Smart tag packaging technologies: a qualitative investigation of consumers' needs and expectations

Smart Tag Packaging Technologies: A Qualitative Investigation of Consumers' Needs and Expectations

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Abstract

In this paper, we attempt to better understand concerns, needs and expectations of European consumers towards the use of intelligent packaging technologies as this topic appears to need further investigation from a marketing point of view. Thus, this study contributes to the currently limited body of research on the application of *smart tag* technologies on food packaging by exploring information benefits to consumers and by providing insights for marketers on how these technologies could be further employed to create value for consumers, manufacturers and regulatory bodies.

A qualitative user-centred approach was employed to get insights about consumers' shared views on future packaging solutions that could be introduced by European stakeholders of the food industry using different smart labels. Focus group discussions (FGDs) were conducted online in five European countries: United Kingdom, Finland, Spain, Poland, and Iceland.

Respondents indicated that food safety and quality were the most important issues connected to the food value chain. Participants also identified and expressed their preferences for information that stakeholders of the food industry should deliver with *smart tag* labels. Smart tag labels should inform consumers about ingredients, food storage, food preparation, shelf life, health, real-time freshness, recycling and personalised deals. In terms of preferences for different smart labels, participants indicated QR codes and freshness indicators to be the technologies of the future for stakeholders of the food industry.

Keywords: intelligent packaging; packaging technologies; value chain; food information; labels; focus group

1. Introduction and background

Packaging is an integral part of consumer goods. In a practical sense, it protects and contains the product, preserving quality and facilitating transport. For food products, this also means maintaining the safety of the product.[1] Packaging also frequently serves marketing functions, providing information and imagery which can communicate product or brand value in some form. Packaging may also be designed in a way that offers convenience to the consumer, such as ready-to-consume food and drinks. Sometimes there is even value in the packaging without the product. Empty wine bottles are used as home décor[2] and children can derive significant entertainment from a box used to transport a large household appliance.[3] In this paper, however, the focus is narrowed to food packaging with its contents still enclosed.

The primary functions of food packaging can be organised into four groups: protection, communication, convenience, and containment.[4,5] Traditionally, food packaging has used inert materials such as paper, glass, or plastic, which come into contact with the food to serve these functions. However, contemporary technologies exist which can make food packaging *smart* by allowing useful interactions between the packaging environment and food as well as between the food product and consumers.[6] For example, a *smart* packaging system could indicate when food is spoiled or communicate information digitally with technologies such as a smartphone.

A framework was originally proposed by Yam et al.[7] showing the functions of modern packaging systems (see Figure 1). Such smart packaging systems are characterised by *active* and *intelligent* packaging technologies.[6,8] The terms *active* packaging and *intelligent* packaging were previously used interchangeably[7]. However, the consensus today is that active packaging technologies change the condition of the packaging to extend shelf life or to improve safety (e.g., by adding carbon dioxide emitters, and oxygen scavengers), whereas intelligent packaging technologies allow different actors of the value chain to communicate each other. By displaying the condition of perishable goods during transport, storage, and consumption, stakeholders of food supply chains can make information in food markets more transparent and available in real time.[6,8] For example, Kuswandi et al.[9] introduced a new prospect to the packaging framework, connected packaging, which can take advantage of the increasing network of the Internet of Things technology to provide constant feed of information to distributors, suppliers, recycling companies and also final users.

Much of the research on smart packaging has been from an engineering and design perspective. The feasibility of these technologies is now well-established, with research going back more than a decade. For example, Abad et al.[10] presented a design for a Radio Frequency Identification (RFID) label with incorporated gas sensors which could be applied to monitor food safety along the supply chain. Abad et al.[11] also presented a similar RFID with its potential application in the fish supply chain, incorporating temperature, light, and humidity sensors. More recent research has incorporated other technologies such as time-temperature integrators (TTI), sometimes also referred to as time-temperature indicators.[12]

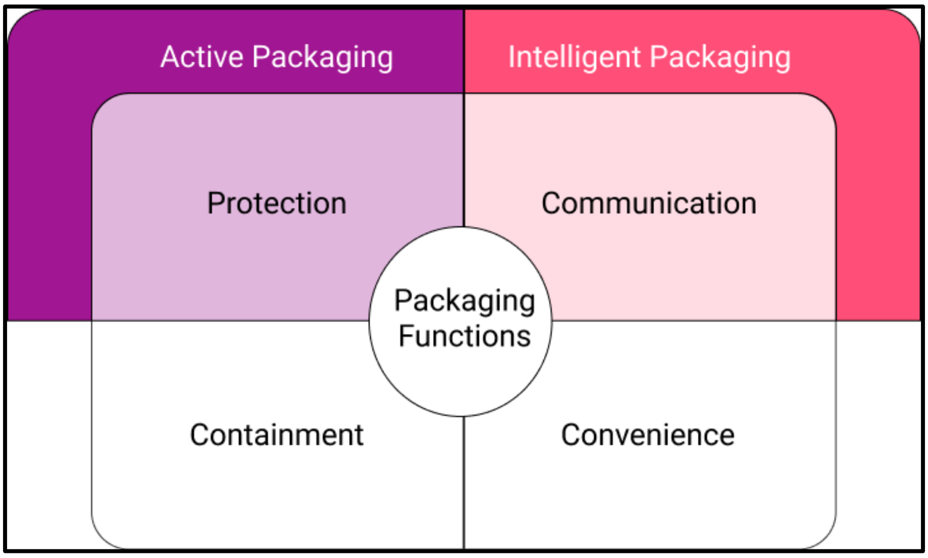

Figure 1. Framework of active and intelligent packaging (Source[7])

With the feasibility of smart packaging being well-documented, it logically follows that research has turned towards the potential applications of these technologies. For example, printed light and temperature sensors made from functional inks are technology in development.[13] Recently, Hakola et al.[14] evaluated different types of functional inks and printed indicators to create *smart tag* services through thermal, humidity, oxygen, and light sensitive 2D (2 Dimensional) bar codes.

Intelligent packaging technologies involve several sub-systems that can be used in combination: indicators, sensors, data carriers.[15–18] Despite well-established research and ongoing technological developments, they remain largely unused. Existing intelligent packaging, for instance, has the potential to provide significantly more information to consumers about their food and provide far more accurate food safety measurements than an estimated expiration date. Therefore, in the following sub-sections, we highlight previous work related to intelligent packaging technologies, then we will discuss smart tags and finally we will explore consumers' perception towards this innovative packaging.

1.1. Existing Intelligent Packaging Technologies

Intelligent packaging technologies are often considered most applicable to the decision-making selection process, allowing consumers to collect information, interact with food products and to aid their purchasing decisions. However, intelligent packaging does not only help consumers to make more informed choices but also improves their knowledge about characteristics of food products and relative supply chains at post-purchase level. Several reviews on technical aspects of intelligent packaging show that this new way of communication between consumers and stakeholders of food supply chains has enormous potential in terms of commercialisation, as it can enhance trust, transparency, and networking along food supply chains.[6,18–20] These technologies can generally be grouped into indicators, sensors, and data carriers, where the first two provide condition monitoring capabilities, and the latter package and/or product identification - even at item level.

1.1.1. Indicators

In their simplest form, indicators are functional inks reacting to environmental conditions, such as temperature, humidity, and lighting. More complex indicators are systems that involve multiple processing steps, such as activation and encapsulation. Usually, the information is displayed by immediate visual changes, e.g., different colour intensities or the diffusion of a dye along the indicator geometry. Therefore, indicators are used to communicate changes in areas such as temperature or freshness of products.[6,19,21] For example, thermochromic inks can detect changes in temperature and develop an intense colour if a predefined temperature threshold is reached.[22] Such indicators on product packages would therefore change colour at a certain level of heat or cold.

Similarly, freshness indicators can provide direct product quality information regarding microbial growth or chemical changes within a food product by displaying a shade of colour, which changes gradually based on the chemicals or microbes detected inside the package.[21] Thus, by changing colours packaging can indicate the deterioration of a product as it approaches spoilage. Literature has highlighted three different types of indicators: time-temperature indicators, freshness indicators and gas indicators.[6,19,21] These indicators can be based on mechanical, chemical, electrochemical, enzymatic, and microbiological changes.[18] Indicators with application to food packaging are time temperature indicators, oxygen and integrity indicators, and freshness indicators.

1.1.2. Sensors

Sensors are electronic devices used to detect a wider range of chemicals[23,24] inside food packages. Although some studies have used the term sensors and indicators interchangeably[9], a widely accepted distinction is that sensors allow detection, recording and transmission of information about biological reactions in the package. Unlike indicators which display the state of a product in the package, sensors may also be monitored by an external device.[25] Sensors detect and respond to some type of input from the physical environment, and the subsequent output is generally a signal that is converted to a display that is readable by consumers. [7] Therefore, sensors provide continuous output of signals and often contain two main functional parts, a receptor, and a transducer.[6] Sensors commonly found in the literature include biosensors and gas sensors. Due to their wide range of capabilities, biosensors and gas sensors have been used with fresh meat and vegetables[24] to monitor and quantify gas states, deterioration and microbial contamination.

1.1.3. Data Carriers

Data carriers are used as a medium to support communication and traceability of products. Radiofrequency identification (RFID) and barcodes are the most common forms of data carrier.[7,19] They can facilitate information through the food supply chain efficiently for communication, automation, and traceability purposes. Due to their flexibility, RFID tags in combination with integrated sensors have been used to track and monitor the status of perishable goods such as fruit juice[26] and apples without removing their packaging.[27] As smartphones become capable of reading some RFID tags and most barcodes, data carriers also provide an ideal starting point to enhance communication with consumers.

RFID tags use electromagnetic fields, also known as near field communication (NFC) technology, to allow identifying and tracking which can be passive, active, or battery-assisted passive. A passive tag is the cheapest and smallest solution which uses the radio energy transmitted by the reader for power. An active tag transmits its ID signal periodically and requires a battery power source. A battery-assisted passive tag also uses a battery but is activated only in the presence of an RFID reader.

Linear or 1D (1 Dimensional) bar codes are used in virtually all product packaging to identify the product. However, due to their limited capacity to encode data – typically less than 20 numerical characters – they are not suitable for item-level identification. Also, the need for a specialised reading device presents issues in evaluating the consumer perspective. 2D barcodes, such as QR codes and Data Matrix codes, consist of black and white squares called cells. They provide a larger capacity for information (thousands of characters) with error correction to have data accessible even when the code is partially destroyed. 2D bar codes can serve as a link to a database similar to linear bar codes, but they can also serve as an independent database.

1.1.4. Printed Electronics

Electronic devices such as RFID tags and sensors have successfully been printed on flexible substrates such as polyimide, polyester, and even paper using conductive inks.[8] This means that thin, lightweight, and flexible electronic labels can be produced. Unlike traditional silicon-based production processes, printed electronics consume less time and energy, and produce less production waste, positioning them as an ideal technology for intelligent packaging applications. Advanced technologies used in printed sensors include biosensors, capacitive sensors, piezoresistive sensors, piezoelectric sensors, photodetectors, temperature sensors, humidity sensors and gas sensors. Hakola at al.[28] presented a fully printed smart label on paper consisting of an NFC tag and an electrochromic display for anti-counterfeiting purposes.

1.1.5. Blockchain Technology

In a separate vein of research on supply chain traceability, recently blockchain technology has also become quite popular due to its robustness against label counterfeit.[29] Unlike the traditionally centralised approach where supply chain traceability information is stored in a centrally managed database, a blockchain traceability framework follows a decentralised approach and uses a smart contract protocol.[30] This allows only trusted supply chain entities with access rights to create transactions in the ledger. These transactions are trackable and irreversible. Customers can then retrieve these transactions by scanning RFID tags, barcodes, or similar data carriers.

1.2. Smart Tags

Smart tags, a term coined by a few researchers to refer to a unique combination of intelligent packaging technologies, are visible electronic markers (or tags) with environmental sensing ability combined with software intelligence (e.g., machine vision, user information, and location)[11,13,14,31] thus combining data carriers with indicators or sensors. Previous applications of smart tags provided context-aware services for end users and enabled connectivity to the Internet of Things (IoT). One recent publication shows reversible thermochromic ink being used in a QR code, which is printed on the label of a beer bottle and becomes visible when the temperature reaches a certain level, essentially modifying the original QR code.[13] Furthermore, there are commercially available RFID or NFC tags that have integrated temperature sensors.

With evolving food regulations in the European Union (EU), it is critical to better understand how smart tags can contribute to improved quality assurance systems and what information they could communicate along supply chains. Smart labels can help consumers to process information better because of the immediate visual communication of quality and safety attributes. European consumers are also concerned about increased food waste caused by additional packaging materials.[32] They also may not trust the information provided by these innovative labels. Consumer trust for food information is a topic which has been thoroughly explored regarding the food industry.[33–35] Higher trust in information sources and actors in the food system has been found to increase consumer acceptance of food technologies.[36] However, European consumers' trust regarding intelligent packaging technologies remains understudied. Simultaneously it has been proved that issues of sustainable development, sustainable value chain and innovations are increasingly gaining researchers' attention.[37] Moreover, consumers are willing to choose sustainable brands[38] provided that the information about it is easy to find.

1.3. Consumers' drivers and barriers of intelligent packaging

To investigate consumer perception towards the use of intelligent packaging technologies, we conducted a literature search on consumer attitudes towards intelligent packaging. The four repositories (Science Direct, Web of Science, IEEE Xplore and ACM Digital Library) queried from 2010 to 2020, produced an initial set of 259 articles. From this initial dataset, we selected 18 relevant articles describing empirical studies that include the assessment of intelligent packaging technology such as QR codes and TTIs.

While traditional labels are used by manufacturers mainly to convey information in line with Regulation (EU) No 1169/2011 on different types of packaging material like plastic, paper, metal, glass, or a combination of those materials,[39] QR codes and TTI provide them with an additional intangible communication layer by means of increased traceability and communication. This aspect of innovative labels can be extremely important in case of food safety incidents observed in different EU countries such as the 2022 salmonella outbreak linked to Kinder chocolate[40] and the 2013 horsemeat scandal[41]. Thus smart labels can help to mitigate the loss of consumers' confidence in regulatory agencies, producers and other stakeholders in case of food safety incidents.[42–44]

QR codes have the ability to store more data than barcodes and traditional labels, and they have been thoroughly investigated in studies dealing with supply chain traceability.[45] QR information that is highly valued by consumers is the history or timeline of a food product throughout the supply chain[46] such as information about pesticides, fertilisers and other agronomic practices, and dietary rations fed to animals. Like conventional labels, claims conveyed by QR codes are often supported by an independent government or a certifying body and they are perceived as a driver to facilitate the use and acceptance of this technology. Such an independent government or certifying body would be responsible for food safety and hygiene standards and could provide consumers with reliable information about food and drinks. Even though QR codes are a relatively easy technology to implement, consumers' apparent lack of knowledge and interest in food traceability[46,47] and health consciousness[48] appear to be significant barriers to their introduction on the market.

A number of recent works have also started to focus on smart contract protocols[30,49], which are based on the blockchain technology, allowing multiple trusted supply chain entities to create immutable transactions which customers can retrieve by scanning RFID tags or barcodes. However, blockchain technology is new to most supply chain entities[50] and technological incompatibilities along the supply chain currently require a significant number of manual actions for implementation.[51]

Time-temperature indicators, placed on individual or bulk packages to convey the time-elapsed temperature history of a product,[21] are particularly useful for products in the cold chain. The potential benefits of TTIs include easy interpretability, food safety benefits and quality assurances.[32] Irreversible colour changes also prevent misrepresentation of a product's safety or quality. In contrast to the potential benefits, consumers may be concerned with increased packaging waste and price due to the indicator. In addition, consumers may perceive a risk that indicators could leak substances onto food, cease contact with food (decreasing reliability) or be manipulated by retailers. Recent studies have started looking into developing safer products such as edible pH sensor[52] and natural product-based oxygen indicators[53]. However, studies conducted by Aday and Yener[54], and O'Callaghan and Kerry[55] found that from a consumer point of view, the perceived risk of being misled with innovative packaging claims was still a barrier to adoption. Consumers may be more willing to accept a technology after viewing educational commercials.[54] Food suppliers also showed similar concerns indicating that there is a risk of misconduct which could lead to liability issues. Some of these concerns apply to all smart packaging technologies.

According to O'Callaghan and Kerry[55] and Paunonen et al.[56], consumers also found that higher costs of any new technology represent a barrier for consumers' adoption. Besides, new technologies may be incompatible with existing packaging machinery for most food suppliers as they add technical complexity and require massive investment. O'Callaghan and Kerry[55] also found that consumers' acceptance of new food packaging technologies is influenced by the age of the end-users. For instance, consumer acceptance decreased with increasing age, and the preference for no technological interference with food was higher for individuals over the age of 35.

Recent developments in intelligent packaging technologies, including thermochromic and photochromic inks capable of changing colour when the intensity of temperature or light changes, and various printed electronics solutions, are contributing to increased interest and application of intelligent packaging technologies. Despite this, we have not yet seen intelligent packaging technologies being used widely in the market. Among the 18 empirical studies we reviewed, research which specifically assessed the concept of intelligent packaging, comprising indicators, sensors, and data carriers, is more limited. Only one article[32] specifically focused on time-temperature indicators, an intelligent packaging technology, while the rest assessed either a general smart packaging concept, or a traceability application (e.g., the use of QR codes, and labels).

These studies show that to date, limited research has explored consumers' perception of these technologies from an economics or marketing perspective. More research is needed to understand consumers' concerns, needs and expectations of innovative packaging technologies for food and beverages. Therefore, the objectives of this study are to understand to what extent European consumers are concerned about issues of food supply chains, their needs and expectations in terms of information conveyed by smart tags and what type of smart tag they would like to see on the market. To achieve these objectives, we tackled the following research questions:

RQ1: What kind of information about food value chain is valuable for European consumers?

RQ2: What type of information conveyed by smart tags can satisfy need and wants of European consumers?

RQ3: What are the most appealing innovative packaging technologies to European consumers?

The remainder of this paper is organised as follows. Section 2 will explain the qualitative methodological approach used to answer previous research questions. Section 3 will present results. Section 4 will discuss the implications of our findings. Section 5 will conclude the article with limitations and insights for further studies.

2. Materials & Methods

To achieve the stated objective and answer research questions, qualitative research was conducted running focus group discussions (FGDs) in selected European countries. FGDs offer researchers the opportunity to interact with several participants systematically and simultaneously, and promote discussion to obtain insights on a particular topic.[57] This qualitative method is not concerned with generalising findings but to use social interaction to generate data.[57,58]

In this study, FGDs were based on a co-creation approach where participants shared their views towards future packaging solutions. A total of 12 FGDs were held across 5 countries (Finland, Iceland, Poland, Spain, and the United Kingdom) interviewing 86 individuals in total (Table 1). To be eligible for this study, participants had to live in the above-mentioned countries, be 18 or older, be a primary food buyer for their household, and recognise at least one type of smart tag out of the options presented to them using images of barcodes, QR codes and biosensors. Researchers involved in the recruitment process balanced the selection of males and females other than in Iceland where one of the two focus group discussions was conducted with females only. In the UK, the recruitment was conducted by a market research company, while in the other countries participants were tracked down using the snowball sampling method where each potential participant was sent a questionnaire with qualifying criteria.

Furthermore, to address problems commonly encountered with this method, within each group participants were homogenous in terms of age as suggested by Acocella.[59] As shown in Table 1, participants were split into age groups 1 (18-30), 2 (31-45), 3 (46-60), and 4 (over 60). Each FGD was identified by the country code followed by the age group number. For example, UK1 indicates participants interviewed in the UK and aged between 18 and 30, while Fl4 a focus group conducted in Finland with interviewees that were older than 60. Table 1 also shows that only in the UK four focus groups were conducted (one for each age bracket), while in the remaining countries two focus groups were performed interviewing participants belonging to two of these four age groups. The number of respondents for each focus group ranges from 4 to 8 as recommended in the literature[60] with about 67% of focus groups comprising eight participants.

Table 1. Number of participants by country, age and gender. *

	United Kingdom				*Finland*		*Spain*		*Poland*		*Iceland*		Total *countries*
FG identification	UK1	UK2	UK3	UK4	FI1	FI4	SP2	SP3	PL1	PL2	IC1	IC3	
Age groups	18-30	31-45	46-60	60+	18-30	60+	31-45	46-60	18-30	31-45	18-30	46-60	
Sample size	5	8	8	8	8	8	8	7	4	6	8	8	86
Male	3	4	4	4	4	4	4	4	2	3	0	4	40
Female	2	4	4	4	4	4	4	3	2	3	8	4	46

* UK=United Kingdom, Fi=Finland, SP=Spain, Pl=Poland, IC – Iceland and numbers after each country code indicate age groups:(1 = “18-30”, 2 = “31-45”, 3 = “46-60” and 4 = “older than 60”)

The focus group protocol was first developed in English and then translated in the other European languages. Before running FGDs, this protocol was submitted to ethical committees to verify its compliance with ethical standards existing in each country. Researchers conducted interviews between June and October 2020 and because of the coronavirus pandemic, all focus groups were conducted via video conference using Zoom taking advantage of breakout rooms and a virtual whiteboard. Regardless of the pandemic, the use of online focus groups has been growing over the past decade, mainly because of the rapid improvement of the internet facilities.[61] Each FGD lasted around 2.5 hours and at least two facilitators were engaged with each session which included splitting participants into breakout rooms of 2-3 people.[60]

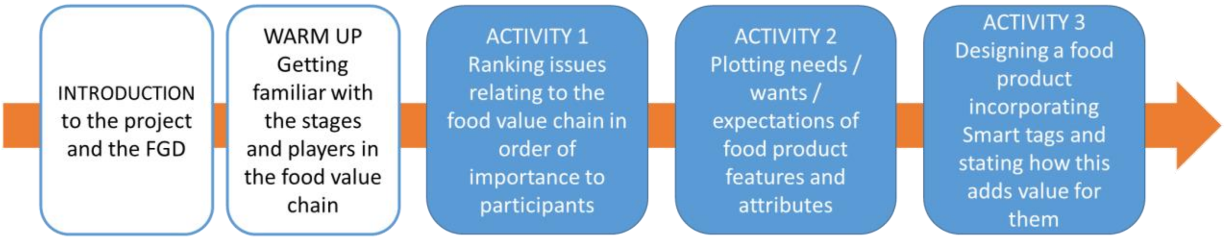

Figure 2. Focus group procedure.

As illustrated in Figure 2, FGDs started off introducing the project to participants and discussing the stages and players of the food value chain with them. Participants were shown a short game where they were asked as a group to place the different stages of the value chain in the correct order. Subsequently, interviewees were involved in three main activities. The first two activities aimed at introducing the topic gradually and to provide a solid foundation from which the participants could have enough information about the subject in order to design a solution for it[62]. In particular, activity 1 had the objective to get a shared understanding of issues regarding the food value chain.[60] For this activity, participants were split in different online breaking rooms and had to discuss a list of issues presented by the moderator. This discussion was concluded with the ranking of issues on a vertical axis from the most important to the least important averaging the scores of respondents.

Instead, activity 2 had the purpose of exploring needs and wants of participants in relation to features and benefits of information conveyed by smart tags. A *need* refers to something that is a necessity for consumers and therefore provides a strong reason for purchasing it[63]. Because there is a variety of smart technologies, participants were shown examples of these innovative packaging for feedback, focusing on the value that information could add to consumers. Participants had to compare their needs with their expectations to understand what kind of information they expect to be available when purchasing food products. On the other hand, a want is something unnecessary but desired because it can increase quality of life. Thus, they also had to indicate some features that they would like to have (*want*) to potentially improve their lives or purchasing experience. After having identified features and benefits of smart tags information, participants, as a group, were asked to plot different characteristics and advantages in a Cartesian space which consisted of the “Want/Don’t want” vertical axis and the “Don’t need/Need” horizontal axis. Features and benefits plotted in the first quadrant of this hypothetical Cartesian space could help participants and researchers to identify potential smart tags delivering the highest information utility.

The third activity was a co-creation task that aimed at discovering the acceptability of different smart tag solutions. Participants were split into smaller groups and given separate virtual rooms to work in with their own moderators[60]. Participants were asked to synthesise the information from the first two activities with their own ideas and design a smart tag solution as a group[60]. For this task, persona creation and experience mapping methods were used as introductory techniques[62]. Then participants selected the product and developed a smart tag solution that fits needs, expectation and wants of a hypothetical persona. Focus group facilitators ensured that the conversation was easy to follow and that each participant was engaged with the group discussing individual opinions and experiences[60].

All FGDs were recorded using Zoom and recordings were transcribed and translated into English. Research teams from each country prepared a report summarising the salient aspects of these discussions. Since FGDs were conducted in local languages, thematic analysis was carried out by individual researchers in their respective countries. A deductive content analysis was performed on themes that emerged from the literature review conducted on this topic (Citation) and the analysis of participants' wording followed the structure of the three activities of the interviews.

3. Results

Results are presented according to the three focus group activities described above: food value chain issues (activity 1), expected smart tag features and benefits (activity 2), and smart tags co-creation (activity 3). The following three subsections provide detailed results in relation to these three activities.

3.1. Food Value Chain Issues

Participants generated a list of issues that consumers associate with the food value chain. These issues were in line with those observed in the literature review: food safety, food waste, freshness, product quality, traceability and product origin, sustainability, recycling, ethical practices, trust in product, trust in brand, and price (which, according to Lauternborn[64] constitutes cost to the customers). The discussion over the importance of these issues is summarised with selected illustrative quotes of various focus groups in Appendixes 1 and 2. The positive, negative and undetermined direction of these explanatory quotes show that even if some differences can be observed across focus groups, there is also a convergence on the importance of issues like food safety and quality which dominate participants' concern when they make their purchasing decisions. This means that other issues, even if they matter, often appear to be the second or third best concern in their buying decisions. This is also evident from Appendix 3 where the ranking of these issues confirms the cross-cultural convergence for food safety and to some extent for food quality as observed for young participants in Finland, Iceland and the UK, and older participants in Finland and Iceland this not rated as one of the most important issues. Furthermore, Figure 3 illustrates the average ranking of all these issues, that are of high importance for European consumers so that the information about them constitutes value for consumers (RQ1). It has been confirmed that food safety and product quality were considered the most influential concerns of their food choices. However, it is also surprising to observe that despite the importance of recycling in terms of environmental impact this appears to be ranked the least on the list of these issues.

"*We should receive a clear information about food safety.*" (PL2)

“*When I see quality, I feel that it is really an umbrella over everything else, that quality reflect everything else*.” (IC3)

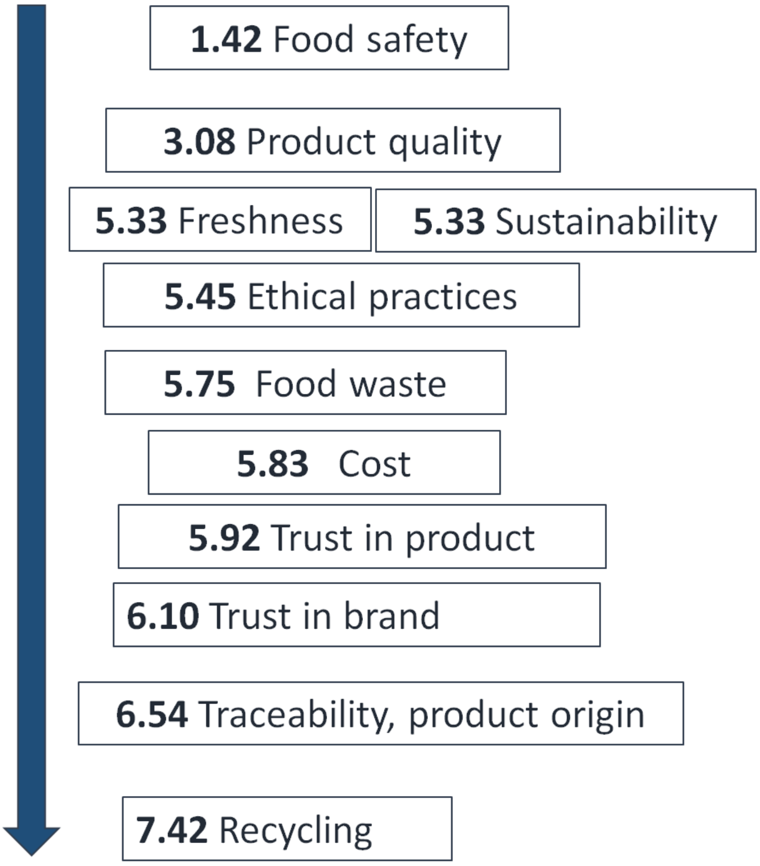

Figure 3. Participants perceived ranking of the most important issues in food value chain (most important = 1; least important = 7.42).

When justifying their preferences for food safety and quality, some participants expressed concerns for their health about possible chemical residues contained in fruit and vegetables and foodborne pathogens that can contaminate food products.

“(…) hygiene issues or also that what chemicals are used if there is a crop or anything else that ends up in our stomachs, then it is quite interesting if these are safe products”. (FI1)

“*Diseases and bacteria and stuff like that, that it shouldn’t be in the food or at least minimise the risk of contamination*”. (IC1)

Simultaneously some respondents suggested that quality is not obvious, usually assessed just by the appearance of a product and on the other hand not always plays a crucial role especially when meals are made combining different products.

“*We assess very often the food quality by its look*” (PL1)

“*If you are just going to put everything in a pot and make a soup, then the quality of each product maybe does not matter as much. Also, if I am paying a lot for a product, I expect better quality. It is different if I am just buying* *something from a can, then I might not expect the same quality as if I am buying something fresh.* (IC1)

The evaluation of food quality was also based on organoleptic characteristics of products such as colour and taste. As shown in table 2, quality was also strongly connected to price[1] as less expensive products were generally perceived of lower quality (UK1, SP2, also SP3). However, it is interesting to observe the way in which price fits in this ranking because its importance was perceived inconsistently across and within groups. Some participants gave low importance to price (IC3, FI4, PL2). They were willing to pay a premium price for food products only if higher prices could be justified by the rise in costs that producers incur to make their businesses more ecological and sustainable. Low importance to price can also find its justification in the life-cycle hypothesis of economics according to which spending and saving habits of people change over the course of a lifetime and thus during middle age people might have more available income compared to when they were younger[65]. Actually, the salience of price decreased with the age of participants in all countries.

Table 2. Selected quotes of the participants' perceived importance of price by focus groups.

Low importance	High importance
PL2: *I am able to pay a little bit more for products of better quality. And of course, if I am sure that a producer incurs some costs due to their adjustment to ecology or sustainability then I could also be willing to pay more but not much more.* IC3: *We look at it a bit differently depending on what life stage we are at. I can allow myself much more now than I could twenty years ago.* FI4: *For me, it should remain the least important of those.*	PL1: T*he cost should be reasonable and justified.* UK1: *Realistically price is the most important thing for me when I do my shopping.* UK1: *it's not necessarily the cheaper the better, if it is higher, then it might make you think it's better quality or that will be nice for a treat kind of thing but obviously everyone likes a bargain as well.* SP3: *I look for a balance between the product quality and the price. And there would be the food safety, as well, for me those are three essential points, basic to buy or select a product.*

Also trust in product and brand and environmental issues such as sustainability and food waste were inconsistent in terms of importance across focus groups. Product origin was least important for consumers in United Kingdom and Poland (see appendix 2). It is worth highlighting, that in Iceland respondents appreciated ethical practices.

"*I also think it is very important. There are for example many brands that I try to avoid and try to choose alternatives for, just because I know that when the product is traced, the ethics at the place of origins are not ok, for example when they are choosing the cheapest labour or producers, often in third world countries*." (IC1)

[1] Despite price and cost are not the same, participants were using these two terms as synonyms but in most of the cases they were referring to the price of food products.

In Finland, respondents paid more attention to ethical practices in the food value chain than consumers in other participating countries. Generally, this issue seems to be difficult to take into account while buying, though.

> "*(...) it can sometimes be difficult to make choices, consumption choices on the basis of this issue* (ethical practices – authors' note), *but it is important*." (FI1)

> "*If I knew something was unethical then, yes, I would avoid it, but I do not go out of my way to search for a company or a product to see whether it is ethical or not*." (UK1)

Both age groups in Finland also highlighted environmental responsibility. In contrast, while the younger group emphasised solutions to inform a conscious consumer of what happened in the earlier parts of the food chain, the older group was more interested in empowering the consumers to actually use the food products in a smart and responsible way to support both sustainability and health of the consumer. The food value chain issues connected with sustainability and ethics are presented in appendix 3.

As far as sustainability is concerned, consumers in Iceland are those who appreciated sustainability issues more than other focus groups participants and considered sustainability equal to food safety, but what should be noted is that they did not take it as a main criterion in decision-making, just like in other countries.

> "*Yes, I agree, that sustainability is up there (...). But at the same time, I would not choose a product just because it is sustainable if food safety was not secured."* (IC1)

> *"It is important, but it is not something that I particularly look into myself, but I do think that today it is very important, and I should take more notice of it."* (UK1)

Interestingly, consumers may believe that it is not their role to look for sustainable products and that it is a producer who should ensure that their choices will not have a negative impact on the environment and society.

> "*Again, producers should think about it and ensure that."* (PL1)

In addition, participants in Iceland considered decreasing the amount of food waste and recycling of high importance, but also highlighted the responsibility of producers or more attention on behalf of consumers when they plan the consumption of their food purchases.

> "*I also think it is important in the production, I do not know how bad it is in this country, but very often products are being discarded that are perfectly fine but do not look perfect and we as consumers do not want that. (...) for example, if a carrot is a few millimetres too short, then it does not reach the consumer and is eventually just discarded."* (IC3)

> "*Definitely. It is good to not waste food, but it requires a great control over your fridge*." (PL1)

Respondents also expressed their confusion regarding the effort that they make to reduce waste and recycle correctly.

> "*I think for me, as a consumer, I sort my waste and recycle single use packaging, but I do not know what happens to the waste I have sorted.* (IC2)

3.2. Most and Least Desired Information Conveyed by Smart Tags

In the second focus group activity, expected features and outcomes of smart tags technology were analysed employing the need-want-expect mapping approach described in section 2. Appendix 4 and Appendix 5 report quotes of the most and least wanted, needed and expected information that smart tags should convey to consumers. Generally, consumers across all groups expressed a desire for more detailed information about ingredients, highlighting that it may affect their food choices.

> "*I tend to get annoyed when they do not have the actual details, when it goes "Flavourings!" I have no idea what those are, it is non-specific. I am interested, mostly, I will look and go "I wonder what that is. Oh, it has flavourings. Wonderful!". So, I would want that quite a lot personally*." (UK1)

> "*At least things get all messed up if it does not exist. And I guess it suggests that is what I want to read. I expect to get, and I need, yes and it is number one indeed*." (FI1)

Information about how to store or how to prepare food was also considered of high needs, wants and expectations, as they influence the safety of food, and they are not always obvious to consumers.

> "*It is probably quite obvious that it needs to go in the freezer or the fridge or a cupboard, but it is still good to have it there because some things you do find out that other people have been storing it in the fridge and you have been putting it in the cupboard, like sauces and those kinds of things."* (UK1)

> "*Usually, you know how but anyway such information should be given."* (PL2)

On the contrary, participants had a negative response to being provided with recipes, as they do not add value, and there are better sources for recipes.

> "*It is not that it does not add, it just gives an additional value, it is a plus, like, well, if I also tell you how to cook it in another way, well we can try, it is not something necessary, but it would not be something I am not looking for."* (SP2)

> "*I have never used such recipes. And I do not know anybody who did it. I am not sure if they work, what will be the effect, there is no picture of the effect."* (PL1)

Also, geo data was something that respondents did not appreciate too much.

> "*Taking an avocado for example, it would be good to know its journey. Well actually it may be interesting but... but probably still not expected."* (PL1)

> “*It is no more than curiosity; it is definitely not a need*.” (UK1)

Surprisingly respondents did not expect, even did not need nor want to be informed about competitions, perceiving this offer as of little value and in which they do not take part.

> “*I very rarely take part in competitions, food-related ones, and I have definitely never won anything.”* (UK1)

> “*They are of little value to me.”* (PL2)

> “*I do not really care about this, honestly.”* (SP2)

Consumers’ preferences for information connected with personalised deals (loyalty programmes) and recycling were inconsistent across the groups. These were generally wanted, but consumers indicated they did not feel well informed and did not expect to see this information.

Participants explained that personalised deals were nice, sometimes handy, but not all of them needed offers like this.

> “*I would not want, need or expect it, but I can see how it would be beneficial to some people, definitely. It probably would be beneficial to everyone if they had a Clubcard, but I have never had one myself.”* (UK1)

> “*I have a Clubcard so I think I would quite like this. It would be quite handy*.” (UK1)

> “*It is not something I crave or urgently need, but if it is there, I use it.”* (SP2)

As far as information connected to recycling is concerned, some respondents suggested that they would not necessarily follow such instructions, whereas simultaneously others found it useful. Informing consumers on how to proceed with packaging is perceived as an obligation on the producers' side.

> “*I still think it is important. I have seen it on products, and I do think about it, like, if this is not recyclable, and I often buy based on that. If it is recyclable, I am more likely to buy it.”* (IC1)

> “*I would ask for information about the second life that this packaging could have. Maybe I can use it as a flowerpot and I will not throw it, because I was looking for one. Or maybe I can use something as a footrest, or well, it is an information that I do not expect, but if you give it to me, well, I can give it a second life or recycle it myself*.” (SP2)

> “*Most western countries are now really placing the responsibility of recycling on individuals, so it is important that it also comes from the producer, how to recycle the packaging because there is a lot of packaging that just ends up in the trash because people do not know. Like the others have pointed out, you do not know if it is this kind of plastic or that kind of plastic.”* (IC1)

This activity, which allowed us to answer RQ2, was concluded with the mapping exercise where, as shown in figure 4, there sems to be a convergence across

European participants towards the most and least desired type of information that smart tags should communicate to consumers. Information about ingredients, food storage and preparation, shelf life and health information fall in the high right-hand corner of the positive quadrant of this hypothetical Cartesian space and therefore it appears to be the most desired by participants. Also, information about the freshness of the product, recycling and personalised deals falls in the positive quadrant but as it is closer to the intersection of two axes seems to be less preferred than the previous one. Surprisingly, traceability and the origin of products fall in the negative quadrant close to the zero point of this Cartesian space. Instead, information about recipes, maps/geodata and competitions appear to be unwanted, unexpected and unnecessary.

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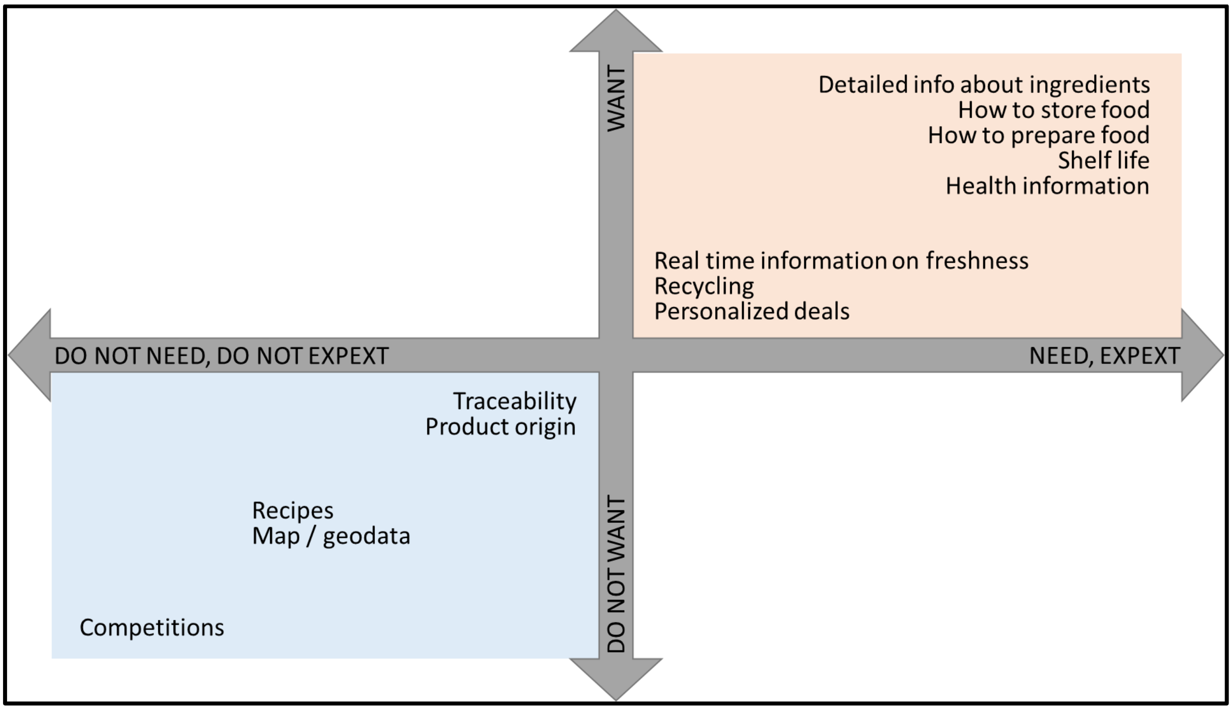

Figure 4. Wanted, needed, and expected information to be provided by smart tags

3.3. Smart Tags Co-creation

To answer RQ3, in the third focus group activity, participants were split into two virtual rooms to develop their own proposals for smart tags justifying the added value of information conveyed by this innovative packaging. Groups were willing to combine various smart tags and their functionalities, even if they did not know certain technologies or had not seen them in the market. Participants did not propose any abstract, non-existent technologies. It is worth noting that several groups chose to not include some smart tags due to the risk in product quality. Participants found QR codes, freshness indicators, and temperature indicators highly interesting. Barcodes and RFID were also mentioned.

The popularity of different sets of smart tags proposed by participants during this activity is presented in the table 3. The results from the proposals developed by the subgroups in each FGD are summarised in Appendix 6. It turned out that out of 24 sub-groups, 19 referred to QR code technology. This type of smart tag was proposed for wines, beers, and beverages with its usefulness mainly concerned with product origin. Several groups mentioned the importance that freshness indicators should be used in conjunction with "common sense".

> "*QR code(s) [are] good for the retailer, good on wine, anything you'd be sitting relaxing with but ultimately there is more to life."* (UK4)

> "*I, for example, quite like QR. The QR, for example, we are now getting used to going to restaurants and looking at the menus with a QR, the QR allows you to put a lot of information so maybe the ideal is to combine a simple information in the box, put the origin in a general way, and hey, whoever wants more information, there is the QR."* (SP1)

In addition to QR codes being mentioned as a preferred technology, they were perceived as valuable to those with allergies who need or want more information on processing or ingredients. QR codes were also perceived useful to recommend food products to friends.

> "*Hormones, and stuff like that… so this could also include what kind of feed the chicken was fed and then alert people with allergies.*" (IC1)

> "*It is easy to use, and you could get specific detailed info about the product without searching the internet and you can send this info to your friend if you were asked for recommendation."* (PL2)

Several groups mentioned the importance that freshness indicators should be used in conjunction with "common sense". Freshness indicators were proposed by many sub-groups (10 times in total) especially for meat and fish including frozen products. Respondents highlighted the ease of use of freshness indictors as a significant advantage.

> "*Sometimes the freshness or even edibility depends on the temperature of storage*." (PL2)

> "*It shows that the cold chain is implemented, or if it breaks, then the colour code will tell you that the product is no longer usable."* (FI4)

> "... *visual and passive, it does not require a concrete action from the consumer to see the information."* (SP2)

Table 3 summarizes the popularity of different sets of smart tags proposed by respondents. It is worth noting that the QR code and the freshness indicator were relatively frequently combined by participants as they were perceived to increase informative added value (5 times paired and 2 times with another smart tag). However, the freshness indicator was never proposed as a standalone smart tag like QR codes and time-temperature integrators. Moreover, in relation to the smart tags proposed by sub-groups, participants reported that technology would add value to the product by increasing trust and confidence. Participants identified three main added values from smart tags: (1) an increase in confidence and trust in the producer, the quality of the product and its freshness, in the whole food chain, brand and product; (2) the communication of useful information about ethics, sustainability, product quality and health properties; and (3) an improvement in consumers' purchasing decisions in relation to what to buy and to whether a product is "good" or not.

Table 3. Popularity of different sets of smart tags proposed by participants during the co-creation activity

Set of Smart Tags						Popularity of a set of Smart Tags (numbers of FGD subgroups)
QR						6
QR	Freshness indicator					5
QR		Thermochromic label				3
QR	Freshness indicator		Barcode			1
QR	Freshness indicator				RFID	1
QR		Thermochromic label	Barcode			1
QR				TTI		1
QR			Barcode			1
	Freshness indicator			TTI		1
	Freshness indicator		Barcode			1
	Freshness indicator				RFID	1
			Barcode			1
				TTI		1

4. Discussion

The primary functions of food packaging include protection, communication, convenience, and containment. Today, contemporary technologies enable active and intelligent communication with smart solutions for food packaging. This study improves European consumers' understanding towards intelligent food packaging technologies, including the value that they attach to information conveyed by smart tags.

As regards RQ1, results show a cross-cultural convergence for food safety and food quality as they were considered the most important issues of the food value chain.

Getting participants to agree on the top ranking of these issues was relatively easy because food safety and food quality are often communicated to consumers with certifications on food packages by third-party agents or governments. Interestingly, aspects remarked in the literature[38] as important for contemporary consumers such as recycling, food waste, sustainability or ethical issues were not ranked high up by interviewees.[32,35] Thus, even if participants of some focus groups emphasised the importance of ethical issues or sustainability, when they had to compare this information with that related to food safety or food quality, they always preferred smart tags conveying the latter rather than the former. This cross-cultural pattern can be explained by the fact that food safety and food quality are intimately connected to the immediate consumption experience of a product and can be easily checked by consumers, whereas information about ethical issues or sustainability rely more on trusting stakeholders' communication.

Results also suggest that sustainability and ethical features of food products should be more under the responsibility of producers because participants felt that they did not have enough knowledge to make more sustainable and ethical buying decisions. They stated that they would be willing to pay a small amount of money for more sustainable food brands, but they did not want to think about this type of information when they go shopping. For example, Polish interviewees pointed out that they do not usually think about the end-of-life information on the package/product when shopping. In the UK, participants indicated that the importance and ease of recycling does not affect their purchasing decisions and in Iceland respondents stated that they were not sure about what happens after they have taken food waste to the collection point. Some participants felt that decreasing food waste is challenging and as a result they did not necessarily pay much attention to information regarding this aspect. Alternatively, other interviewees felt that the reduction of food waste was one of the most critical issues. In Iceland they also discussed the importance of ethical issues in the supply chain. Despite their importance for many consumers, they claimed it was difficult to discover this information when shopping. However, when they know or perceive that some brands are unethical, they boycott these products

For price, its relevance leads to an interesting trade-off with food quality. Price was rated inconsistently between groups, and there was a clear influence of age on price, as price information was more often rated as an important issue for younger participants. This is most likely due to older participants having higher economic resources than younger people whose available income may be affected by number of dependants at home, mortgages and so on. Nonetheless, there was a general agreement that a high price can be indicative of quality even if this does not automatically make a product better.

Also, for RQ2 our analysis shows cross-cultural convergences for information that is wanted, needed, and expected when using smart tags. Potential information conveyed by smart tags should focus first on what is already shown on conventional labels of many food products such as nutrient profiles, shelf-life, traffic lights, nutri-scores and so on. Participants equally rated needs and wants of information regarding ingredients, food storage and preparation, shelf life and health information very high.[66,67] It is likely that QR codes and other intelligent and active packaging technologies can pave the way for the digitalisation of food information displayed on conventional labels. As well as accelerating the digitalisation of food information already contained on food packaging, smart tags can add further value to supply chains helping consumers to evaluate the freshness and safety of food products on the spot and to appreciate more issues like recycling which participants found difficult to follow and understand. These new packaging technologies can also help retailers to devise marketing strategies tailored to specific people or groups of customers. Our results also indicate that real-time information communicated by freshness indicators, information about recycling and personalised deals were needed and wanted by participants. However, digging deeper into the expected smart tag features and benefits we have observed that traceability conveyed by smart tags was not so strongly desired. It is likely that this information is more difficult to verify and thus participants perceived it to be of less value in comparison to other pieces of information discussed previously. When consumers can trust information available to them this can increase their acceptance of food technologies.[36] Information about recipes, maps/geodata and competitions/contests did not attract participants as they perceived this information available through smart tags more like marketing strategies that would not add value to food products. They found the Internet more useful than smart tags to look for recipes and competition as consumers expect high-quality information content that offers them additional value.[31]

Regarding RQ3, although participants were presented with multiple smart tags technologies, almost all the most appealing solutions included a QR code as the tool to store and display information. There was a perception that QR codes are well-known, easy to use and affordable. From a technological point of view, the use of QR codes is also increasing due to their ability to store more data than barcodes and traditional labels.[45] Interestingly, the contents of issues rated as less important (recycling, ethical issues, sustainability) were proposed as the ones to be included in the QR codes. It appears that QR codes were perceived as a tool which offers heterogeneity of information that consumers can cherry pick according to their interests and preferences. For example, some participants stated they could see this type of smart tag as an excellent tool to communicate allergens.

The second most commonly proposed smart tag solution was that of freshness indicators, even though some participants expressed concerns over their use. They were concerned about practical issues such as increased waste and price of the new packaging, and the likelihood that indicators could leak substances onto food and/or become unreliable once they are not in contact with food or are potentially manipulated by retailers.[32,55]

Smart tags were of interest to all groups because interviewees perceived the new packaging technology as a way to add extra information and not to reduce what is already displayed on conventional packaging and considered essential. However, participants often showed lack of knowledge and/or interest for information regarding traceability[46,47] and benefits of healthy eating[48] which could represent a significant barrier for technology development. Thus, retailers and policy makers should invest more on consumer education because QR codes and freshness indicators can still increase transparency and consumers' trust along food supply chains.

Intelligent packaging enables improved communication between consumers and stakeholders within food supply chains and has an enormous commercial potential as various options are available.[6,18,19] As a practical implication, it is important to consider how benefits are communicated when smart tag solutions are brought to the market. In this way consumers can understand the difference between traditional and 'smart' solutions, appreciate the added value and be ensured that the trust levels in the product and food chain are maintained or increased.

4.1. Limitations

Although this study covered consumers from five EU countries, it should be noted that only in the UK did participants cover all age groups, while in the remaining countries focus groups were conducted only with two of the four age groups. Another limitation was imposed by the COVID19 pandemic as FGDs took place via an online platform and thus with limited the interaction with interviewees. Nevertheless, such online FGDs may be recommended for future research due to their ease, low cost and technological advantages of interactive whiteboards that facilitate respondents' engagement.

Furthermore, findings of this study are exploratory and qualitative in nature, and thus they provide initial insights towards consumer perceptions. These findings should be further evaluated in quantitative studies on an internationally representative sample.

5. Conclusions and Suggestions for Future Work

In this paper, our aim was to understand European consumers' attitudes towards issues regarding food supply chains and information conveyed by different smart tags. Smart tag technologies can add value to food supply chains in terms of confidence in quality, food safety and freshness evaluation at post-purchase level providing unique and personalised information to consumers. However, even if intelligent packaging technologies can offer smart communication from the fork to the farm of supply chains, they do not replace or reduce the importance of conventional labels already familiar to most consumers. Considering lack of knowledge for these technologies, the most popular smart tags such as QR codes could be used in conjunction with conventional labels to increase transparency of supply chains. This would allow consumers to get familiar with smart tag technologies and enhance their trust towards products and suppliers.

Furthermore, what is also worth mentioning is that the price of new packaging technologies was considered important by several participants, but there were only a few studies exploring this aspect. Assessing the economic value of different intelligent packaging technologies can be paramount in estimating the marginal benefit of additional information provided by different smart tags. Contingent valuation and stated choice studies can provide useful information in terms of profitability of intelligent and active packaging. Intelligent packaging can communicate more complex information such as food spoilage, freshness, and traceability but this may not necessarily translate into efficiency gains for stakeholders along the food supply chain. Consumers regularly see and use different types of labels, claims, and codes on food packaging, but are often disappointed by the quality of the information provided. It is clear that we need more studies on the type of information conveyed by smart tags for which consumers are willing to pay a premium price.[31] Our results also seem to indicate that information communicated by smart tags could also be linked to social values as indicated by Den Ouden.[59] However, considering the qualitative nature of this study we cannot assume that the economic value (consumers' willingness to pay) of smart tags is linked mainly to information regarding food safety, quality and freshness of products. More studies must be conducted to assess how food information and other values[59] such as ecological (e.g., eco-footprint), happiness (e.g., personalised deals) and belonging (e.g., product origin) are interlinked and traded off in consumers' heterogeneity of preferences. Understanding how values for money, sense of belonging, happiness and ecological ideals are linked to information conveyed by smart tag can help marketers to devise marketing strategies that can satisfy needs and wants of specific groups of consumers. Further consumers' studies could also explore how psychological components related to the use of smart tags could influence consumers' acceptance and purchasing behaviour.

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Appendix 1. Most important issues in food value chain from consumers perspective; illustrative quotes related to food safety and quality.

Food value chain issues	Sign*	Illustrative quotes
Food safety	(+)	FI1: (...) *hygiene issues or also that what chemicals are used if there is a crop or anything else that ends up in our stomachs, then it is quite interesting if these are safe products.*
	(+)	IC1: *Diseases and bacteria and stuff like that, that it shouldn't be in the food or at least minimise the risk of contamination.*
	(+)	PL2: *We should receive a clear information about food safety.*
	(+)	SP2: (One of) *three essential points, basic to buy or select a product.*
Food quality	(+)	FI1: *I want to eat quality food.*
	(+)	PL1: (...) *the health effects but also the taste.*
	(+)	PL1: We *assess very often the food quality by its look.*
	(+/-)	IC1: *If you are just going to put everything in a pot and make a soup, then the quality of each product maybe does not matter as much. Also, if I am paying a lot for a product, I expect better quality. It is different if I am just buying something from a can, then I might not expect the same quality as if I am buying something fresh.*
	(+)	IC3: *When I see quality, I feel that it is really an umbrella over everything else, that quality reflect everything else.*

Direction of the statement: (+) positive statements; (+/-) ambiguous statements; (-) negative statements.

Appendix 2. Illustrative quotes of food value chain issues connected with sustainability and ethics.

Food value chain issues	Sign*	Illustrative quotes
Sustainability	(+/-)	IC1: *Yes, I agree, that sustainability is up there (...). But at the same time, I would not choose a product just because it is sustainable if food safety was not secured.*
	(+/-)	UK1: *It is important, but it is not something that I particularly look into myself, but I do think that today it is very important, and I should take more notice of it.*
	(+/-)	PL1: *Again, producers should think about it and ensure that.*
	(+/-)	PL2: *These issues are important, and I am aware that we should be more sustainability oriented as consumers. But it seems not so easy for me. I do not feel well informed about it and what I should do more than waste segregation.*
Recycling	(+/-)	PL1: *Well, I actually do not think about it in the shop when buying. It is important that producers could foresee that.*
	(+/-)	UK1: *I personally find it easy. I do not think it is, you know, it takes two seconds out of your day to read the back of the packaging to see if can or cannot be recycled but having said that I do not think it would turn me away from a product if I liked that particular product and it did not come in recyclable packaging.*
	(+/-)	IC2: *I think for me, as a consumer, I sort my waste and recycle single use packaging, but I do not know what happens to the waste I have sorted.*
Food waste	(+/-)	PL1: *Definitely. It is good to not waste food, but it requires a great control over your fridge.*
	(+/-)	SP3: *Well, at the end of the day, the food waste, unfortunately, in my case I think it is not among the most important issues in the food value chain…*
	(+)	IC3: *I also think it is important in the production, I do not know how bad it is in this country, but very often products are being discarded that are perfectly fine but do not look perfect and we as consumers do not want that. (...) for example, if a carrot is a few millimetres too short, then it does not reach the consumer and is eventually just discarded.*
	(+)	IC3: *I think we have done a lot on this issue here in Iceland. You can always choose a product that is about to expire if you are going to use it the same day. I think that is important. That we are not throwing away food.*
	(+)	FI4: *I think that reducing waste is very important, that it also goes to the top of the list. It is essential.*
Ethical issues	(+)	IC1: *I also think it is very important. There are for example many brands that I try to avoid and try to choose alternatives for, just because I know that when the product is traced, the ethics at the place of origins are not ok, for example when they are choosing the cheapest labour or producers, often in third world countries.*
	(+/-)	FI1: *(...) it can sometimes be difficult to make choices, consumption choices on the basis of this issue, but it is important.*
	(+/-)	UK1: *If I knew something was unethical then, yes, I would avoid it, but I do not go out of my way to search for a company or a product to see whether it is ethical or not.*

*Direction of the statement: (+) positive statements; (+/-) ambiguous statements; (-) negative statements.

Appendix 3. Ranking of the most important issues in food value chain by focus group (most important = 1; least important =11)

	UK1	UK2	UK3	UK4	FI1	FI4	SP2	SP3	PL1	PL2	IC1	IC3
Food safety	2	**1**	**1**	**1**	3	**1**	**1**	**1**	3	**1**	**1**	**1**
Food waste	3	11	9	5	4	3	7	10	4	9	2	2
Freshness	8	2	3	3	11	10	3	5	2	2	8	7
Product quality	5	4	2	2	7	7	**1**	**1**	**1**	**1**	5	**1**
Traceability, product origin	10	10	7	7	5	NA	4	6	10	6	**1**	6
Sustainability	4	6	4	8	8	9	5	4	9	5	**1**	**1**
Recycling	7	5	10	11	10	6	9	9	6	8	3	5
Ethical practices	3	8	5	9	**1**	2	8	8	8	4	NA	4
Trust in product	6	3	6	6	9	5	2	7	11	7	6	3
Trust in brand	9	9	8	10	2	4	6	3	7	3	NA	NA
Price	**1**	7	11	4	6	11	**1**	2	5	10	4	8

Appendix 4. Most wanted, needed and expected information to be provided by smart tags, including illustrative quotes.

Information content	Sign*	Illustrative quotes
Food ingredients	(+)	UK1: *I tend to get annoyed when they do not have the actual details, when it goes "Flavourings!", I have no idea what those are, it is non-specific. I am interested, mostly, I will look and go "I wonder what that is. Oh, it has flavourings. Wonderful!". So, I would want that quite a lot personally.*
	(+)	PL2: *I do not read it every time, but I want to have the possibility.*
	(+)	PL2: *You have to know what you eat and if the list is indicated, then you may expect that nothing else is added that could be harmful for your health.*
	(+)	FI1: *At least things get all messed up if it does not exist. And I guess it suggests that is what I want to read. I expect to get, and I need, yes and it is number one indeed.*
	(+)	SP2: *I want to see exactly what there is in the product. Because when I read it contains E's, I do not buy it.*
Food storage	(+)	UK1: *It is probably quite obvious that it needs to go in the freezer or the fridge or a cupboard, but it is still good to have it there because some things you do find out that other people have been storing it in the fridge and you have been putting it in the cupboard, like sauces and those kinds of things.*
	(+)	FI1: *It is so essential that they are also clear enough to do so, because it makes it very easy for the consumer to act, so one would expect them to be found there.*
	(+)	PL2: *Usually you know how but anyway such information should be given.*
Food preparation	(+)	UK1: *I need to know how to cook whatever I have bought, what temperature it needs to be at and for how long.*
	(+)	FI1: *I do feel that that instruction, the instruction of how to prepare the food is needed more than those recipes, that you know just how long you should cook those groats. It is perhaps even more important to know that, rather than what it can be used for.*
	(+)	PL2: *For me it is important, I would like to be informed about it even if the product is simple. I cannot remember e.g., the time needed for cooking every single product.*
Shelf life	(+)	UK1: *If that information could be presented well, it would be really, really interesting and useful rather relying on Use By dates or whatever, I can go "Yes, this is good".*
	(+)	IC3: *I think that is something that everybody wants.*
Health claims	(+)	PL1: *Well probably something more connected with its effect on our health, vitamins, but also allergens.*
Real time freshness	(+)	IC1: *It sucks when you buy something and then you keep it in the freezer for one day and then it is ruined.*
	(+/-)	FI4: *It is what I might want, yes, I do, I do not necessarily need it.*
	(+)	PL2: *Such information would be very useful. Of course, you can see or smell if some food products are fresh but sometimes you may still be confused.*
Recycling	(+)	IC1: *I still think it is important. I have seen it on products, and I do think about it, like, if this is not recyclable, and I often buy based on that. If it is recyclable, I am more likely to buy it.*

	(-)	UK1: *To be honest, I think I do not even pay it, because it has just become so second nature to either recycle or not recycle things, I do not even really check packaging on it anymore, whereas I think when I first started maybe living independently, I was checking things, whereas now I do not really pay any attention to it.*
	(+)	SP2: *I would ask for information about the second life that this packaging could have. Maybe I can use it as a flowerpot and I will not throw it, because I was looking for one. Or maybe I can use something as a footrest, or well, it is an information that I do not expect, but if you give it to me, well, I can give it a second life or recycle it myself.*
	(+/-)	SP2: *If they mention it, it is okay, but if they do not, I do not really care.*
	(+)	FI1: *At least nowadays, when there are so many different trash cans in that yard. At least, that is how I study those packages all the time, as I expect it to tell me where I am going to put it.*
	(+)	IC1: *Most western countries are now really placing the responsibility of recycling on individuals, so it is important that it also comes from the producer, how to recycle the packaging because there is a lot of packaging that just ends up in the trash because people do not know. Like the others have pointed out, you do not know if it is this kind of plastic or that kind of plastic.*
Personalised deals (loyalty programmes)	(+/-)	UK1: *I would not want, need or expect it, but I can see how it would be beneficial to some people, definitely. It probably would be beneficial to everyone if they had a Clubcard, but I have never had one myself.*
	(+)	UK1: *I have a Clubcard so I think I would quite like this. It would be quite handy.*
	(+/-)	SP2: *It is not something I crave or urgently need, but if it is there, I use it*.

*Direction of the statement: (+) positive statements; (+/-) ambiguous statements; (-) negative statements

Appendix 5. Less wanted, needed, and expected information to be provided by smart tags, including illustrative quotes.

Information content	Sign*	Illustrative quotes
Competitions/ Contests	(+/-)	IC1: *It is really not important but nice to know.*
	(-)	UK1: *I very rarely take part in competitions, food-related ones, and I have definitely never won anything.*
	(-)	PL2: *They are of little value to me.*
	(-)	SP2: *I do not really care about this, honestly.*
Recipes	(+/-)	SP2: *It is not that it does not add, it just gives an additional value, it is a plus, like, well, if I also tell you how to cook it in another way, well we can try, it is not something necessary, but it would not be something I am not looking for.*
	(+)	SP3: *It can give you a hint, to change or try something new.*
	(-)	FI1: *I would prefer the manufacturer to spend that money on that product and not try in such desperate ways to sell it to me.*
	(+/-)	IC1: *It would be nice, but you can always google the information yourself. So, it is not necessary but nice.*
	(-)	PL1 *I have never used such recipes. And I do not know anybody who did it. I am not sure if they work, what will be the effect, there is no picture of the effect*

Map/geodata	(+/-)	PL1: *Taking an avocado for example, it would be good to know its journey. Well actually it may be interesting but... but probably still not expected*
	(-)	UK1: *It is no more than curiosity; it is definitely not a need.*
Traceability and product origin	(+/-)	UK1: *It is a nice idea but in reality, I do not care. I do not necessarily even trust the traceability on there with certain things, like, I am quite interested in how things get so lost in the food system and you get fake food and stuff and traceability is quite easily faked or it is hard to tell what is real traceability and fake traceability. I do not really look, in reality. It is a cute idea but it is of minimal importance to me.*
	(+/-)	IC1: *If its traceability, and if the place of origin is disclosed, then I do not really need anything visual, it is enough to be able to read it.*
	(+)	PL2: *Sometimes it may influence the nutrients value or the quality and sometimes it is about the national expertise - so it would be good to know.*

* Direction of the statement: (+) positive statements; (+/-) ambiguous statements; (-) negative statements.

Appendix 6. Summary of results related to smart tag technologies.

	UK1		UK2		UK3		UK4		FI1		FI4		SP2		SP3		PL1		PL2		IC1		IC3	
Barcode							x	x								x	x	x						
RFID												x		x										
QR code	x	x	x			x		x	x	x	x	x	x		x		x	x	x	x	x	x	x	x
Freshness indicator		x		x		x	x	x				x		x	x				x		x			
TTI				x	x																	x		
Thermochromic label									x								x			x			x	