysis 1 revealed the following considerations:

- Despite consumers declaring that they know what Sicilian ancient grains are, there is no correct understanding of them; limited information is available on SAG.
- Consumer interest in foods made from Italian and Sicilian ancient wheat is recognized for both its health benefits and sensory characteristics.
- Young people are the most interested in consuming SAG-based products for their sensory and health qualities.
- There is insufficient information regarding BT for agri-food products, but it is considered important because it is associated with concepts of food safety and quality.
- A public certification authority is considered more appropriate to control blockchain certification.
- Public authorities need to provide more information about blockchain certification of products made with SAG, communicated adequately through mass media and institutional publicity.
- Consumers request affordable prices.

- The presence of QR codes on labels to gain information about products certified with blockchain technology is desired.

## 4.2 Results of Analysis 2: focus groups with consumers

This part of the research aimed to supplement the results of the questionnaires with qualitative information gained through focus groups with consumers (Osei et al., 2021). It investigated consumers' knowledge about SAG and blockchain certification for food supply chains. The products made from Sicilian ancient grains that consumers were asked to discuss regarding the possibility of blockchain certification included pasta, bread, and pizza. Moreover, participants were asked about different means to access the required information, such as QR codes.

Table 8 shows the questions asked to participants during the sessions and the frequencies of their answers. The results indicate that the group discussions led to a single shared perspective among individuals. Consumers discussed the quality of the food products they usually consume, the related label characteristics (such as the possibility of having additional information on them), and the link between food products and sustainability. The results show that only 62.5% of respondents are aware of the quality of the food they consume. Only 46.8% regularly read product labels, and 31.3% sometimes do so. The most sought-after information by consumers on labels was the expiry date (30.7%), followed by nutritional information (14.7%). Regarding the additional information that consumers would like on the label, "attention to consumer health" was prioritized (30.7%), followed by "attention to the environment" and "production method" (20.9%).

About the willingness to change their eating habits for sustainable behaviors, respondents are inclined to change their habits, with 65.6% of the total; 31.3% are reluctant to change. However, consumers are

TABLE 5 Consumer preferences for pasta, bread, or pizza made with grains grown in Italy, Sicily, and with SAG.<sup>1</sup>

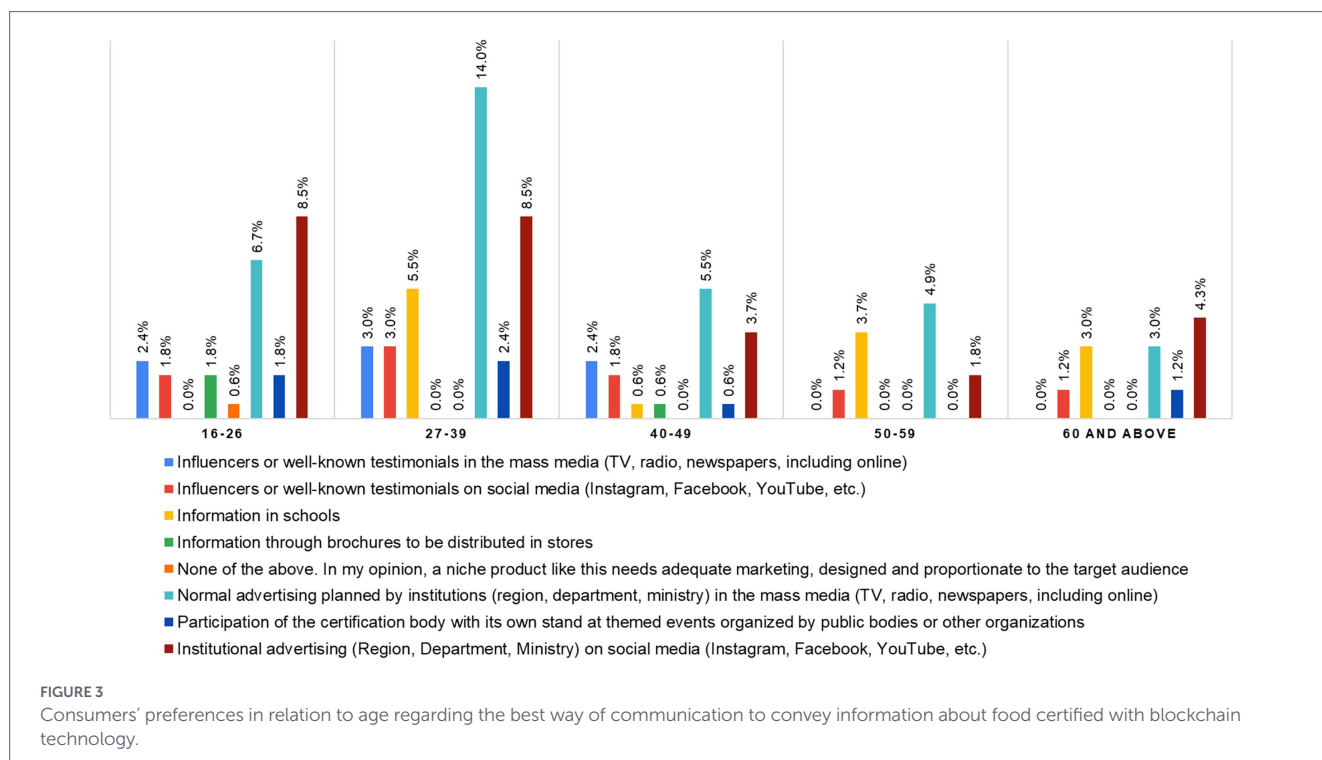
Preferences (variables)	Levels of preference*	Frequency (%)
Prefer pasta, bread, or pizza made with grains grown in Italy	Extremely preferred (10–9)	43.6
	From decisive to moderate (8–7)	23.9
	Sufficiently preferred (6–5)	12.1
	From moderate to poor (4–3)	20.4
	Slightly preferred (2–1)	0
Prefer pasta, bread, or pizza made with grains grown in Sicily	Extremely preferred (10–9)	56.7
	From decisive to moderate (8–7)	14.9
	Sufficiently preferred (6–5)	12.8
	From moderate to poor (4–3)	15.6
	Slightly preferred (2–1)	0
Prefer pasta made from SAG (e.g., Tumminia, Perciasacchi, and Russello) over pasta made from current wheat	Extremely preferred (10–9)	34.7
	From decisive to moderate (8–7)	25.2
	Sufficiently preferred (6–5)	11.3
	From moderate to poor (4–3)	28.8
	Slightly preferred (2–1)	0
Prefer pizza made from SAG (e.g., Tumminia, Perciasacchi, and Russello) over pizza made from current wheat	Extremely preferred (10–9)	33.2
	From decisive to moderate (8–7)	23.9
	Sufficiently preferred (6–5)	13.1
	From moderate to poor (4–3)	29.8
	Slightly preferred (2–1)	0
Prefer bread made from SAG (e.g., Tumminia, Perciasacchi, and Russello) over bread made from current wheat	Extremely preferred (10–9)	36.3
	From decisive to moderate (8–7)	20.8
	Sufficiently preferred (6–5)	13.8
	From moderate to poor (4–3)	29.1
	Slightly preferred (2–1)	0
	All these and others	3.5
Prefer pasta, bread or pizza with quality certification (e.g., organic, PDO, and PGI) or any sustainability/traceability certification	Extremely preferred (10–9)	30.8
	From decisive to moderate (8–7)	27.7
	Sufficiently preferred (6–5)	11.8
	From moderate to poor (4–3)	29.7
	Slightly preferred (2–1)	0
Prefer pasta, bread or a pizza enriched with vitamins, beta glucans, antioxidants, fiber, omega-3, or other functional components	Extremely preferred (10–9)	10.4
	From decisive to moderate (8–7)	8.6
	Sufficiently preferred (6–5)	10.1
	From moderate to poor (4–3)	70.9
	Slightly preferred (2–1)	0

\*Scale of preferences from 1 to 10: 1–2 = slightly preferred, 3–4 = slightly preferred, 5 = moderately preferred, 6 = sufficiently preferred, 7–8 = fairly to absolutely preferred, 9–10 = extremely preferred.

<sup>1</sup>Information about other baked goods is not included in this table due to space constraints. No noteworthy differences, compared to those reported for pasta, bread and pizza, were found. The data are available on request.

willing to spend more money to buy food that contributes to environmental sustainability, responding positively to the possibility of paying a price markup of between 5 and 20% more. They have stated that they are willing to do so if this represents their contribution to human health and environmental sustainability. This is in line with social responsibility theory, which argues that individuals and organizations may want to act in ways that benefit society and the environment, not

just themselves. It is an ethical framework that suggests consumer behavior can be influenced by awareness of its impact on the community at large and the environment and that individuals should strive to maintain a balance between economic growth, social well-being, and environmental sustainability. In practice, decisions and actions should be guided by moral values and a sense of what is right and wrong for the collective good.



Moreover, the results of Analysis 2 revealed that focus groups have little knowledge of blockchain for the agro-food sector, but they know food products with quality certifications, such as Protected Denomination of Origin (PDO), Protected Geographical Indication (PGI), DOC (Italian PDO for wines), or organic (Ingrassia et al., 2022a). They also requested information on the percentages of SAG used in the preparation of products (like pasta, pizza, and bread) and tables to help them know the quantities of SAG contained. The information desired in the QR Code covers both the companies involved in the preparation of the product (from the farms to the final processor or distributor) and the technologies used in the various stages of processing, thus making the supply chain traceable and transparent. Furthermore, participants highlighted their desire to access information about BT and SAG, asking that it be provided in a clear and easy-to-understand manner to understand what blockchain certification is, what the advantages and added value are for consumers, the costs and commitments required by businesses, and the valuable characteristics of SAG. The opportunity emerged to use channels accessible to all, such as schools, social networks, and stands in high-traffic areas where it is possible to interact with communicators. In addition, there is a need to experience these products in public places such as school and university canteens or hospitals, to enhance credibility and awareness through consumer experience.

The key elements that emerged from Analysis 2 are the following:

- Declared good knowledge of Sicilian ancient grains; however, their knowledge of them is incorrect.
- Limited knowledge of blockchain in the food sector.
- General knowledge of quality certifications (e.g., organic, PDO, PGI, and other sustainability or traceability certifications).
- Request for standardization of taste to identify products made with SAG and information on the quantitative percentage of SAG in products made with SAG.

- Information by the QR code about the production phases and the entrepreneurs that adhere to BT certification for transparent traceability.
- Required information about blockchain certification of these products through various information channels (social media, TV, radio, etc.), but with the supervision of a public authority for better credibility.
- Adopt a public certification authority.
- Corporate social responsibility.
- Desire for affordable prices of products made with SAG and certified with BT.
- A brand name, logo, or other symbol (like that of organic products) that may help them to univocally recognize the products made with SAG and certified with BT.

### 4.3 Results of Analysis 3: focus groups with experts

This part of the research aims to gain in-depth information through focus groups with experts. During discussions, the experts expressed their opinions regarding the motivation for achieving certification with BT, investigating their knowledge about this technology and the competence needed to apply it. Moreover, the ideal advantages of BT for the certification of the SAG supply were discussed. Participants also discussed the funds and resources needed for implementing the requirements to achieve this certification, as well as the possible target market and marketing/communication strategies. The main reason for adopting BT for the SAG supply chain lies in the desire to give these wheat varieties a quantifiable and demonstrable added value, giving producers greater bargaining power against wholesale intermediaries. As for marketing, participants discussed suitable strategies for positioning the “new products” in the market. In this context, the price was identified as one of the most important marketing levers. In fact, the experts claimed that to commercialize

TABLE 6 Respondents' preferences regarding control issues on blockchain certification, certified food labeling, and communication.

Variables	Items	Preference rating (%)
Certification authority and controller of blockchain certification for foods produced with SAG	Presidency of the Region of Sicily	8.3
	Department of Agriculture, Rural Development and Mediterranean Fisheries	23.3
	Italian Ministry of Agriculture and Food Sovereignty	25.8
	Ministry of Business and Made in Italy	4.2
	Regional research consortium specializing in cereals	24.2
	Private organization	14.2
	Additional information requested on the label accompanied by the QR code for foods produced with SAG and certified with BT	A specially created logo
	The words "Certified with blockchain system"	32.5
	A link from which you can download a special application on your mobile phone (Ancient Grains and the blockchain system)	13.3
	Nothing else, just the QR Code	12.5
Preferred channel for communicating information about foods produced with SAG and certified with BT	Publicity through mass media (TV, radio, newspapers also online) planned by the institutions (Region, Department, Ministry)	35
	Influencers or well-known testimonials in the mass media (TV, radio, newspapers also online)	14.9
	Institutional publicity (Region, Department, Ministry)	29.2
	Influencers or well-known testimonials on social media (Instagram, Facebook, YouTube, other)	9.2
	Information in schools	11.7

such 'new products' of high quality—which require higher production costs—and to communicate this quality (in a way that is perceived, understood, and accepted by consumers), a price differentiation should be made, with slightly higher prices than those of similar products without blockchain certification. The higher price positioning stems from several factors intrinsic to this type of market, such as specialization, higher perceived quality, and higher production costs for smaller volumes. However, according to participants, the final pricing strategy should depend not only on the specific market structure but also on the decisions of entrepreneurs in the supply chain who would like to market these products at relatively affordable prices for consumers (locally in the first instance). The presence of one or more mills and pasta factories dedicated to serving a cooperative producer might give producers greater negotiating power, as they would no longer have to depend exclusively on wholesalers, intermediaries,

TABLE 7 Distribution of consumers according to their willingness to pay a percentage price increase for pasta, bread, and pizza made with Sicilian ancient grains certified using blockchain technology compared to the market price of the same common products<sup>1</sup>.

Range of price percentages	Distribution of consumers according to their willingness to pay a price percentage increase (%)		
	Pasta	Bread	Pizza
Same price	14.6%	14.6%	12.2%
Max 5% more	27.4%	26.2%	29.9%
5 to 15% more	31.2%	36.6%	32.9%
15 to 30% more	20.1%	18.9%	20.7%
More than 30%	6.7%	3.7%	4.3%
Total	100%	100%	100%

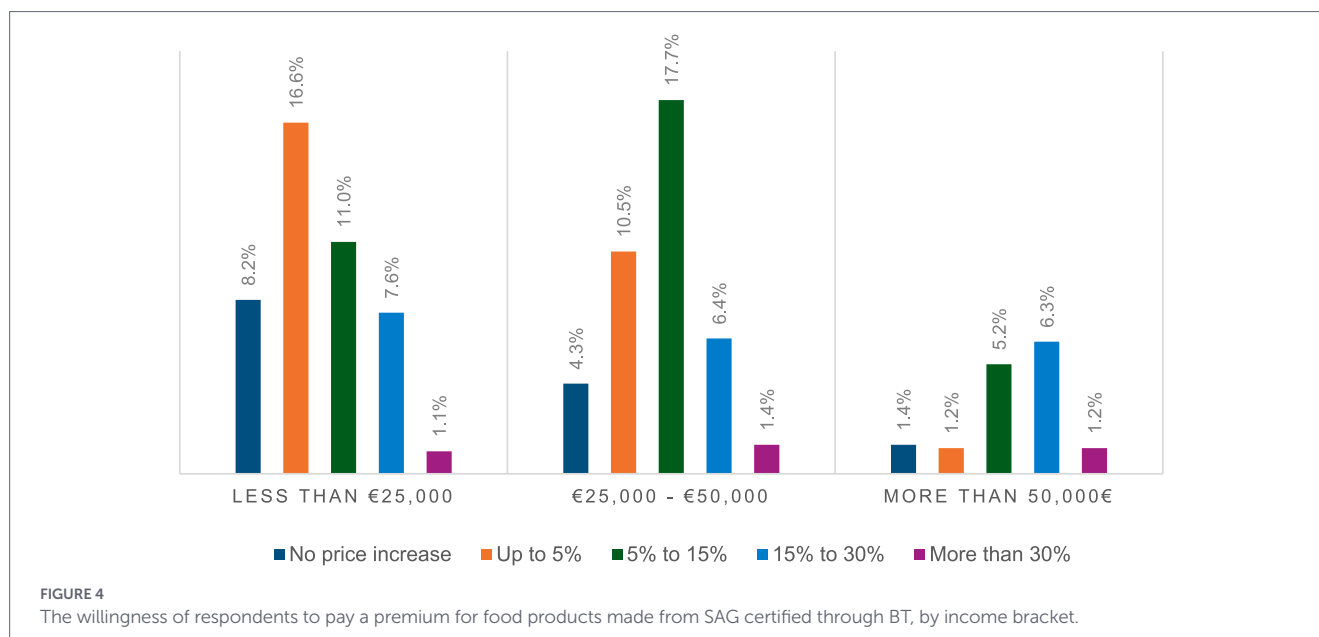
<sup>1</sup>Information about other baked goods is not included in this table due to space constraints. No noteworthy differences, compared to those reported for pasta, bread and pizza, were found. The data are available on request.

mill owners, and pasta factories to set the selling price of wheat. This would mitigate the costs of production and implementation of the BT for farmers, allowing for greater profits.

A new brand name and a new logo for these 'new products' with blockchain certification appeared crucial to univocally recognize these products in the market and to design a specific marketing strategy. This would help consumers recognize and differentiate these products from common ones. The added value of these 'new products' therefore derives not only from the high value of unique raw materials and socio-economic characteristics but also from the certification with BT for authenticity of products, food safety, and traceability of production, processing, and logistics.

Regarding the topic of communication, one important factor that emerged was the role of public institutions in communicating appropriate information to consumers and stakeholders and in educating consumers about sustainable food consumption.

VOS Viewer (van Eck and Waltman, 2010) software was used to visualize the interconnections between the main topics discussed by experts. This software simplified the authors' interpretation of all the issues addressed and highlighted the latent connections that are difficult to grasp from simply reading the transcripts of the six focus group discussions. This software analyzes the text by creating a map of interconnections that highlights the co-occurrences of words within a text/discussion (Kirby, 2023). The co-occurrence map generated by the software allowed us to see how the various words are linked to each other through many connections. The larger spheres, whose size indicates the number of co-occurrences and connections with other topics, represent the words that were mentioned very frequently during the discussion, thus reflecting the main topics discussed by the participants. The words in the center of the map are the crucial ones to consider for the design of the marketing model. The starting point for analyzing the content of the discussion consisted of a faithful transcription (verbatim methodology), ensuring that the natural language used by the participants was preserved in its entirety. This methodological choice was essential for preserving the semantic richness and expressive nuances of the qualitative data. Subsequently, the raw text corpus underwent a cleaning or normalization phase, necessary to optimize the input for VOS Viewer-assisted analysis. Specifically, extra-linguistic components (e.g., "um," "ah," "laughter") and



annotations not relevant to the discourse content were removed, followed by punctuation formatting and finally the removal of high-frequency functional words (articles, prepositions, conjunctions, etc.), whose exclusion does not alter the semantic content but improves the effectiveness of the lexical analysis. After obtaining the normalized text corpus, it was then imported into the VOS Viewer software to visually map the relationships and thematic clusters emerging from the participants' discourse. As a first step, after entering the data into the software, it emerged that, with a minimum number of occurrences of a term equal to 5, of the 1,053 terms present in the text, 114 met the threshold. Based on this score, the most relevant terms were selected. The default setting of the software is to select the 60% most relevant terms, which led to the selection of 68 terms.

The conceptual network in Figure 5, proved to be dense, and the terms with the highest centrality and frequency were "company," "product," "supply chain," and "system." These terms represent the pillars around which all the participants' discussions developed, and in fact, the map confirms that the debate focused on the complex relationship between the need for management innovation (Red Cluster), the market structure and logistics (Green Cluster), and the central role of the wheat producer and the product (Yellow Cluster), all supported by information systems and projects (Blue Cluster).

In the second stage of analysis, further screening was carried out to focus the analysis on the most frequent and central themes. Of the 1,053 terms in the text, with 9 as the number of occurrences of a term, 53 met the threshold. Based on this score, the most relevant terms were selected. The default setting of the software is to select the 60% most relevant terms, which led to the selection of 32 terms.

The removal of low-frequency terms produced a more compact and interpretable network (Figure 6), and the previously identified central nodes ("company" and "supply chain") were reconfigured. The conceptual network shows that the primary interest of the participants is not only technological innovation (blockchain) but its targeted application (Project) to a specific value product such as Ancient Grain (Yellow Cluster), whose success depends on the integration of strategic vision (Red Cluster), operational efficiency (Green Cluster), and a solid collaborative environment (Blue Cluster).

Finally, in the last phase of the analysis, a further selection was made. With 20 as the number of occurrences of a term, of the 1,053 terms present in the text, 16 met the threshold. Based on this score, the most relevant terms were selected. The default setting of the software is to select the 60% most relevant terms, which led to the selection of 10 terms. Figure 7 illustrates the logical path of the debate and shows a focused discussion that develops sequentially from the starting point (Blue Cluster), with the concepts of "ancient grain," "supply chain," and "traceability," identifying how to trace and guarantee the origin of the raw material, the turning point (Green Cluster) where the term "blockchain" acts as a pivotal point and technological solution that responds to the need for 'traceability' and connects the "supply chain" directly to the "consumer," creating a mechanism of trust, and finally (Orange/Red Cluster), culminating in the practical and regulatory aspects, represented by "logistics," "market," "certification," and "code of ethics".

The most important and recurring words during the discussion were the following: *blockchain*, *supply chain*, *certification* linked thanks to *traceability* and *ancient grain*. It is possible to see three main clusters: the green cluster (blockchain, consumer, partnership), the blue cluster (supply chain, traceability, ancient grain), and the red cluster (certification; market, logistics, and ethical code). The green cluster represents what entrepreneurs want to achieve with blockchain. The blue cluster expresses their desire to attribute value to ancient grains and is directly linked to the green cluster via the word blockchain. Finally, the red cluster highlights how entrepreneurs want to present themselves to consumers in the market through certification, a code of ethics, and smart logistics.

The main attributes considered fundamental by the expert entrepreneurs are ultimately connected with two interesting findings: partnership and ethical code. Partnership means that the experts ask for strong "cooperation" among all the interested parties, showing the will of entrepreneurs to base their choices on a common vision, the ethical code, and the importance they attribute to blockchain for the certification of the entire supply chain. The ethical code appears to be a very interesting finding, as it represents a declared commitment to social responsibility toward consumers and the environment (but also

TABLE 8 Results of the consumers' discussions about consumption behavior and label characteristics.

Questions	Possible choices of answers	Frequency (%)
Do you consider yourself sufficiently aware of the quality of the food you consume?	Yes	62.5
	No	25
	I do not know	12.5
When you buy food, do you always look at the label?	Yes	46.8
	No	21.9
	Sometimes	31.3
If yes, what are you most interested in among the information generally given on the label?	Due date	30.7
	Place of origin	13.6
	Ingredients and their percentages	13.7
	Brand	12.5
	Nutritional information	14.7
	Mode of storage	4.6
	Presence of allergens	10.2
What would you like to know in addition to what is already on the label or packaging?	Production method	20.9
	Voluntary quality certifications	16.2
	Attention to the environment	20.9
	Attention to animal health	11.3
	Attention to consumer health	30.7
Are you willing to change your eating habits to contribute to sustainable development?	Yes	65.6
	No	3.1
	I do not know	31.3
If you had to spend more to do so, how much would you be willing to spend as a % incidence on your current food expenditure?	5% more	21.7
	10% more	18.8
	15% more	21.9
	20% more	18.8
	25% more	6.3
	30% more	9.4
	35% more	3.1
	40% more	0
Do you feel sufficiently informed about the link between agriculture, food quality, and environmental sustainability?	Yes	28.1
	No	37.5
	I do not know	34.4
If you would like to receive more information about the links between healthy eating and environmental sustainability, how would you like to receive it?	Through a logo recognizable by Google Lens	18.2
	Through QR code	29.5
	Through stands in places where people gather or frequent, such as supermarkets	15.9
	Through an educational setting (various school levels, university, seminars, etc.)	36.4

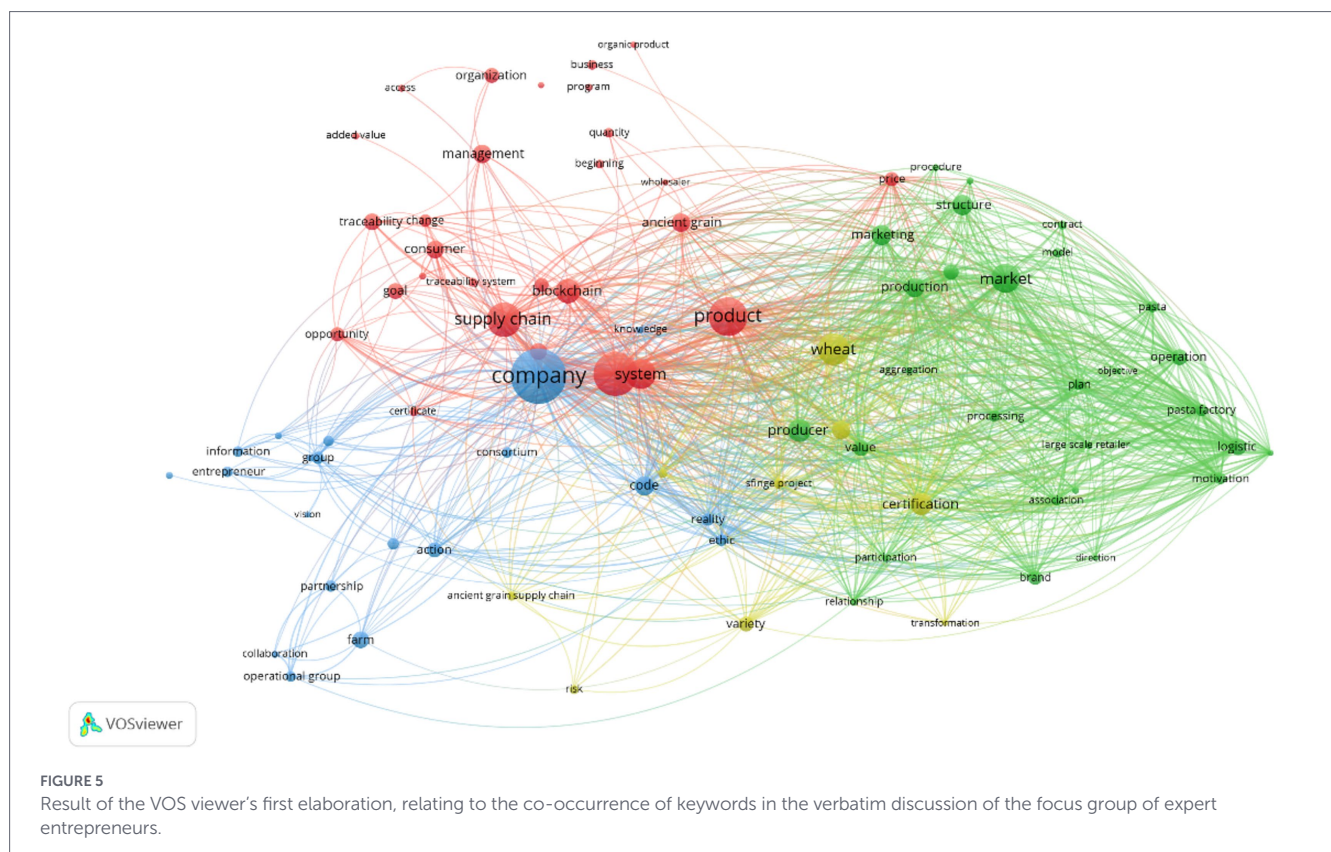
toward producers, who are the weakest link in the supply chain of ancient Sicilian grains).

To summarize, the main takeaways from Analysis 3 are given below:

- 1 Ethical code to declare a commitment to offering “healthy food,” spreading and sharing values and behaviors aimed

at sustainability (environment, economy, public health); support the ancient grain supply chain, particularly protecting farmers on one hand and consumers on the other.

- 2 Transparency in production processes and clarity in the certification process; build trust through effective communication of blockchain certification.



- 3 Position 'the new products' (SAG products certified with BT) in the market for a specific consumer segment at a higher price compared to similar products without BT certification.
- 4 Shared ethical commitments.

### 4.4 Results of Analysis 3: marketing and communication model

The proposed model of strategy comes from the authors' elaboration of results from Analyses 1, 2, and 3 and on solid literature on marketing systems (Kotler and Keller, 2015; Kotler et al., 2019). Thanks to these findings, a suitable marketing model for the supply chain was designed. The main aim of the model was to exploit blockchain certification as an added value to be communicated for these products to consumers and stakeholders. Moreover, another important element to be considered in this model is the cooperative role of all the entrepreneurs in the supply chain, since competition among actors in the supply chain would have damaged all entrepreneurs, especially farmers. The marketing strategy identified is the implementation of an integrated, multi-channel, cooperative (non-competitive) marketing system (Kotler and Keller, 2015; Kotler et al., 2019), as it was considered the best solution to create value for products made with certified SAG using BT in the various phases of the marketing strategy (positioning, marketing, and communication). This marketing system, in this case, is one in which the players in the supply chain cooperate rather than compete (Kotler and Keller, 2015; Kotler et al., 2019). This model has the advantage of allowing entrepreneurs to meet the maximum possible demand (a significant share of the market, if not, at least initially, all local demand) and reducing mark-up disparities between the different levels of the supply chain. This

could allow for a fairer distribution of profit margins, to the benefit of grain producers, who are generally the weakest link in the chain. It envisages the use of multiple commercialization channels (pasta factories, bakeries, restaurants, pizzerias, retail stores, large-scale distribution, etc.), and so it seems the most suitable in this case. In fact, through the integration of these channels, it will be possible to increase the target market share, have lower costs of access to certain channels, and make more customized sales for specific target groups. Moreover, results of questionnaires and focus groups with consumers and experts revealed that 'food safety' or 'traceability' and 'sustainability' are the key elements for both entrepreneurs and consumers.

Therefore, the shared elements through which entrepreneurs satisfy consumer needs are given below:

- Introduce a certification, with BT, to guarantee traceability, authenticity, quality, and safety of products.
- Have a public supervisory authority to control the blockchain.
- Shared social responsibilities.
- Try to position the product in the market with affordable prices.

It is interesting to note that both groups believe that these new products should not be sold at too high prices but rather at prices affordable to average incomes. In addition, both entrepreneurs and consumers feel a responsibility to the environment and future generations and therefore share ethical values that are represented by these products. Ultimately, both consumers and entrepreneurs agreed on some salient elements characterizing these new products with a certified supply chain, namely that a public authority to ensure safety for consumers and entrepreneurs should supervise blockchain certification.



#### 4.4.1 Findings of communication analysis by using the AGIL model

As described in the methodology, the first quadrant represents the ‘persuasive’ dimension of communication. It refers to a key aspect of communication and is represented by means of communication such as social networks, mobile messaging applications, and the Internet. In this dimension, it is assumed that the efficient use of resources and methods can be convincing enough to persuade an individual. Indicators are chosen on a case-by-case basis according to the various social structures and related communication means or approaches, such as persuasiveness. The aim is to adapt communication approaches to different social structures, such as the market, mass media, digital media, or, in some cases, institutions. Results revealed that the most important communication dimension is the persuasive dimension (A - Adaptation) with 42.9% through experience: creating experience by storytelling through social networks and digital influences showing tastings, events, fairs, exhibitions, forums, cooking classes, also at schools, exhibition centers, supermarkets, etc. (Ingrassia et al., 2022b). Then the Educational/Informative dimension (G - Goal attainment) at 23.3%, which expresses the cognitive aspect of communication and represents the informative function of communication and the importance of information to respondents. The indicators are the means of information through which the respondents could receive information about blockchain-certified SAG. This percentage confirms that, for respondents, the quality of information acquired through school, graduate, and post-graduate studies is important. Analysis of the results also showed that the Brand-land relationship of SAG, accredited by word of mouth from trusted individuals, such as relatives, family members, and friends who live in the same region, expresses the identitarian and territorial component of these products (dimension I: Integration), which also appears important (19.7%). This is a dimension in which people, from passive subjects who receive information through communication, become active subjects who, in turn, communicate and transfer information among their peers, in a context of democratization of information. In particular, this result is in line with the findings of the expert focus group, which emphasized the importance of giving these products a clear name that uniquely represents their origin, namely a brand that should contain the words “Sicilian ancient grains.” The fourth quadrant is the dimension linked to communication as a means of expressing one’s identity, both individual and collective. This dimension represents the values of the community in which communication takes place, as well as the principles and traditions shared by the communicating community. Finally, the collective dimension resulted in being the least important (dimension L: Latent pattern) at 14.1% (Table 9). This dimension represents the community of people that together convey values or messages. This result is also in line with the findings of the focus group with experts, which hoped to share ethical vision and behavior with consumers (relationship and common purpose between entrepreneurs and consumers). This dimension is still very ineffective at this time because it is a dimension of communication that can only be consolidated after having full knowledge of the product in question, and it is impossible for consumers to be aware of this in the early stages.

Figure 8 shows the authors’ elaboration of the communication model for ‘the new products’ (products made with SAG and certified with BT at the regional level) based on the results of Analysis 1, 2, 3, and 4 and on the value communication theory. This model is aimed at communicating the value of the ‘new products’ with a unique message

and through a unique communication strategy to a specific niche consumer target group. The model summarizes the combined communication strategies that it would be desirable to adopt to effectively communicate the added value elements of these products given specifically by certification with BT.

Specifically, the figure represents all the necessary communication strategies and aims to show that effectiveness derives from the combination of all of them. It highlights the importance of the role of schools and universities in shaping a culture on these issues that can positively change behavior. It also emphasizes the importance of public authorities discussing these products and this type of certification through their own channels, not only institutional ones but also social ones (institutional social networks, websites, use of influencers or famous people) and through traditional advertising in the mass media (TV, newspapers, etc.). Finally, the experience of these products is of fundamental importance because experience, in addition to creating a hopefully positive memory, has special significance for food products, as sensory characteristics are the primary drivers of food purchases. This experience, through distribution in university canteens, hospitals, schools, etc., as well as through trade fairs and dedicated events, will help consumers recognize and differentiate these new products and encourage them to incorporate them into their consumption habits.

Finally, entrepreneurs’ social media channels can also be effective if communication is clear, simple, and comprehensive, as they help to persuade, provide information, and create an identity and community of consumers who share the same needs in terms of food safety, food quality, health, authenticity, traceability, and environmental, social, and economic sustainability. All these elements were found to be true by both entrepreneurs and consumers.

## 5 Discussion

Results revealed that there is a lot of misinformation among consumers regarding ancient grains. However, they show that although most respondents are aware of the existence of SAG and have purchased and consumed them, both at home and outside the home, they are not familiar with the different varieties, knowing only the main ones: *Timilia*, *Perciasacchi*, and *Russello*. Another characteristic of importance is the assumed better digestibility of this wheat and the interest in knowing which variety of ancient grain and what percentage of the total flour is used for different preparations. Their tendency to associate these grains with characteristics such as greater digestibility and enhanced nutraceutical properties increases the appeal of these products and their willingness to pay for them (Joye, 2019; Gulati et al., 2020). It should be noted that, among the scored preferences, organic products were of high interest to consumers (Fantechi et al., 2023). Moreover, respondents showed considerable interest in the sanitary and health aspects of SAG and their products (Drugova et al., 2020). Nevertheless, consumers are willing to pay for these products at prices not much higher than those of similar products made with modern wheat flour (Farooq et al., 2024).

Regarding the use of blockchain technology to authenticate the origin of SAG, the interviewees appeared particularly interested, in line with other studies (Liu et al., 2023); this variable consistently received the highest score for the analyzed products. Although respondents were not aware of the blockchain certification for food

TABLE 9 AGIL results of dimension effectiveness.

AGIL dimensions	Sub-dimensions	Indicators	DimEff (%) <sup>1</sup>
Persuasive (A-ADAPTION)	Response to/manipulation by external environment (influence the behaviors and purchase intentions)	<ul style="list-style-type: none"> <li>• Social networks (TikTok/Instagram/X (formerly Twitter))</li> <li>• Mobile Messaging App (MMA) (WhatsApp/Telegram/other)</li> <li>• Internet</li> </ul>	42.9
Educational/informative (G-GOAL ATTAINMENT)	Defining and achieving primary functions (communicating information about product characteristics)	<ul style="list-style-type: none"> <li>• School</li> <li>• Academic degree</li> <li>• Post-graduate degree (master's/PhD/etc.)</li> </ul>	23.3
Integrative (I-INTEGRATION)	Highlighting and coordinating parts or functions or characteristics that identify an identity (identifying with something or someone)	<ul style="list-style-type: none"> <li>• Family and friends/acquaintances</li> <li>• Work's colleagues</li> <li>• Other than institutional sources</li> </ul>	19.7
Collective (L-LATENT PATTERN)	Membership in groups that support and influence the motivation for purchasing action and behavior	<ul style="list-style-type: none"> <li>• Newspapers and magazines</li> <li>• Radio</li> <li>• Digital Disclosure Platforms (YouTube/PayTV/other)</li> </ul>	14.1

<sup>1</sup>Percentage value of dimensions' effectiveness (DimEff) considering all Indicators.

products, they all agreed on the importance of this new technology, which can guarantee not only the healthiness of products but also the authenticity of high-quality local productions (Yang et al., 2025; Fanelli, 2025; Kamble et al., 2025). Product certification using BT allows consumers to be aware of what they are buying and to be sure of the origin of the products and how they have been processed. Knowing where a product comes from is undoubtedly a form of protection for consumers, but it also enhances the value of the food product for producers. Blockchain certification, therefore, thanks to modern AI technology (Kamble et al., 2025), has become an additional option for farmers and processing industries to protect their products and assure consumers of the origin, healthiness, and safety of what they eat (Rezzi et al., 2024).

The four analyses conducted showed that these new products need specific positioning among a consumer segment marked by average income, interest in food quality and traceability, and ethical commitments to the environment and future generations.

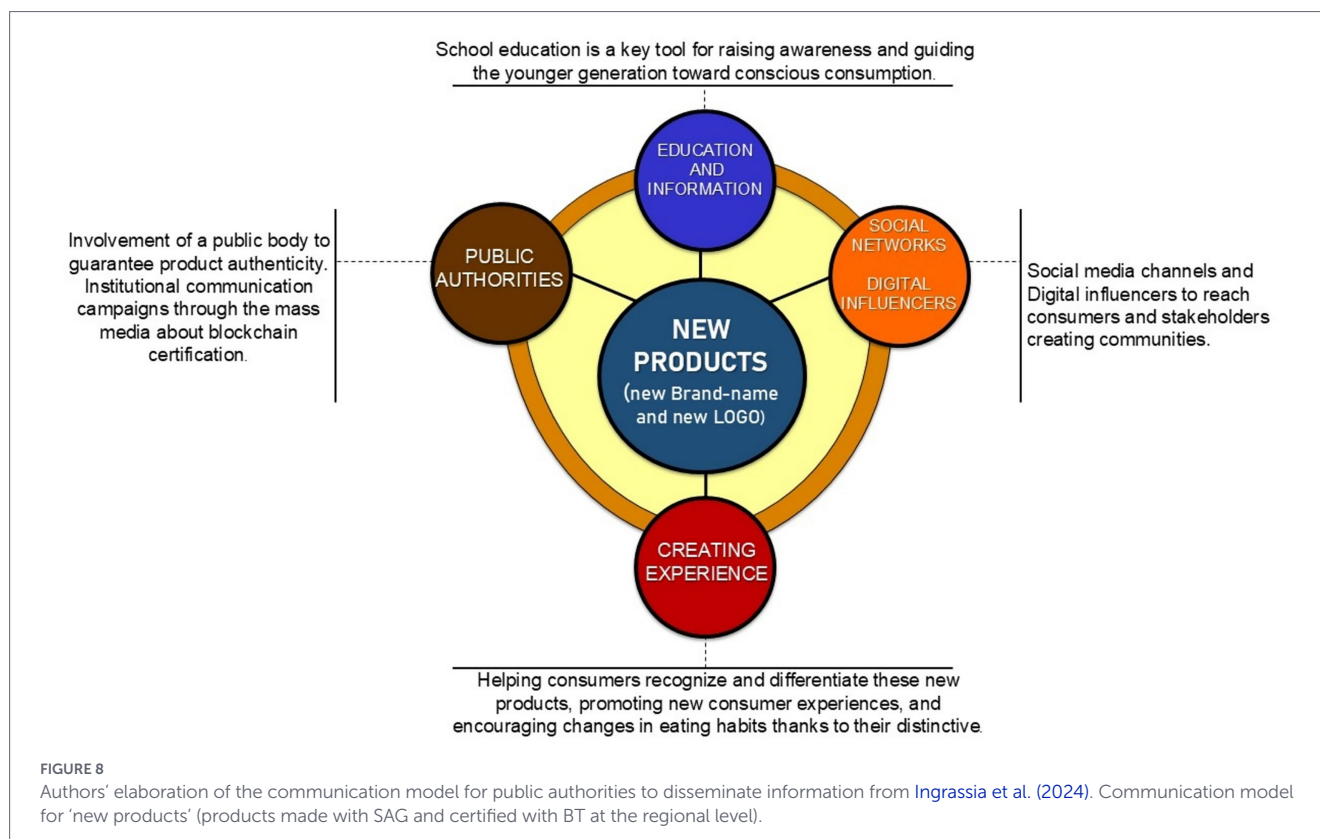
This positioning will require, in addition to an "affordable" price, a unique and shared communication strategy that successfully transfers understanding and acceptance of the added value of SAG-based products provided by blockchain certification. Moreover, in that view, annexing mills or pasta factories within the certified supply chain would help distribute profits more equitably throughout the supply chain.

Entrepreneurs in the supply chain highlighted the importance of a shared strategy and code of ethics to ensure fair incomes for the weakest links in the supply chain, namely grain and flour producers. Thus, the most suitable marketing model was found to be the integrated, multi-channel, cooperative (non-competitive) marketing system (Kotler and Keller, 2015; Kotler et al., 2019), as it was considered the best solution to create value for these 'new products' in the various phases of marketing, including communication. This study revealed that both consumers and producers share the same sense of social responsibility, the same interest in food health, and the same desire for certification that guarantees traceability, authenticity, and quality. Therefore, these new products fully satisfy the needs of consumers, entrepreneurs, researchers, and stakeholders simultaneously. It is a theoretical meeting point between the supply and demand of a product that represents a mutual commitment, social responsibility, and sustainability (Castro-González et al., 2025).

Ecosystem services are the many direct and indirect benefits that humans obtain from functioning natural ecosystems. According to the most widely used classification, developed by the Millennium Ecosystem Assessment (Millennium Assessment Reports, 2025), ecosystem services are divided into four main categories: Provisioning Services, Regulating Services, Supporting Services, and Cultural Services. The continued cultivation of ancient grains in Sicily to produce goods such as pasta, bread, and other baked goods can offer some essential ecosystem services to the region. Specifically, "Provisioning Services," as food (both agricultural products and processed products) is a material product obtained from the ecosystem; and "Regulating Services," i.e., the benefits derived from the regulation of natural processes by ecosystems, in this case, carbon fixation, air and water purification, flood and soil erosion control, and crop pollination by insects; "Supporting Services," i.e., in this case, the maintenance of biodiversity and natural habitats; and finally, "Cultural Services," i.e., the non-material benefits that people obtain from ecosystems through spiritual enrichment, cognitive development, recreation, and esthetics. In this case, we are talking about the esthetic value of the landscape, cultural heritage and sense of place, and physical and mental well-being. Understanding ecosystem services is essential because their value (often economic) is frequently overlooked in land-use planning and development decisions, leading to the loss of these vital functions due to human activity, such as overbuilding.

So far, BT has been commonly used by many international companies to create value along the supply chain. In Italy, too, many local, medium-sized, and large companies are already adopting this system, which can protect local specificities and products made in Italy by bringing together different companies (Verna et al., 2025; Giannini et al., 2025). To increase the value of their products, companies in the Sicilian ancient grains supply chain should adopt both mandatory and optional standards of quality, and the blockchain certification is fully included among the latter (Venturini, 2025; Farooq et al., 2024). This certification would support the Sicilian ancient grains supply chain, particularly farmers in terms of guaranteeing fairer incomes, and consumers in terms of guaranteeing authentic, healthy, tasty products that respect the environment, the landscape, the territory, and the local community.

The marketing model developed highlights how blockchain for ancient Sicilian grains and products based on them is a strong point



because it is of interest to potential consumers. However, the results of this study suggest that a significant obstacle in terms of information must first be overcome. A significant finding is that approximately 80% of respondents were unaware of the existence of blockchain in the food sector, let alone for ancient Sicilian grains. This "limited" knowledge was also confirmed by the focus groups. The results of the AGIL method also confirmed the respondents' desire to obtain information through institutional channels, such as schools and universities. The AGIL results showed that respondents prefer the Internet and social networks as channels for obtaining information quickly, a clear sign of the current way in which people search for and obtain information quickly and communicate with each other. However, when information is considered important and complex to understand or, as in this case, concerns the so-called "credence" characteristics of a product, consumers prefer to obtain information from those who have the authority and credibility to do so, i.e., institutions.

This study also sought to discuss the best way to communicate these valuable attributes. The communication model for "new products" developed showed that, on the one hand, schools and universities have a duty to educate the younger generation, building a culture that leads to real change in everyday behavior. On the other hand, public authorities must move beyond traditional large-scale, one-way communication models and, to raise awareness of these "new" products, adopt a multi-channel strategy that combines traditional advertising in newspapers and on television with more modern and impactful social media communication, capable of exploiting the language of great communicators such as celebrities and influencers.

But they must also undertake concrete initiatives to raise awareness of these products through real and concrete experiences; for example, promoting them through trade fairs, agri-food exhibitions,

B2B agri-food events, festivals, or food fairs, where these products can be tasted. Or they could introduce them for consumption, given their intrinsic qualities, through school canteens, hospitals, universities, and other public places to promote awareness and demand.

This study and its findings may be of interest to policymakers in the agricultural sector at the European Union, national, and regional levels. In fact, their decisions can influence agricultural policies and, consequently, the allocation of expenditure to certain sectors or areas. In this case, their role is very important in helping to strengthen the ancient grain supply chain in Sicily through financial support to entrepreneurs, both farmers and others at subsequent levels of the supply chain, to mitigate the costs of implementing and managing blockchain certification. In this way, the higher costs would not be borne entirely by the end consumer but could be "supported" by non-repayable grants for the implementation and management of a smart supply chain for these niche products, given the multifaceted value of these "new products," which consists of biodiversity value, sensory quality value, food safety and human health value, and, last but not least, ecosystem service value for the territory. Moreover, it appears useful for this territory to apply communication strategies (see Figure 8) that may enhance the contribution of rural areas to the development of a sustainable food system like that of "Roma Capitale," inspired by the Mediterranean Diet (Ingrassia et al., 2023).

The proposed marketing model, with the necessary adjustments, can be useful for similar short supply chains of food products with high quality and values (Balan et al., 2023), because it may be beneficial to make the technological characteristics of blockchain certification, such as guarantees of traceability, authenticity, quality, and food safety, accessible and understandable to consumers and stakeholders.

## 6 Limitations

One limitation of this study is that it only looked at the opinions of consumers in one Italian region, namely Sicily. Although Sicilians are more suitable to be surveyed in this initial phase because they are more familiar with ancient Sicilian grains than other consumers, it would be desirable to examine the opinions of a larger and more diverse sample of Italian consumers to generalize the results and validate them.

Furthermore, the implications that emerge from the results should be analyzed in greater depth with regard to the relationship with the public bodies involved in this marketing model. In particular, one limitation is that institutions were not involved in this study. It will therefore be crucial to establish systematic collaboration between entrepreneurs in the supply chain and local institutions and bodies to put the results of this study, which is of great regional interest, into practice.

## 7 Further research

Certainly, these results will be the starting point for further studies and projects aimed at developing this innovation and extending blockchain technology to the entire SAG supply chain.

Furthermore, the implications emerging from the results should be analyzed and proposed for other niche food products of high quality and value for consumers, producers, and the local economy. This could be developed not only in this territory but also in other territories like Sicily, where there are food products with a strong territorial identity or socio-economic importance that require integrated promotion and marketing strategies, as in this case.

## 8 Conclusion

The transition toward sustainable innovations is profoundly transforming the agricultural sector (Aiello et al., 2022). Long-term resource overexploitation has fostered the rediscovery of crops such as Sicilian ancient grains, regarded as cultural and historical assets of the Italian territory. Their cultivation enables the production of foods appreciated for both sensory properties and intrinsic quality, in terms of healthiness and wholesomeness. Additionally, these products generate intangible territorial benefits by providing ecosystem services (Ray et al., 2025; de Rinke Dias Souza et al., 2025; Ludzuweit et al., 2025), strengthening landscape and cultural identity (Weathersby and Julian, 2025), and contributing to human well-being and environmental sustainability (Li, 2025; Chen et al., 2025).

Within this context, blockchain certification in the Sicilian ancient grains supply chain emerges as a key value attribute for consumers seeking quality, transparency, and social responsibility (Kamal, 2025). This study proposes a multi-channel cooperative marketing system, supported by a dedicated communication model, for companies operating in the Sicilian ancient grain-based products supply chain certified with blockchain technology. The system aims to convey product value through a unified strategy targeting specific consumer segments, integrating

experiential dimensions, strategic use of social networks, and educational activities focused on blockchain certification for Sicilian ancient grains (SAG). Within this model, which is strongly rooted in territorial identity, the sharing of a common vision and ethical commitments between entrepreneurs and consumers is essential to achieving shared objectives (Obeng et al., 2025; Han et al., 2025; Yazıcı and Çiçeklioğlu, 2025).

Policymakers may draw on these results for strategic planning and management of EU funds allocated to Sicily through the Rural Development Program 2021–2027, both for conserving endangered ancient varieties and for implementing innovative technologies such as blockchain.

## Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

## Author contributions

MI: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration. SB: Conceptualization, Writing – original draft, Validation, Supervision. SC: Conceptualization, Writing – original draft, Validation, Supervision. SG: Data curation, Writing – original draft. GR: Conceptualization, Funding, Writing – original draft, Project administration.

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## Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fsufs.2026.1768230/full#supplementary-material>

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