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Food handling practices and expiration dates: Consumers' perception of smart labels

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ABSTRACT

Household food waste is a major sustainability problem to solve. Smart labels can alleviate the contributing factor of incorrect interpretation of expiration date labels. However, so far little research has studied consumer handling practices and perceptions of such labels in the context of use. We address this through a qualitative, asynchronous and text-based focus group study with 18 UK smart label early adopter and mainstream consumers, using the case of smart labels on red meat packaging. Results show that consumers are heavily reliant on either expiration date or their own senses, and that trust in the label is a key factor towards including smart labels in everyday food handling practices. Findings imply that in-store demonstrations and information would support and foster uptake of smart labels.

1. Introduction

Despite calls put out in recent years at both national and international level to reduce food waste (EPA, 2015; United Nations, 2020), 931 million tonnes of food are still wasted each year (United Nations Environment Programme, 2021), with significant consequences in terms of greenhouse emissions (Scialabba, 2015). Specifically, around 61 percent of food waste is generated inside the household (UNEP, 2021), underlying the urgency of developing new and more effective consumer-targeted solutions to curb the negative effects of this phenomenon.

As a reaction, technological efforts have centered around the development of new innovations aimed at helping consumers make more informed choices, ultimately reducing food waste. For instance, recent developments have seen the rise of new packaging solutions aimed at extending the shelf life of products and at helping consumers better track the quality and freshness of food (Firouz, Mohi-Alden, & Omid, 2021; Liegeard & Manning, 2020). These include *intelligent packaging*, that is, packaging containing sensors or indicators that monitor the condition of food during its life cycle (Heising, Dekker, Bartels, & Van Boekel, 2014), but also *smart labels* placed on the package that tell consumers whether the food is still fresh (Morrison, 2020a). In this sense, unlike *static* and overcautious expiration dates (Charles, 2017; Gaukler, Ketzenberg, and Salinc, 2017), these novel tools are *dynamic* as they provide real-time feedback to the consumer about the quality and freshness of food (Poyatos-Racionero, Ros-Lis, Vivancos, & Martínez-Máñez, 2018). Hence, it is expected that innovations such as *intelligent packaging* and *smart labels* can reduce consumers' heavy reliance on expiration dates when evaluating food freshness (e.g., Kavanaugh & Quinlan, 2020; Davenport, Qi, & Roe, 2019). Indeed, prior research has shown that consumers have an insufficient understanding of expiration dates (e.g., Leib et al., 2016; Newsome et al., 2014), which leads to confusion and misunderstanding (Kavanaugh & Quinlan, 2020; Yu & Jaenicke, 2021), and in turn to the disposal of food that might still be edible (Schmidt, 2019). Thus, the adoption of tools that extend the shelf life of food could effectively contribute to the reduction of food waste (Yu & Jaenicke, 2021).

However, while the introduction of these innovations is on the rise (Morrison, 2020a), there is scant research about consumers' response to these novel tools (e.g., Aday & Yener, 2015; Brennan et al., 2020; Pennanen et al., 2015). Furthermore, prior literature on this topic has largely neglected to account for the everyday context in which these innovations should be integrated and how these could affect consumers' daily practices (Brennan et al., 2020). Hence, the aim of this work is two-fold: first, to explore consumers' existing food handling practices and the role of expiration dates in the decision-making process in relation to purchase, use, storage, and disposal of food; second, to investigate consumers' perceptions of smart labels by understanding how these tools could be integrated in the dynamics of consumers' everyday life. Food handling practices can be defined as the collection of practices and

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activities involving food in various ways (Hebrok & Heidenstrøm, 2019) and have been shown to be a key determinant of consumer-generated food waste (Dobernig & Schanes, 2019; Evans, 2011). As such, methodological approaches focused on the understanding of how practices form and can change, have been considered most appropriate for the investigation of consumers' food waste behaviors, and more fitting than approaches focused on consumers' attitudes and motivations (Brennan et al., 2020; Dobernig & Schanes, 2019; Evans, 2012). Furthermore, we focus on *smart labels* as the demand for innovations that tackle food waste is growing for both manufacturers and consumers (Morrison, 2020b), and smart labels could meet this need by complementing expiration dates.

To explore the objectives of this work, we have conducted a qualitative study with UK consumers. Qualitative approaches are deemed appropriate for the investigation of consumers' practices inside the household (Dobernig & Schanes, 2019; Chammas & Yehya, 2020; Evans, 2012), and calls have been made for more qualitative contributions on the understanding of consumer behaviors in relation to food waste (Koivupuro et al., 2012; Porpino, 2016). Furthermore, a lack of qualitative research has been noted in relation to the investigation of consumers' perceptions of new, smart solutions aimed at tackling food waste (Brennan et al., 2020), suggesting the need for contributions more situated in consumers everyday contexts. In this sense, our work is in line with recent calls for more works focused on how consumers perceive and engage with new packaging technologies (Brennan et al., 2020). Finally, we focused on the UK market because here the relationship between expiration dates and food waste has gained greater awareness (Smithers, 2021), with both retailers (Smithers, 2017; Weinbren, 2017) and companies launching smart labels (Morrison, 2020a) that are aimed at extending the shelf life of food products as well as reducing the impact of expiration dates on food waste.

2. Materials and methods

2.1. Procedure and materials

Three online focus groups were conducted in February '21 with UK consumers. The data collection was conducted in collaboration with Mimica, an award-winning design-led UK company who has developed Mimica Touch, a patented label or cap integrated into the food or beverage packaging, that turns bumpy when food or drinks should no longer be consumed, based on actual temperature conditions. Mimica Touch provides an accurate, real-time indication of the product's freshness with a tactile interface and it is planned to launch on juice and red meat in 2022, with the aim of further expanding into other kind of perishable food groups (e.g., seafood, diary). Thus, it provides the ideal setting to explore consumers' perceptions of new smart labels and how these could affect consumers' use of expiration dates in their everyday practices.

The focus groups were *asynchronous* and text-based (Stewart & Williams, 2005), with participants receiving tasks at regular intervals and being asked to complete them on an online platform. This allowed participants to have more time to process the questions received and to reply when it was more convenient to them (Stewart & Shamdasani, 2017); In addition, this format mimics social media and blog interactions and is thus familiar to most consumers. Details about tasks assigned to participants during the focus groups are reported in section 2.2. Specifically, the focus groups run over the course of seven days, with questions being posted at the beginning of each day and with participants receiving a reminder to complete the tasks two days after the questions were posted. Participants gave their consent and were introduced to the platform the day before the start of the data collection. All participants completed all the tasks assigned to them.

The data collection took place on the online platform "Revelation" from Focus Vision. The first author received training on how to use the platform and acted as moderator during the focus groups. A contact person from Focus Vision was responsible for programming the questions and for answering queries from participants about possible technical issues or problems with the platform. Participants also received contact details of the first author for potential clarifications about the tasks.

2.2. Food handling practices and consumers' perceptions of smart labels

The data collection focused on consumers' practices and perceptions of smart labels in relation to red meat. Red meat was chosen as focus of the investigation as consumers are concerned about the freshness of meat (Bernués, Olaizola, & Corcoran, 2003) and use expiration dates when choosing which products to buy (Borgogno, Favotto, Corazzin, Cardello, & Piasentier, 2015). Red meat is also the food category with greatest climate impact (González, Marquès, Nadal, & Domingo, 2020), thus food waste of this category is also relatively worse and in turn most urgent to address. As such, they provide an ideal context to investigate consumers' practices in relation to expiration dates and how smart labels might affect their behavior, while also food waste's climate impact.

The focus groups were organized in three main phases: consumers' general perception of freshness and expiration dates (Day 1); consumers' practices in relation to purchase, use, storage, and disposal of red meat (Days 2–4): consumers' perception of smart labels and how these could affect consumers' food handling practices (Days 5–7).

2.2.1. Phase 1: Consumers' general perception of freshness and expiration dates

This task was aimed at familiarizing participants with the topic of the study by allowing them to provide their insights about their main concerns in relation to freshness and expiration dates. Furthermore, participants were asked to elaborate in detail about the strategies they adopt to assess the freshness of red meat (e.g., expiration date, characteristics of the meat), and to recall past experiences in which they had thrown away meat before or after the expiration date and why.

2.2.2. Phase 2: Consumers' practices in relation to purchase, use, storage, and disposal of red meat

The second phase of the focus groups ran over the course of three days and focused on consumers' food handling practices in relation to red meat. Specifically, the first day was focused on consumers' practices in relation to the purchase of red meat with participants being asked to visualize a typical shopping trip (Ngapo et al., 2004) and to discuss the actions they take when going grocery shopping for the product. To aid the visualization task, participants were also shown two examples of packages of meat (see Fig. 1) commonly found in supermarkets. Overall, this task was aimed at uncovering the main drivers of choice in store and the influence of expiration dates in this sense. For this reason, participants were asked to take a picture of a package of meat that they had recently bought; this was aimed at probing them to think about a recent purchase of meat with the aim of getting more realistic responses during the discussion.

The second day was focused on consumers' practices in relation to the use and storage of red meat at home. Specifically, participants were asked to post a picture of their fridge and to discuss their habits in terms of how and for how long they store meat before consumption or disposal. Indeed, fridges have been shown to provide useful insights into consumers' everyday food practices (Joosse & Marshall, 2020), as they provide a window into household food consumption and waste behavior (Davenport et al., 2019). This is particularly relevant as consumers' competences and routines for the proper storage of food have been shown to play a key role in food waste generation and prevention (Dobernig & Schanes, 2019; Graham-Rowe, Jessop, & Sparks, 2014). Furthermore, participants were asked to elaborate about their use of and the actions they take when deciding to consume meat, including possible preparatory actions undertaken before consuming the products.

On the third and last day of this phase of the focus groups,

Fig. 1. Examples of meat packages shown in Phase 2.

participants were instructed to discuss their behavior in relation to the disposal of meat, focusing on the underlying factors leading them to dispose of meat and on their specific disposal choices (e.g., general waste, recycling).

2.2.3. Phase 3: Consumers' perception of smart labels and their effect on consumers' food handling practices

The third phase of the focus groups was aimed at exploring consumers' perception of smart labels and how these could be integrated and influence consumers' practices in relation to purchase, use, storage, and disposal of red meat. This phase ran over the course of three days, with participants on the first day being shown a description and pictures of the Mimica Touch label developed to assess freshness of red meat. Specifically, the label was described as a temperature-sensitive indicator that feels smooth when the food is fresh, but becomes bumpy when the food is no longer good for consumption (see Fig. 2). After being introduced to the label, participants were instructed to discuss their opinion of the label and how this would affect their purchase of red meat in store. During the second day of this phase, participants were prompted to discuss whether and how the presence of the smart label would affect the way they use and store their red meat at home. Participants were also prompted to elaborate on how the smart label would influence their reliance on expiration dates when deciding to consume meat. Building on this task, participants were finally asked - during the last day of data collection - to think and write down about the effect that they thought the smart label would have on their disposal decisions in terms of both meat and packaging.

2.3. Participants

Participants were recruited in the UK and were screened based for having purchased meat in the previous three months and for being at least partially responsible for grocery shopping in their household. Consistently with evidence showing that smaller groups are more constructive and foster more self-disclosure (Mann & Stewart, 2000; Williams, Clausen, Robertson, Peacock, & McPherson, 2012), six participants took part in each of the focus groups, for a total of eighteen participants recruited for the study.

Each focus group was composed by three early adopters of smart labels and three participants were considered *mainstream* consumers. The early adopter participants were either *sustainability-oriented*, *price-conscious*, or *having children*, while the mainstream participants included consumers not being concerned about sustainability or price, and with no children. Table 1 summarizes the demographic characteristics and profile of participants.

2.4. Data analysis

Data from the online platform was extracted and analyzed using the program NVivo 12 (Burlington, United States). A content analysis was carried out to interpret the data (Hsieh & Shannon, 2005), which resulted in qualitative categories corresponding to the main themes emerging from the text, and frequencies representing the number of participants mentioning each specific theme (Moldavska & Welo, 2017).

Table 1
Demographic characteristics of participants.

Focus group 1 (N = 6)	Age	Gender	Profile
Participant 1	30	Female	Mainstream
Participant 2	50	Female	Sustainability-Oriented
Participant 3	56	Male	Mainstream
Participant 4	46	Male	Mainstream
Participant 5	32	Female	Price Conscious
Participant 6	43	Male	With Children
Focus group 2 (N = 6)			
Participant 1	38	Male	With Children
Participant 2	34	Male	Mainstream
Participant 3	56	Female	Price Conscious
Participant 4	60	Male	Mainstream
Participant 5	29	Female	Mainstream
Participant 6	30	Male	Sustainability-Oriented
Focus group 3 (N = 6)			
Participant 1	33	Male	With Children
Participant 2	36	Male	Mainstream
Participant 3	60	Female	Mainstream
Participant 4	54	Male	Price Conscious
Participant 5	44	Female	Sustainability-Oriented
Participant 6	28	Female	Mainstream

Fig. 2. Example of smart labels shown in Phase 3.

After familiarizing with the data, an inductive approach was applied, in which no coding list was defined a priori and categories were identified during the process of analysis (Bengtsson, 2016).

3. Results

Results of the content analysis are discussed by presenting the themes and subthemes emerging from the discussion, alongside representative quotes aimed at providing evidence of the way participants vocalized their opinions and thoughts in relation to each subtheme. Results are also summarized in tables, in which frequencies corresponding to the number of participants mentioning the specific subtheme during the focus groups are reported. Each mention was counted for each subtheme mentioned by each participant during the focus group discussion. An overall overview of the findings is also presented in Fig. 3.

3.1. Consumers' general perception of freshness and expiration dates

When discussing their general perception of and main concerns about product freshness in relation to red meat, participants mentioned two main strategies to assess the freshness of the product: *sensory characteristics* and *expiration dates* (see Table 2). On the one hand, participants elaborated on how they rely on characteristics such as colour, smell, and texture of red meat when judging whether the product is still fresh: "*To decide what is and what isn't fresh I go by the look and colour of the meat. It's one of those things through experience where you can "just tell""* (male, 36, mainstream). On the other hand, the expiration date emerged as another important cur for assessing freshness: "*I mainly decide if something is fresh or not based on the expiration date. This is the same for all types of meat I buy*" (female, 30, sustainability-oriented). Specifically, these strategies are often adopted in tandem, with meat thrown away before expiration date if it does not pass the "nose" or "look" test, or after expiration date even if it still looks or smells good: "*Plenty of times I have binned meat before and after the expiry date has passed […]. If the meat has a smell or odour, I will throw it. If there is slight discolouration, it will be binned*" (female, 44, sustainability-oriented); "*I usually always go by the expiration date but if I am going to leave it an extra day without freezing then I would check the colour, the smell and texture of the meat before deciding if its ok to cook/eat*" (female, 28, mainstream). However, while consumers are open to the consumption of meat after expiration date, this is highly contingent on the type of meat, with consumers voicing stronger concerns about poultry than red meat: "*I would never use fresh chicken past its sell by but would consider beef or lamb for about 2/3 days, as long as it smelled fine"* (female, 56, price-conscious).

Table 2
Consumers' general perception of freshness and expiration dates.

Main theme	Subtheme(s)	Examples	Frequency (N = 18)
Strategies to assess freshness of meat	***Sensory characteristics***	Colour, smell, and texture of the product	14
	Expiration date	Assess freshness by checking expiration date, either in isolation or together with appearance of the product (i.e., colour, smell, texture)	7
	Package	Changes or damage to the package	1
Strategies to overcome short shelf life	***Freezing***	Freezing right after purchase; freezing products not for immediate consumption; freezing products close to their expiration date	9
	Consumption past expiration date	Depending on type of product (e.g., bacon, red meat, but not poultry)	6
	Search for products with the furthest away expiration date	Actively searching for back-of-the-shelf products with longer expiration dates	3

As a result, freezing emerged as the most common and encompassing strategy to overcome the short shelf life of meat, as participants commented about freezing both meat close to its expiration date or meat not for immediate consumption: "*If I get a short date and know I won't use the meat, I will aim to freeze it straight away at home*" (male, 43, with children).

3.2. Consumers' drivers of choice in store

Consistently with results from the previous task (see Table 3), the sensory characteristics and expiration date of red meat emerged as important drivers of choice in store, with consumers actively making efforts to find products with what they consider the "right" expiration date or appearance: "*I always inspect the expiration date first and shuffle through the shelf to try and find a better expiration date if it's not good enough*" (female, 28, mainstream); "*I always go for "good colour" first. That is the tray I pick up; the one that has the best-looking meat product*" (male, 33, children). Package size was also often mentioned as an

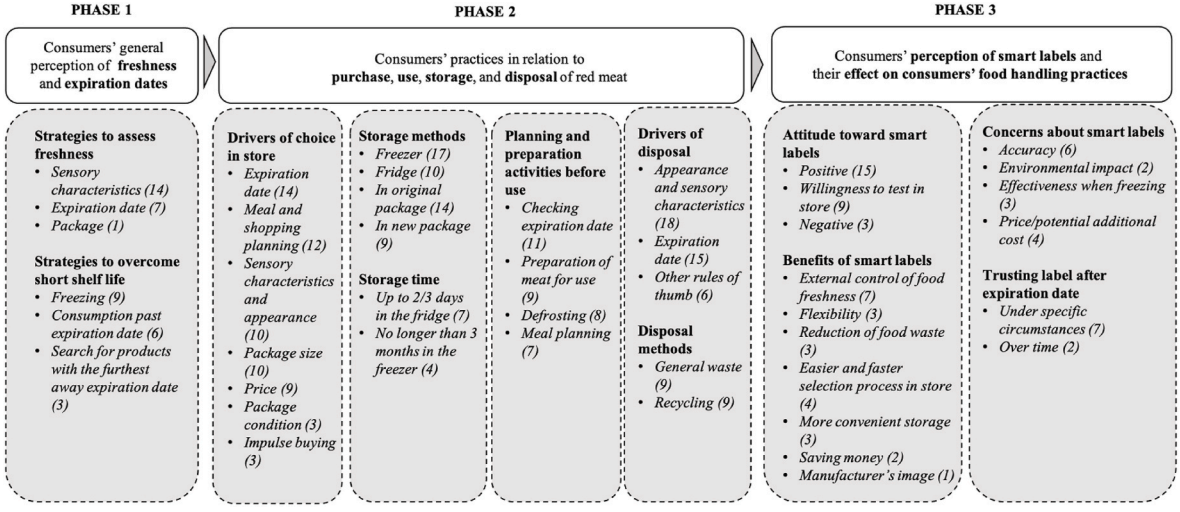

Fig. 3. Summary of findings. Themes are presented in bold; subthemes are presented in italics. Frequencies are shown in parentheses.

Table 3
Consumers' drivers of choice in store.

Main theme	Subtheme(s)	Examples	Frequency (N = 18)
Drivers of choice in store	***Expiration date***	Choosing products with latest expiration date; assessing expiration date based on how soon consumer plans to use the meat	14
	Meal and shopping planning	Buying meat based on plan for weekly meals or based on shopping list written down beforehand	12
	Sensory characteristics and appearance	Colour, fat, freshness, texture	10
	Package size	Portion size; quantity of meat in package	10
	Price	Buying in bulk when items are on sale; choosing meat to buy based on discounts and promotions	9
	Package condition	Checking the package for leakage or damage	3
	Impulse buying	Deciding to buy on the spot based on offers or new products available	3

important characteristic to consider when choosing which products to buy, in line with the finding that most of the participants go to the store with already a meal and shopping plan in mind: "*I discuss our shopping requirements for the week ahead with my partner and try to loosely plan our meals*" (male, 46, mainstream); "*Size of package has to be suitable for a family of 4*" (male, 43, with children). Nevertheless, the choice is often made on the spot if offers or new products are available: "*If there's something new/premium/on offer or something that catches our eye we might be impulsive and buy that on top of our shopping list to try that at a separate time*" (male, 38, children).

3.3. Consumers' food handling practices inside the household

When discussing their storing habits (see Table 4), participants almost unanimously mentioned the freezer as their preferred storing method, considering it particularly convenient as it allows for more flexibility in meal planning by extending the shelf life of meat: "*My usual practice is to freeze it as soon as I get home. That way the sell by date doesn't matter and I can use it in my own time"* (female, 56, price-conscious); "*I sometimes buy larger packs in order to have more to freeze, as this allows more flexibility on meal choice on a given night*" (male, 34, mainstream). The convenience of freezing meat interestingly emerged also in connection with online deliveries, as online grocery shopping does not allow consumers to personally handpick the product with the expiration date most in line with their needs: "*I do try to plan to avoid putting meat in the freezer but online deliveries often let me down with dates and it has to be frozen*" (male, 43, children). Specifically, meat is frozen for no longer than three months and it is often stored in different smaller containers or bags so food can be more easily stored and used at the time of consumption: "*Most of the time I take it out of its packaging and put it in a plastic bag in the freezer. I do this, so that I can separate large portions and also for better storage as I have a small freezer*" (female, 56, price conscious). Conversely, participants discussed about storing food in the fridge when planning to consume the meat in a short time span, with the product often kept in its original package to preserve freshness and avoid any inconveniences: "*I won't remove the meat from the original packaging and decant before storing. It doesn't make sense to do that*" (male, 38, with children).

Table 4 summarizes findings about participants' use of meat, with expiration date emerging as the main factor affecting participants'

Table 4
Consumers' food handling practices inside the household.

Main theme	Subtheme(s)	Examples	Frequency (N = 18)
Storage methods	***Freezer***	Right after purchase for products not for immediate consumption; flexibility as there is always meat available (e.g., bulk purchases); to save up space in the fridge; online deliveries where the consumer cannot check expiration date before purchase	17
	Fridge	For purchases for immediate consumption or for consumption in a short timespan (about 1–2 days)	10
	In original package	Meat taken out from the original package only at time of consumption; to preserve freshness; to avoid leakage from meat	14
	In new package	Airtight containers; stackable containers; freezer bags	9
Storage time	***Up to 2/3 days in the fridge***	Consumption within 24 h from purchase; meat kept in the fridge for a couple of days before opening package	7
	No longer than* 3 months *in the freezer	Meat kept in the freezer for 2–3 weeks max; less than a month/up to three months	4
Planning and preparation activities before use	***Checking expiration date***	Making sure to use products that are closer to expiration date; use after expiration date, but never beyond a certain threshold (1–2 days); adapting meals to use products that are expiring and to avoid waste	11
	Preparation of meat for use	Washing meat; season and marinade; taking meat out of the fridge to make sure it is at room temperature before using	9
	Defrosting	Taking meat out of the freezer the night or few hours before use	8
	Meal planning	Planning when and how to use the product	7
Drivers of disposal of meat	***Appearance and sensory characteristics***	Disposal in case of changes in colour and/or smell of meat, even before expiration date	18
	Expiration date	Disposal when the product reached its expiration date or max.1–2 days after expiration date	15
	Other rules of thumb	Disposal when: product has been outside of original packaging for a certain number of days; product has been in the freezer for a long period of time; meat has been	6

(*continued on next page*)

Table 4 (*continued*)

Main theme	Subtheme(s)	Examples	Frequency (N = 18)
		cooked and was kept in the fridge for a few days without being consumed	
Disposal methods	***General waste***	Disposal of package in general waste regardless of whether the package is empty; reluctance to clean package before disposal because of disgust and health concerns	9
	Recycling	Package cleaned and separated into recycling bin	9

decisions about what to cook and consume inside the household. Indeed, participants were particularly careful about using food before expiration, with some participants even arguing about how they plan or reassess their meals around the meat that has the closest expiration date: "*I always check the expiration date and make a note of it so I can ensure I eat it before it expires*" (female, 28, mainstream). Once a decision has been made about what to eat, participants engage in different activities to prepare for the meal such as defrosting the food overnight or marinade it for added flavour: "*For me it is very important that the meat is washed thoroughly, then I would proceed to season the meat and leave for marinating in the fridge. Then prepare everything else whilst meat is in the fridge then I would start cooking*" (female, 44, sustainability-oriented). This reveals the complexity of household cooking practices, whose understanding requires the investigation of several actions affecting a single decision.

Findings of phase 1 of the focus groups (see Table 1), were confirmed when asking participants about their disposal behaviors, with consumers relying on sensory characteristics of red meat and expiration date when deciding when to dispose of the products: "*We would mostly go by expiry, look and smell. If the smell of the meat isn't right (and it looks and is in expiry date) we would still throw away. Also, if it doesn't look right and is within expiry and smells fine, we would throw away*" (male, 38, children). Furthermore, while some participants were willing to make the effort of recycling the package by cleaning it and separating it from any food left inside, other participants more commonly dispose of the package in the general waste as this prevents them from experiencing the disgust and the concerns associated with having to deal with leftover meat: "*The main thing once I have put the meat and wrapper in the bin is that I am aware that it will start to smell quite quickly. I don't wash the wrapper that would be too much trouble*" (female, 60, mainstream).

3.4. Consumers' perception of smart labels

Themes and subthemes emerging in relation to consumers' perception of smart labels are summarized in Table 5, while Table 6 provides a more granular picture of the findings by showing the frequency with which each subtheme was mentioned across groups (i.e., mainstream vs. early adopters). Specifically, when discussing their thoughts about the smart label (see Table 5), the majority of both mainstream and early adopter participants mentioned being "excited", "interested" and willing to try it in store or at home: "*It's extremely intuitive and easy for everyone to understand. Even my 96-year-old grandmother would understand if bumps appear on the label that it's time to throw it away*" (female, 28, mainstream). Conversely, only a small number of participants reported being negatively oriented towards smart labels (see Table 7 for characteristics of consumers showing a positive vs. negative attitude towards the label). Specifically, the smart label was perceived as a reliable guarantee of the freshness of the product above and beyond

Table 5
Consumers' perception of smart labels.

Main theme	Subtheme(s)	Examples	Frequency (N = 18)
Attitude toward smart labels	***Positive***	Interested; excited; good idea; inclined to try; positive step towards the reduction of food waste	15
	Willingness to test in store	Consumers prone to test in store to check if product is fresh	9
	Negative	No additional benefit; unnecessary	3
Benefits of smart labels	***Reduction of food waste***	Avoid of food waste that would occur when judging food freshness based on expiration date or sensory characteristics of the product	9
	External control of food freshness	Easier to judge whether the product is still fresh; more reliable than expiration date and judgment of sensory characteristics of the product (i.e., appearance, smell); guarantee of food freshness for online deliveries where consumers cannot check the product before purchase; avoid the sale of food that is no longer fresh	7
	Flexibility	Longer period to consume the product (e.g., after expiration date); more flexibility in deciding meal plans for the week	3
		Avoid of food waste that would occur when judging food freshness based on expiration date or sensory characteristics of the product	3
	Easier and faster selection process in store	Extra guarantee of quality of price-reduced meat; faster selection in store as the consumers does not have to check for expiration dates; more comfortable buying something with the label on it	4
	More convenient storage	No longer need to freeze meat; better storage of food	3
	Saving money	Saving money by reducing the volume of food wasted at home	2
	Manufacturer's image	Positive perception of manufacturer's practices	1
Concerns about smart labels	***Accuracy***	Need of demonstration or instructions on how the label works; concerns about tampering (e.g., bump forced back in with force, label damage); concerns about possibility the label is bumpy when product is still fresh	6
	Environmental impact	Extra plastic added to the product; label affecting the recyclable nature of the container; doubts	2

(*continued on next page*)

Table 5 (*continued*)

Main theme	Subtheme(s)	Examples	Frequency (N = 18)
		about composition of chemicals in the label and its effect on the environment	
	Effectiveness when freezing	Doubts about whether the label is effective when meat is frozen	3
	Price/potential additional cost	Label will increase the price of the product; consumers having to bear the cost of the additional label/technology	4
Trusting label after expiration date	***Under specific circumstances***	If appearance and smell of meat suggest that the product is good to consumer; if package is unopened	7
	Over time	Consumers feeling confident in consuming the meat after expiration date after becoming familiar with the label and how it works	2

expiration dates and own senses, while also reassuring consumers of the freshness of groceries bought online: "*My "nose test" still doesn't give me total confidence, this is much better*!" (male, 34, mainstream); "*I think it would even help with online deliveries where I get nervous that they pick out any item for you, without those freshness checks, so this would allow me to know straight away*" (female, 32, price-conscious). In this sense, the label was seen as an effective tool towards the reduction of household food waste, while also allowing for a change in storage practices (e.g., freezer vs. fridge): "*I think it would change the way we purchase and store meat products. For example, I would be reluctant to store it in the freezer*" (male, 33, children) "*I think it's a positive step towards reducing waste as I know a lot of people that obsess over sell by dates*" (female, 29, mainstream). Specifically, the beneficial effect that the smart label would have in terms of reduction of food waste was recognized by mainstream consumers and price-conscious consumers, while no evidence for awareness of the link between smart labels and food waste emerged from the other categories of early adopters (i.e., consumers with children, and sustainability-oriented consumers). Interestingly, preliminary evidence emerged on the role that smart labels could play in increasing consumers' likelihood of recycling. In particular, smart labels could help in using up all of the food before disposal, thus making recycling easier and avoiding the inconvenience and fear of contamination associated with dealing with potentially spoiled food: "*I believe that the label would make recycling easier, as I would be less likely to waste food, and therefore once I had consumed the product I would be able to put the remaining packaging into the recycling, whereas if I had decided to throw the meat away because it had spoiled I would have been more likely to just throw the whole package into the regular trash*" (male, 46, mainstream). As such, the label was recognized as a tool for more sustainable behaviors in terms of both food waste and recycling.

The smart label was also seen as facilitating the selection process in store and as providing more flexibility in meal planning by allowing to use the food for a longer period of time: "*It would be beneficial because it would probably speed up the shopping process. When I shop, I have to spend time inspecting the meat dates, colours, etc. With the label it would be quick and easy*" (female, 44, sustainability-oriented); "*I like to sometimes be spontaneous with what I cook, so I prefer having the meat "ready" rather than planned for a specific day. This label would really help with that*" (male, 34, mainstream). Overall, these findings show how the smart label was considered by participants as a potential influence on an overarching set of household practices, including storing and disposal of food.

Nevertheless, participants across groups expressed some concerns, especially in relation to the accuracy of the novel label, mostly stemming from the lack of precise knowledge about its inner workings: "*I would be concerned about how accurate the label is if it's still fresh. Like what if they get it wrong*" (female, 30, mainstream). Other concerns included the surge in price and the environmental impact that adding an extra label to the package could generate: "*I would be concerned that the fancy label could affect the price of the product*" (male, 56, mainstream); "*I might be concerned about the ingredients of the label and whether these are damaging to the environment, whether they affect the recyclable nature of the container*" (male, 43, with children).

Building on this discussion, participants across groups further reflected that they would not fully trust the label at first but would still rely for some time on the sensory characteristics of the product and/or the

Table 7
Consumers' characteristics based on attitude towards smart labels.

Main theme	Positive attitude (N = 15)	Negative attitude (N = 3)
Average age (SD)	41.40 (11.43)	49.67 (6.51)
Gender	7 female, 8 male	1 female, 2 male
% of mainstream consumers	53.33%	33.33%
% of early adopters	46.67%	66.67%

Table 6
Consumers' perception of smart labels across groups.

Main theme	Subtheme(s)	Mainstream (N = 9)	With children (N = 3)	Sustainability-oriented (N = 3)	Price-conscious (N = 3)	TOTAL
Attitude toward smart labels	***Positive***	7	3	2	3	15
	Willingness to test in store	6	2	1	0	9
	Negative	1	1	1	0	3
Benefits of smart labels	***Reduction of food waste***	6	0	0	3	3
	External control of food freshness	4	1	0	2	7
	Flexibility	2	0	0	1	3
	Easier and faster selection process in store	1	1	1	1	4
	More convenient storage	2	1	0	0	3
	Saving money	1	1	0	0	2
	Manufacturer's image	1	0	0	0	1
Concerns about smart labels	***Accuracy***	3	1	1	1	6
	Environmental impact	1	1	0	0	2
	Effectiveness when freezing	1	2	0	0	3
	Price/potential additional cost	3	1	0	0	4
Trusting label after expiration date	***Under specific circumstances***	4	1	1	1	7
	Over time	2	0	0	0	2

expiration date to make a choice, especially for products past their expiration date: "*I would use the labels indication along with my own sight and smell, I would not let the label override my own physical interaction with the meat, but would consider it alongside the usual checks. I might well eat meat that was after the expiration date providing it looked and smelt ok and if the label also indicated it was ok what would be very reassuring*" (female, 60, mainstream). This finding is in line with results shown in Table 2 and summarized in Section 3.1, and further underline the role of sensory characteristics and expiration dates as main cues that consumers use to decide which foods to use and which ones to throw away.

4. Discussion

Through an asynchronous and text-based focus group study with UK consumers, this work has investigated consumers' food handling practices, and the way in which smart labels could be integrated into individuals' everyday practices in relation to the purchase, use, storage, and disposal food. In this sense, our research is in line with the recent call for more qualitative research on consumers' perception of new technologies for tackling food waste (Brennan et al., 2020). However, while prior literature has been limited to consumers' responses to intelligent packaging (e.g., Aday & Yener, 2015; Pennanen et al., 2015), this work provides a novel perspective by focusing on consumers' perceptions of smart labels. Furthermore, by adopting a situated investigation of consumers' perception and use of expiration dates, this work is in line and contributes to the need for more research accounting for the everyday context in which consumers make decisions (e.g., Dobernig & Schanes, 2019; Koivupuro et al., 2012; Porpino, 2016).

Findings from the present work suggest the key role played by expiration dates in affecting consumers' food-related decision-making processes. As such, they are consistent with prior contributions documenting consumers' heavy reliance on expiration dates when evaluating food freshness and deciding about which products to purchase or consume (e.g., Davenport et al., 2019; Kavanaugh & Quinlan, 2020). At the same time, they highlight consumers' use of their own senses when making decisions about food, for instance judging it based on its appearance (e.g., colour) or smell. Specifically, consumers appear to use expiration dates and sensory characteristics of meat either in tandem or in isolation. In this sense, this work advances knowledge and contributes to literature on consumers' food handling practices and household consumer-generated food waste (e.g., Dobernig & Schanes, 2019; Hebrok & Heidenstrøm, 2019).

Furthermore, consumers' long-established dependence on expiration dates and their own senses emerged as significant barrier to the acceptance of smart labels as participants expected to still rely on these cues before fully trusting the label and using it as a sole driver of choice. Nevertheless, participants viewed smart labels as useful for reducing food waste through better storage and disposal practices. Interestingly, smart labels were also seen as potentially beneficial in terms of recycling at home; by increasing the likelihood of consuming food, the label would prevent the need to deal with spoiled food, thus possibly increasing household recycling rates.

The findings of the present work provide useful insights and have important implications for companies developing and commercializing smart labels aimed at tackling food waste. First, findings suggest that educating consumers is key to overcome the initial reluctance towards these innovations, ultimately leading to acceptance. For instance, in-store demonstrations could reassure consumers about the inner workings of the label, while at the same time helping them understand the value and benefits associated with the use of these tools inside the household. Indeed, in-store demonstrations offer consumers the opportunity to gain more in-depth information about the label and are recognized to be useful to get a more hands-on experience with the product (Bogomolova et al., 2021). Second, findings about the benefits identified by consumers in the use of smart labels suggest potentially effective arguments to be used by companies developing these tools to engage and convince retailers to use such labels in their stores or on their products. Retailers play a key role in influencing consumers' food decisions and preferences, and as a result have been identified as important agents of change to achieve the overall objective of reducing food waste along the food supply chain (Aschemann-Witzel, de Hooge, and Norman, 2016). Selling products with smart labels could help retailers effectively contribute to this goal. For manufacturers, adding smart labels to their products would communicate their active commitment to sustainability, thus boosting their image and reputation. Finally, the extensive positive effects of smart labels in terms of reduction of food waste, and also recycling, provide useful insights to be used by policy makers to pressure actors of the food supply chain towards the broad acceptance of these novel tools.

While our research provides a first contribution in terms of consumers' perception of smart labels for food, there are limitations that should be noted and that provide directions for future research. First, we conducted a qualitative study with a small sample limited to only one country (UK) and using one product category (red meat). Future research could further explore this topic employing quantitative methods and comparing consumers' responses across countries. For instance, survey-based and experimental studies – both in the lab and in the field – could be conducted to measure consumers' response to and likelihood of choosing the label in store. Furthermore, future research could explore consumers' perception of smart labels using different categories of food and investigate whether and how consumers' openness towards these new tools might be different for different types of food. Furthermore, future studies could explore consumers' likelihood of consuming (vs. trashing) food before and after expiration date in the presence of congruent or incongruent information provided by the label.

5. Conclusion

The present research explored consumers' food handling practices and shed new light on consumers' perception of and response to innovations aimed at tackling food waste, namely *smart labels*. The findings of a qualitative study show that consumers mainly rely on expiration dates and their own senses when making food decisions. Specifically, expiration dates and sensory characteristics (e.g., colour) of the food emerged as main drivers of choice in store and of use/disposal of the product at home. As a result, while consumers recognized that smart labels could provide external validation in terms of food freshness, experience and time are needed for consumers to be ready to fully trust the label and use it in their decision-making process in terms of purchase, use, and disposal of food. Thus, trust in the label's reliable functioning, for example through demonstration and experience, is paramount for the acceptance of smart labels in everyday food handling practices.

Ethical approval

This research was granted ethical approval by the Research Ethics Committee of Aarhus University (Project ID: 2021–0210102).

Data availability statement

The data that support the findings of this study are available from the corresponding author, A.M.B., upon reasonable request.

CRediT authorship contribution statement

Ada Maria Barone: Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft, Writing – review & editing. **Jessica Aschemann-Witzel:** Conceptualization, Methodology, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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