

# Thinking on the Box: Design On-pack Information Attributes to Influence Consumers' Food Waste Behavior

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**Abstract:** On-pack date-related labelling is one of the most direct information carriers used by food industry to communicate product shelf-life attributes to consumers. However, it has also been identified as one of the major factors that contributes to consumer food waste problems. Taking a design for sustainable behavior perspective, the present study aims to systematically explore the interplay between on-pack date labelling and consumer food waste behavior. A comprehensive literature review, in-depth interviews and design workshops with 12 general consumers and 10 food industry practitioners regarding the design and use of date labelling communication system and its relation to food waste were conducted in the study. Through applying an activity theoretical lens to analyze the literature and empirical results, we found that consumers' interaction with date labels and storage information in their food consumption activity is highly influenced by their shifting motivations, the changing socio-cultural contexts, and the dynamic interplay between the use of internal sensory perceptions and external on-pack date labels. Based on these insights, we identified 7 design opportunities and implications to improve the current on-pack date labelling communication system. Following that, we developed an AR-based mobile digital prototype which mediates consumers' interaction with on-pack information attributes in their food consumption activity systems. This paper presents the preliminary analytical results of the literature review, interviews and design workshops with a brief introduction to the prototype concept design and development.

**Keywords:** Packaging design, date labels and storage guidance, consumer food waste, design for sustainable behavior, design intervention, activity theory

## 1 Introduction

On-pack date labelling and storage guidance are widely used in food industry as objective and accessible indicators for consumers to make judgement regarding the quality and safety of food products. This interaction model is, to a large extent, established on the prerequisite that each individual consumer can correctly interpret the delivered packaging information and thus make rational decisions (TNS, 2014). However, in practice, the way how consumers judge the edibility of food products can be highly influenced by various factors such as socio-cultural contexts, past experiences, and existing habits. Apart from that, the description, format, and location of the date labels and storage guidance vary, as do consumers' understandings, interpretations, and interaction with these on-pack information attributes. With an estimation that 20% of consumer food waste is caused by the confusion over the meaning of date labels,

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on-pack date labelling has become one of the major factors that contribute to consumer food waste issues (ReFED, 2016).

The on-pack information attributes related food waste is not only a sustainability challenge that the current generation faces today, this issue is likely to continue to increase with the next generation if everything remains unchanged. For example, In the context of US, given the fact that milk is one of the most commonly consumed food products in consumers' daily practices, nowadays fewer people are able to correctly understand the meaning of date labels on milk product than 1980s (Labuza et al., 2001). Moreover, a recent study pointed out that millennials are more likely to view date labels only as a safety indicator. They tend to discard food that past the date on the label without further assessment of the date label descriptions and the food quality (Leib et al., 2016).

From a packaging and food waste perspective, adjustment of date labelling communication system has been identified as the most efficient measure to reduce food waste, which has the greatest economic value per ton in terms of consumer food waste reduction and the lowest costs regarding the business practices (ReFED, 2016). However, until now, most of the studies under this topic have focused on addressing food waste issues which are directly related to packaging, such as the optimization of size, shape, volume, and physical material. The knowledge of the indirect aspects of packaging -- the influence that on-pack date labelling and storage information attributes may have on consumers' food waste behavior, is relatively scarce.

The present study aims to systematically understand the interplay between on-pack date labels and consumer food waste behavior, and develop design implications and interventions to better support consumers in reducing food waste. Given the broad scope of the topic, this study specifically focuses on the consumer-food packaging interaction in household levels, the effects of date labelling and storage related packaging attributes in consumers' purchasing behavior are excluded in the study. A design for sustainable behavior perspective is taken as the main research perspective. Design for sustainable behavior is a relatively new field of inquiry aiming to reduce negative environmental and social impacts of products and services through influencing user behavior towards a more sustainable direction (Wever et al., 2008; Wever, 2012). Recent developments in this field attempt to understand the wicked sustainability problems through both a synthetic and analytical approach, which can enable us to incorporate the factors such as the context of consumers' food consumption, consumer behavior transition and evolution, and the emerging technological mediation into the on-pack date labelling and storage information evaluation and design process.

## **2 Activity theoretical lens**

Most of the existing studies in the packaging related consumer food waste research field, particularly under the topic of date and storage labeling design, tend to purely focus on the interaction between individual consumer and packaging product in a case-by-case basis, thus neglected the broader socio-cultural environment in which such interaction take place, and how the corresponding food waste behavior is triggered and shaped in the historical, technological, and organizational contexts (White et al, 2009). Furthermore, the design and usage of on-pack

date labelling and storage guidance also involves different entities, such as general consumers, food manufacturers and retailers, packaging providers, and government organizations. Given this understanding, we see the urgent need to apply well-grounded theory from other research fields to systematically explore the phenomena.

From a design for sustainable behavior perspective, Activity theory (AT) is chosen as the theoretical framework in the present study. The fundamental concept of AT is the central role of human activity, which is interpreted as subjects' interaction with specific artefacts to achieve specific objects within specific real-life circumstances (Leontiev, 1974). The theoretical origin of AT can be traced back to cultural-historical psychology. In recent decades, AT has been further developed by Leontiev (1978) and Engröm (1987, 1990). And following that, it has also been adopted in various design research studies as the analytical tools to understand complex real-world problems and inform implications for design (e.g. Glad, 2015; Rexfelt & Rosenblad, 2006; Selvefors et al., 2015; Woll & Bratteteig, 2018).

Previously, we have applied the AT theoretical lens to analyze people's food consumption behavior in an explorative case study (Chu et al., 2018). Results from the case study indicated that AT has two main strengths in terms of studying consumer food waste behavior. First, AT particularly focuses on understanding the role that artefacts play in individuals' activity systems. This emphasis can provide us with a unique perspective to view food packaging not only as a physical product, but also as a mediating tool (both internal and external) that consumers interact with to within their daily food consumption activities. Furthermore, as today's artefacts are often product-service combinations, function in networks with other products and other people (Wever et al., 2008), each individual consumers' packaging related food waste behavior thus can be shaped not only by the on-pack labels and their own knowledge and judgment, but also by other people in the system, such as interaction with family members and friends, social norms, industry practices, and government regulations. Second, apart from the emphasis on individual activity, AT also takes rules and norms, community, and division of labor into the account of the context of the collective activity system, which can enable us to incorporate insights collected from food industry practitioners and government regulations into the analysis. The activity theoretical model we adapted in the analysis of the present study is illustrated in Figure 1.

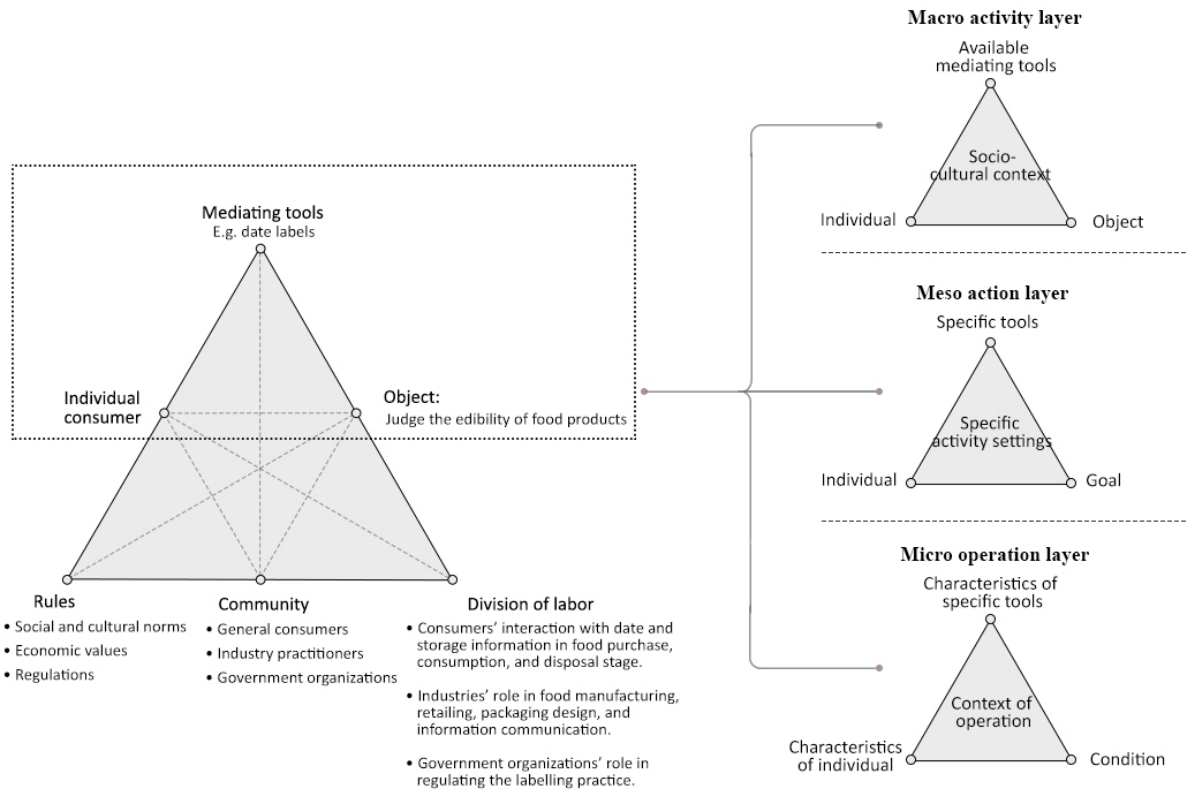


Figure 1. Activity theoretical model adapted from Engeström (1987)

### 3 Methodology

The study is comprised of three stages: (i) literature review, (ii) empirical data collection and analysis, and (iii) design concept development. In Stage1, an exhaustive literature review was conducted to understand how consumers' use of on-pack date labels and storage information is related to food waste issues. Although the literature review can provide a comprehensive view of the question, the literature review results were insufficient to inform enough insights when the question comes to the exploration of practical design opportunities and implications. Therefore, in stage 2, design workshops and interviews were carried out with industry practitioners and general consumers with the goal to develop complementary and more in-depth understandings of how consumers interact with the on-pack date-related information attributes in their daily food consumption practices. In stage3, through applying an activity theoretical lens, the literature insights and the empirical results from the design workshops and interviews were integrated and translated into practical design implications. Based on the design implications, a mobile digital prototype was designed and developed.

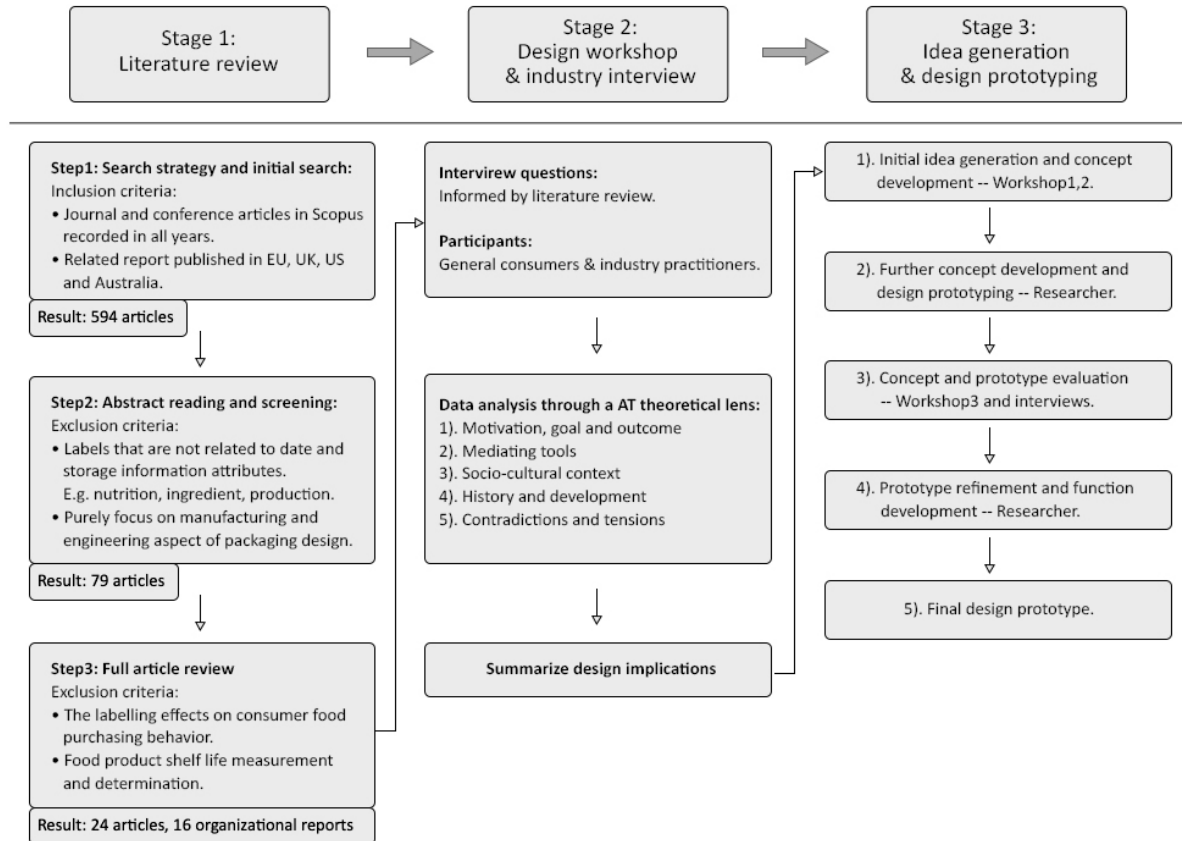


Figure 2. The methodological overview of the study.

### 3.1 Literature review

For the literature search, Scopus was used as the search platform. We began the literature search with simply identify the preliminary search scope. Then we narrowed down the scope to a combination of general search terms, such as 'date label', 'shelf life', 'storage guidance', 'on-pack information', 'food labelling', 'food date', 'food waste', and 'consumer behavior'. After the initial search, the articles went through the abstract screening and full article review process. The inclusion and exclusion criteria regarding the literature review are presented in Figure 2. In the final step, 24 academic journal and conference papers were included in the full article review. Apart from academic literature search, given the fact that consumer household food waste behavior issues are turning into one of the major sustainability challenges people are facing especially in developed countries (Gustavsson et al., 2011), we also conducted another throughout search to review the relevant governmental and research organizational reports published in EU, UK, US, and AU, which resulted in 16 technical reports.

### 3.2 Design workshop and interview

The overall objective of the design ideation workshop and the semi-structured interview is to identify the potential design opportunities to help consumers to avoid unnecessary food waste in their daily food consumption activities. The literature insights from Stage 1 were summarized as guidelines to inform specific interview and design questions. To further narrow

down the scope of the design space, the food categories we chose to discuss in the design workshops and interviews include: 1). fresh produce (fruits and vegetables), 2). meat, 3). bread, 4). dairy products (cheese, yogurt, and milk). These food products were chosen based on two considerations: First, according to the literature review, these food products were reported as the most common waste food generated in consumer household level. Second, consumers' lack of knowledge and confusion over the meaning of date labels and storage guidance were identified as one of the major factors that trigger the food waste. In the workshop and face-to-face interview, different selections of the above food products collected from the local grocery stores were presented for participants to discuss.

The participants of the study include 12 general consumers (in Sweden) and 10 industry practitioners (In Australia). For the industry practitioners, 4 participants were senior packaging experts working in food and packaging organizations, 6 participants were from food and packaging manufacturing industry, their position include packaging development director and CEO. Given the wide variety of participants' background, interview protocols were adjusted for each interview and discussion. For general consumers, the focus is to understand the usage of packaging information in their food consumption and disposal decision-making process. For industry practitioners, the focus is to uncover the opinions and expertise that they have over the date labelling and storage guidance design. For the data presentation in this paper, general consumers were referred as G1 to G12, while industry practitioners were referred as I1 to I10.

The semi-structured interview sessions lasted around 45 minutes. The design workshop lasted approximately 75 minutes, which involves a 35-minute interview/discussion session and a 40-minute design ideation session. In the design ideation session, basic design tools such as pens, papers, cardboard, and clay were provided to facilitate participants to illustrate the on-pack date and storage information attributes related problem that they have encountered in their daily food consumption activities, and then generate design ideas to solve the problem. We also provided the participants with design ideation toolkit to facilitate the idea generation process. The toolkit is comprised of an Activity Cube and Activity Design Ideation Card that we created. The Activity Cube is a 30cm cube bounded by six facets which represent the six key theoretical concepts of activity theory. And the Activity Design Ideation Card is a collection of design questions and examples that match with different facets of the Activity Cube (see Figure 3).



Figure 3. Photo on the left: The participant who sits in the center was talking about a food product which he couldn't tell if it was still edible out or not; Photo on the right: An overview of the design idea generation toolkit used in the study.

## 4 Results and analysis

As illustrated in Figure 4, we divided the existing literature into three categories: 1). Food labeling legislations and regulations; 2). Consumer behavior studies; 3). Food and packaging industry practices. In each of the categories, we further assigned the literature into three groups according to their specific research focuses: 1). Understanding date and storage labelling related practices; 2). Identifying problems within the practices; 3). Proposing and developing solutions to address the identified problems. It is worth mentioning that as a large number of papers and reports covered various aspects and themes, it is hard to define a clear boundary between different groups. As a result, the grouping is dependent on the authors' own interpretation. AT-based analytical approach was used to analyze the literature review and the empirical data. In order to better present the results in the paper, the literature insights extracted from each of the groups were integrated with the empirical data in accordance with AT theoretical concepts.

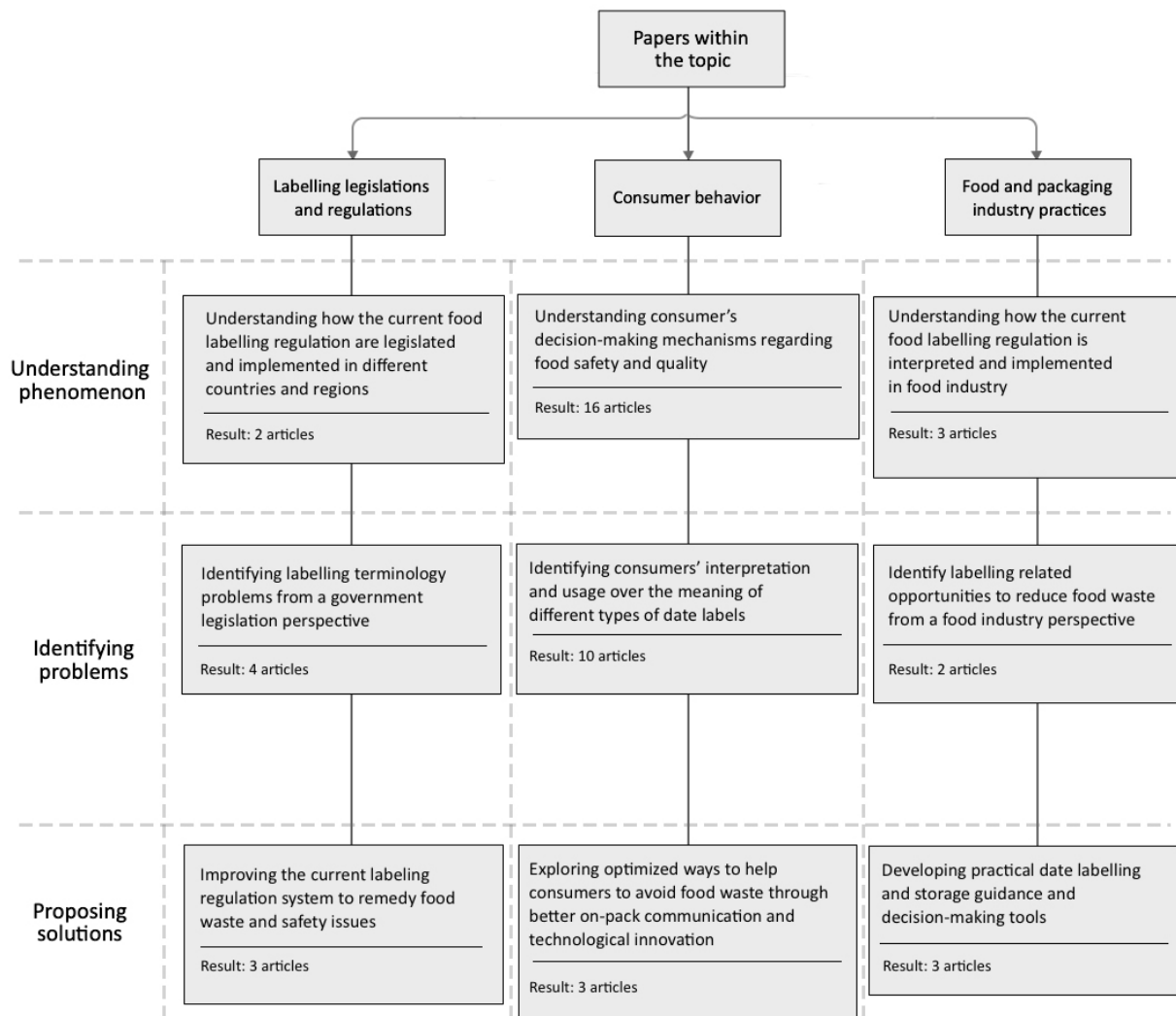


Figure 4. The overarching focuses and research questions in each group.

#### 4.1 Consumers' shifting motivation within the changing socio-cultural contexts

According to AT, human activity is driven by motivations directed toward goals. In the context of this study. Before we dive into uncovering the consumers' interaction with on-pack date labels, we need to take a step back and first understand what is consumers' motivation behind checking food shelf-life information, and what is the goal for food industry to present on-pack date-related labels on food products.

**Historical development:** The development of date labelling system is driven by consumers' changing motivations and goals in their food consumption activities. Taking the evolution of food labelling system in UK as an example, according to Milne (2012), four transition periods can be identified (see Figure 5). Prior to the late 1960s, due to the technical complexity to determine food shelf-life in the supply chain, date labels were coded with the purpose for retailers' stock control. As consumers became more aware of their right to know the food quality status, in the 1970s, the coded date labelling system were replaced by the open dating system. Same transition also took place in US, where quality-based labels -- 'Best-before' date and 'Sell-by' date were introduced to consumers (Leib et al., 2013). In the 1980s, food safety issues, such as the outbreak of Salmonella and Listeria, gradually became one of the major concerns in society. In order to protect consumers from food-borne illnesses, safety-based label -- 'Use-by' date was introduced to the labelling system with the purpose to inform consumers about micro-biological condition of food products. Facing the growing societal concerns on food waste issues in the early 21<sup>st</sup> century, date labels have been assigned with a new environmental responsibility to reduce consumers' unnecessary food waste (Milne, 2012). In order to reduce consumers' confusion over the meaning of different labels, 'Sell-by' date was taken away from the existing labelling system, while 'Best-before' and 'Use-by' date still remained in the current system.

**Contradictions and tensions:** Meeting consumers' changing motivations and goals only from a labelling legislation and regulation perspective is insufficient, efforts also need to be made from food industry to better communicate the key information to consumers. Although the date labels and storage information have been assigned with the role to reduce consumer food waste, the relevant supports from industry practices are still scarce.

As food industry practitioners' focus is to use the labels to better inform consumers' purchasing behavior, the food waste generated in household level has not yet been fully incorporated into the consideration of date labelling. For example, industry participants indicated that *"The brand owner does not want to put the long date on packaging, because it makes the consumers to think they are not buying something that is fresh"* (I1), and *"Date label is something that food manufactures feel that they have to do, but it doesn't help them to sell their products"* (I5). Another concern that food industry practitioners have is the limited packaging space -- *"We are always fighting for space on package...There is a constant fight and battle between the doing the right thing [referring to reduce food waste] and having information [referring to the legislated label information]"* (I5).

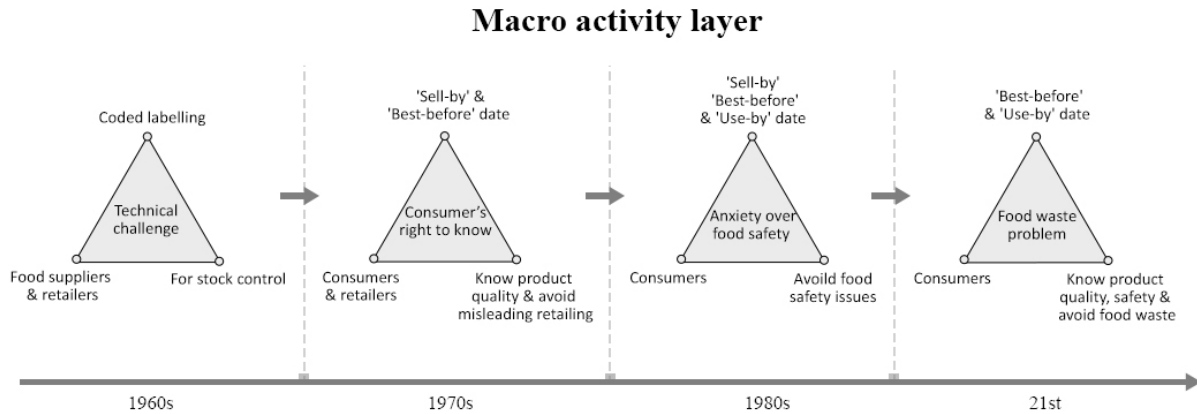


Figure 5. The historical development of consumers' interaction with date labelling system within the changing socio-cultural contexts in UK.

## 4.2 Alternative approaches to judge food safety and quality

In the concept of AT, human activity is mediated by the use of tools. The tools can be external, such as hammer, phone, and computer, which are intended to be used to manipulate physical objects. The tools can also be internal abstract tools, such as multiplication table, cognitive model, and language (Kaptelinin et al., 1999). As indicated in the proceeding section, consumers' interaction with date labels is mainly motivated by the need to be able to easily identify the quality and safety status of food products. In response to that, consumers may use both external tools – the on-pack date labels and storage guidance, and internal tools -- individuals' knowledge and sensory to attain their goal.

### 4.2.1. The use of external on-pack labels:

Date labels can be regarded as a quantitative-based indicator which provides pre-determined date criteria for consumers to make the judgement. It is comprised of two parts (i) a date mark in a calendar form and (ii) a specific indicative text such as 'Best-before' or 'Use-by', which is used in association with the date mark. While general consumers have no troubles interpreting the date mark, the explanatory texts can cause consumers' confusion over the meanings of the labels. For example, In EU, only 47% of the households correctly understand the meaning of 'Best-before' date as food quality indicator, and less than 40% are able to correctly identify 'Use-by' date as food safety indicator (Eurobarometer, 2015). However, this rate is highly dependent on the macro socio-cultural contexts, which include factors such as physical climate, environment, market practices, food-related media communication, educational campaigns, and social norms, which may indirectly influence consumers' food consumption habits (Aschemann-Witzel et al., 2015). For example, with 73% of residents in New South Wales, Australia correctly understand the 'Best-before' date and 61% of the residents correctly understand 'Use-by' date, the rate is significantly higher than EU. ((NSW Environment Protection Authority, 2018).

Consumers' confusion over the meaning of 'Best-before' or 'Use-by' date were also identified by all the packaging industry practitioners who participated in the interview. Furthermore, even the correct understanding of date labels does not necessarily lead to the correct usage.

Participants in this study reported that they usually adopt the use of date labels according to their own ways. For example, I1 stated *“I will totally ignore the best-before date. But if something says use-by, and it has gone past that date, I will check carefully before I eat it.”*

Contextualization is the other problem that the participants encountered when using date labels and storage guidance. In some of the cases, participants complained about readability of the printed marks -- for example, *“The sign of date label could be bigger”* (G1), *“a clear date label and also large font size to read without using glasses. Something that makes it stand-out”* (I1), *“In recent years, the labels are becoming smaller and smaller”* (I6). According to the industry participants, there are two main factors that lead to the smaller date labels: (i) From an industry point of view, in order to present all the legislated labels on packaging, and at the same time communicate the brand identity to consumers, date labels are getting smaller and smaller spaces on product package. (ii) As pointed out by one of packaging experts, the urban household and family size is becoming smaller, people tend to not buy more than they need. Consequently, labels are gaining less attentions from the perspective of both consumer and industry practices.

The 'Use-by' and 'Best-before' date labelling system can also bring further confusions in terms of how long the product can be safely eaten after first opening (Lydhurst, 2012; Moller et al., 2016), especially on highly perishable food products such as dairy products, ready-to-eat meals, and meats, where bacteria such as *Listeria Monocytogenes* can grow rapidly due to incorrect food handling. For example, G4 described the need for specific shelf-life information regarding an opened taco sauce: *“It has been in the fridge for 1-3 months, I don't know how long can opened product stay”*. Facing this particular situation, participants further explained that they can only make rough judgement based on their own experiences and perceptions – *“If it got fungus on it then it's bad”* (G3). However, from the perspective of food manufactures, as the storage conditions in consumer household environment differ, the implementation of such guidance on highly perishable product packaging is beyond the manufactures' shelf-life determination capacity (Lenhart et al., 2008).

#### ***4.2.2 The use of internal sensory perceptions:***

Compared with date labels which provides a quantitative indicator to consumers, the use of internal sensory perceptions can be regarded as a more qualitative-based approach for consumers to judge food quality and safety. In terms of the internal tools, participants in this study stated that they mainly make assessments through checking products' appearances, smells, textual feelings, and tastes. Among these sensory perceptions, appearance and smell were identified by participants as the most common means, as it is relatively easy to make comparison between the product they are handling with the past experiences and memories that participants have – for example, *“For comparing stuff, use visual memories”* (G1), *“If you pour a milk, and it is thready, then it is not okay”* (G3). Participants also reported that in some particular cases they use the textual feelings to make judgment— *“Vegetables might go fluffy”* (I1).

The standard used in consumers' sensory perceptions to assess food quality and safety is highly dependent on personal preferences. For example, in one of the workshop discussion, one participant brought a bag of opened nuts. All the participants assessed the nuts through smell, appearance and taste, and almost all participants came back with the conclusion that it was fine

to eat the nuts, except for one participant, who firmly stated *“it is not okay because it smells not good”* (G3).

Consumer sensory perceptions can have the possibility to be used to open up a window of opportunity to help to reduce unnecessary food waste. According to a lab experiment conducted by Roe et al (2018) in testing how regular milk drinkers would deal with milk products without date labels, results indicated that the discarding rate is lower when respondents had to solely rely upon their sensory perceptions to make the judgement. However, as the the experiment are not based on the real household testing contexts and the data may vary depending on factors including individual preferences, the specific food type under study, and consumers’ socio-demographic background, the result of the above study cannot be generalized to encourage consumers to purely use their sensory perceptions to make judgement. Interviews with food packaging experts also revealed the similar concern that consumers should not overly rely on their sensory perceptions thus ignore the date labels- For example, I1 stated that *“I don’t think manufactures should encourage consumers to make their own judgement, because consumers will still make their own judgment anyway. But they shouldn’t be encouraged. If something goes wrong, they will blame the manufactures.”*

Furthermore, from the food industry’s perspective, the ways how consumer use their internal sensory assessments to judge food safety and quality have also led to practical influences on the shelf-life determination standards. According to Man (2015), food products not only have a microbiological shelf-life and a chemical shelf-life, but also a consumer-focused sensory shelf-life. The attributes such as discoloration, slime, off flavors, and off-odor are commonly used in sensory shelf-life determination process of highly perishable food products including meats, seafoods, fruits, and vegetables (Corradini, 2018).

#### ***4.2.3 Interplay between the use of labels and sensory perceptions:***

Lyndhurst (2008) described peoples’ food consumption decision-making as a spectrum. At one end, people only trust their own knowledge and sensory perceptions to assess food quality and safety. While at the other end, people overly rely on on-pack labels as the only means to make the judgement. In consumers’ food consumption activities, the use of sensory perceptions and on-pack date labeling information attributes are seldom disconnected. It is the cooperation of these two means that lead to the decision of whether food is edible or not (Lyndhurst, 2011).

Individual consumer is never fixed on their food decision-making spectrum. On the contrary, their interaction with both internal and external mediating tools can be largely influenced by different variables existed in the specific food consumption contexts and consumers’ own preferences. As illustrated in Figure 6, three leading factors can be identified in terms of which tool is more likely to be used by consumers in different contextual situations. First, consumers’ past experience and familiarity with particular products: Studies have identified that habit and past experience can influence people’s food handling behavior (Brennan et al., 2007). When consumers are familiar with a particular food product, they are more likely to apply their internal knowledge, sensory perceptions, and past experiences as means to make the judgement. In this case, date labels and storage guidance are often used only as ‘yardsticks’ (White et al., 2009; Lyndhurst, 2008). Second, products’ perceived micro-biological features: For food such as salad, bread, potatoes, and fruits, where deterioration sign can be easily spotted, consumers are more likely to use their own sensory assessments than date labels.

While for products such as yogurt, milk, eggs, chicken, ham, and ready-made meal, consumers are likely to follow on-pack date labels and storage guidance (Lydnhurst, 2008; Samotyja, 2015; Terpstra et al., 2005). Third, existing studies have revealed that consumers' socio-demographic background can also influence their behavior pattern regarding the use of their internal and external tools. According to Lydnhurst (2011), In UK, older people are more likely to trust their sensory perceptions than younger people. However, this is in contradiction to a similar study conducted by Van Boxstael et al (2014) in Belgium, in which questionnaires-based statistical results indicated that younger people tend to rely upon their sensory assessments than elders.

#### ***4.2.4 Lack of knowledge within both internal and external operations:***

Operations are routine processes providing an adjustment of an action to the ongoing situation (Kaptelinin & Nardi, 2006). In other words, it reveals how actions are adjusted and performed in different conditions. Shifting the focuses to the operation layer, the correct usage of both the internal sensory perceptions and the external on-pack label information cannot be separated from the corresponding knowledge and past experiences that each individual consumer owns.

In terms of consumers' use of internal sensory perceptions in operation later, in order to be able to judge the quality of particular food products through sensory assessment, the corresponding knowledge and experiences on questions such as what methods should be used in each particular case, what criteria and standard should be applied to make a judgment, and to what extent can the senses be trusted in the process, need to be gained before the operation takes place. For example, G2 stated that the lack of common food knowledge is an underlying reason for food waste: *"I was about 55 years old when I heard that you can have egg for half year, and use it for a lot of things. It's a problem if you don't know the knowledge."* Similar to the statement, G1 expressed that the lack of past experiences can be a problem to trust own sensory judgment *"We don't know how bad things taste or smell, for example bad milk and butter"*. While some participants expressed the need for gaining the relevant knowledge, some shared their food handling tips based on their own experiences -- *"I can use coffee to [test milk quality], so you pour a bit milk into coffee, see if it has small lumps"* (G3), *"If meat color is dark, it does not mean it has gone bad, it only means it has gotten oxygen"* (I1). In terms of consumers' use of external labels, specific knowledge on the meaning of different types of labels become the mediating tools that consumer use to judge date. It has been identified that consumers' limited food labelling knowledge is one of the major factors that lead to consumer food waste issues (Manzocco et al, 2016).

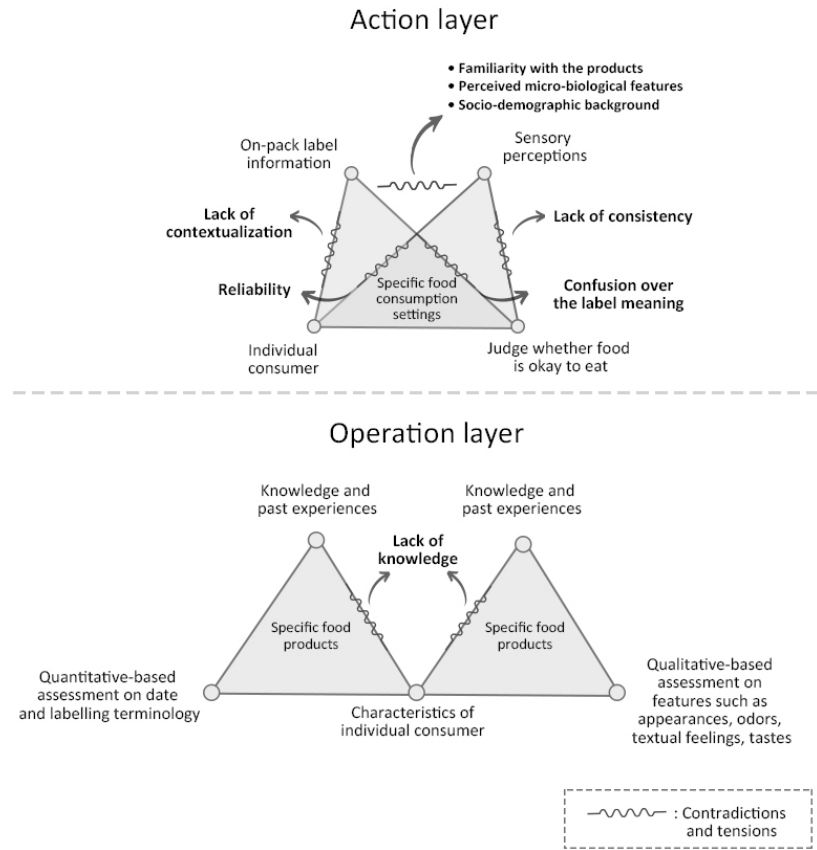


Figure 6. The use of date labels and sensory perceptions as the external and internal mediating tools in consumers' food consumption activity system.

### 4.3 Influences from social interaction

Another factor that might influence the consumers' interaction with on-pack date labels is the social interaction within individual consumers' food consumption activities, which involves the interaction with family members, food handling suggestions from mass media, and building self-confidence about particular food. (Lyndhurst, 2008). For example, people usually learn the food-related knowledge from their families and friends, and then incorporated the knowledge and experience into their existing food consumption activity system (Green et al., 2003). For example, "Some knowledge is also inherited from parents. For example, nuts, the only thing that can go bad is the butter and fat" (G5), "It's a cultural thing. My wife's parents came from a poor countryside, her parents never throw away anything, my wife has learned a lot from that. Both knowledge and the mindset." (G2), "I got the knowledge from my daughters, because she has studied food technology at year 12" (I1). When it comes to the decision-making process regarding whether to eat the food or not, some participants reported that they can be easily influenced by others' opinions – for example, P1 stated "If I am unsure whether a milk product is good or not, I usually pour the milk into glass and taste it, then go to my

roommate and ask does it taste weird. If both of us think it's okay, then it is fine and we will drink it”

#### 4.4 Dynamic interplay between labels, sensory perceptions, and social interaction:

Consumers’ food consumption and disposal decision-making activity patterns are not static but under a dynamic transition process. It is impossible to categorize individual consumers into any of the particular categories. In fact, each individual consumers’ activity patterns might distribute over the matrix as their food judgement can be influenced by the interplay between mediating tools and social interaction. As presented in Figure7, four case scenarios which can trigger consumer food waste behavior can be identified. In Scenario1, as consumers’ particular food consumption decision is only based on the on-pack label information while extremely easy to be influenced by others’ opinions, the lack of internal knowledge about food and concerns for others might lead to overcautious interpretation of date labels, which can result in well preserved food being thrown away before it’s expected expiry date (Lyndhurst et al., 2011). In Scenario2, as consumers overly rely upon their own sensory assessments and others’ opinions to make the judgement, their food disposal decisions can be largely shaped by their own knowledge of food and special concerns for others. For example, it is reported that parents of young children are more likely to pay more attention to the quality of food, they tend to prevent their children eating the product if they are unsure about the quality status (Terpstra et al., 2005). In Scenario3, consumers make decisions only based on their own knowledge and sensory perceptions, thus ignore the on-pack label information or other people’s role in the decision-making process, the potential misperception of food might lead either well preserved food being thrown away before its expiry date, or spoiled food being consumed after its shelf-life. Similar to that, consumers in Scenario 4 tend to overly rely on their own understanding of on-pack labels as the only means to tell whether food is spoiled. Food might be wasted if consumers are unable to identify the correct the meaning of date labels, especially the differences between ‘Best-before’ date and ‘Use-by’ date.

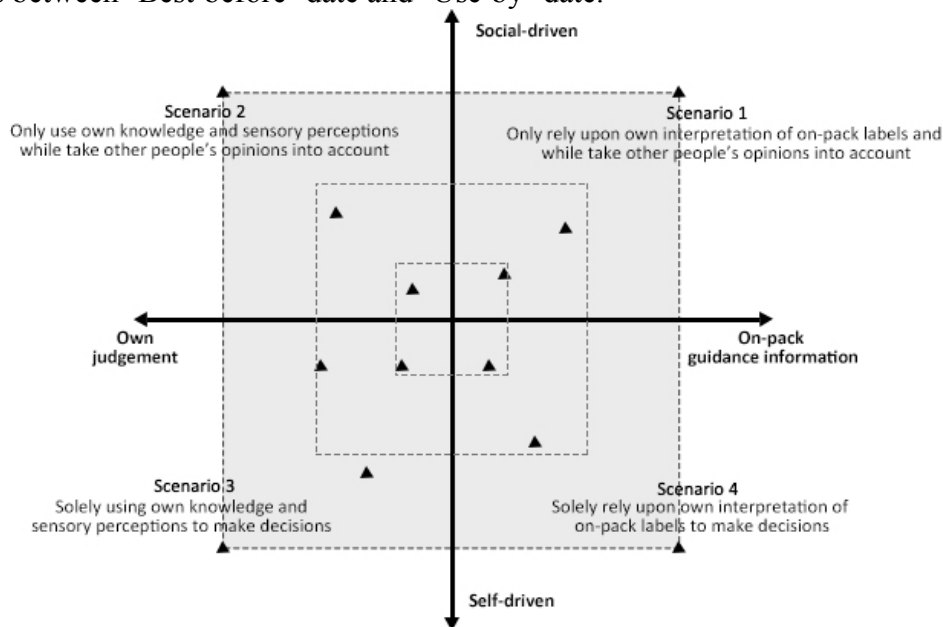


Figure 7. Consumers’ activity patterns in relation to the usage of on-pack labels, own judgement, and social interaction context.

## 5. Development of design implications and interventions

So far, we have summarized the preliminary results summarized from the literature review and the in-depth interviews and design workshops conducted with both general consumers and industry practitioners. Through applying an activity theoretical lens to analyze the literature and empirical results, we have described how consumers' shifting food consumption motivations, the changing socio-cultural contexts, and the dynamic interplay between internal sensory perceptions and external on-pack labels can influence the usage of on-pack date-related labelling in consumers' food consumption activity. The empirical results mentioned above led to the identifications of tensions within each analytical aspect. From a design perspective, these tensions were further translated into opportunities and implications for design interventions listed in Table 1 below.

| Analytical aspects                   | Summary of tensions  | Implications for design interventions  |
|--------------------------------------|--|--|
| Socio-cultural context & Development | Lack of efficient ways to incorporate food waste concerns with consumers' existing motivations in judging food safety and quality.   | Use a more interactive approach to incorporate food waste concerns with existing motivations of judging food safety and quality.   |
| Socio-cultural context & Development | Food industry practitioners focus on using date labels to better inform consumers' purchasing behavior. For example, give discounts to dairy products, breads, fresh produce, and meats when the product is close to expiration date. However, consumers' interaction with labels at household levels have been largely neglected due to the lack of food industries' economic incentives. | Establish connections between consumers and food industry practitioners after the products have been purchased. Informing consumers about the product shelf-life and storage guidance, while at the same time offering product-tailored information such as cooking recipes, brand sustainability values, nutrition benefits, and traceability.        |
| Socio-cultural context & Development | Limited space on packaging. Lack of motivation to present information that does not necessarily improve products' sales performance.   | Compress and store information in image marks or codes on packaging, and make it accessible for consumers to extract the information.  |
| External mediating tool              | Consumer's confusions over the meanings of different types of date labels, particularly 'Best-before' and 'Use-by' date.   | Present explicit information about the differences between different types of labels. However, questions such as should there be only one single designation to guide consumers, and which date labeling terminology should be applied to avoid consumers' confusion, still need further investigation depending on different socio-cultural contexts. |

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|--|---|--|
| External mediating tool                                | The on-pack date and storage information is not contextualized to align with consumers' daily food consumption activities (e.g. lack of guidance on how the product should be stored, and how long it can last after first opening).  | Present product-specific shelf-life and storage information to address consumers' particular concerns (e.g. provide more descriptive label guidance such as 'Use within X days after first opening', 'Can be stored in freezer to extend shelf-life').   |
| Internal mediating tool                                | Consumers' lack of knowledge on the use of sensory perceptions. And lack of interests to search and learn the relevant knowledge.   | Provide product-specific guidance to consumers. As relevant knowledge information already exists on mass media, the focus needs to be shifted to communicate the tailored guidance to consumers in a more interactive and contextualized way when they are carrying out food consumption activities.   |
| Interplay between mediating tools & Social interaction | Consumers' food-related knowledge and awareness have been gradually lost in the changing socio-cultural context. Given the spectrum between the use of sensory perceptions and on-pack labels, consumers' over reliance on either end of the spectrum can lead to food safety and waste issues. | Encourage consumers to use their sensory perceptions in conjunction with date labels to make the judgement. Therefore, design should focus on not only changing the undesired food waste behavior, but also retaining the desired food-related knowledge and behavior (e.g. retain the knowledge on how to judge whether food is okay to eat through sensory assessments from the older generation to the younger generation). |

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Table 1. Summary of identified tensions and the corresponding potential implications and opportunities to improve the on-pack date labels and storage information design.

## 5.1 Design concept development

Based on the proposed design implications, we set the primary goal of the design intervention as to support consumers in using the external mediating tools -- date labels and storage information, in conjunction with their internal mediating tools – their own knowledge and sensory perception, to judge food quality and safety, while incorporating other design implications and solving the tensions within consumer-labelling interaction activity system identified in the Table 1 above.

The concepts generated in the design workshops can be generally grouped into two groups: (i). Concepts in group1 focused on providing an on-pack visual representation of how a spoiled food product can look like, so that consumers would know that it is safe to consume the product before it looks like the picture presented on the packaging. All the similar ideas identified in this group were based on the notion that consumers should be encouraged to use more of their own sensory perceptions to make the judgement. Proposed ideas ranged from using QR code to present visual guidance to consumers to completely replacing any types of date labels by visual images. (ii). Concepts in group2 focused on applying 'smart labels' to give real-time feedbacks to consumers. The design concepts in this group were proposed based on the existing real-time measurement and indication labeling technology, which can change label color according to the variations of temperature, particular gases, or bacterial. However, instead of focusing on the technical design part, more emphasis was put the usability of such labels. For example, how to better inform consumers that the label is about to change its color, how to educate consumers to understand the basic mechanism behind the 'smart labels', and how to avoid consumers' misunderstandings regarding the use of the 'smart labels'. Some of the key design concepts identified in these two groups are presented in the Figure 8.

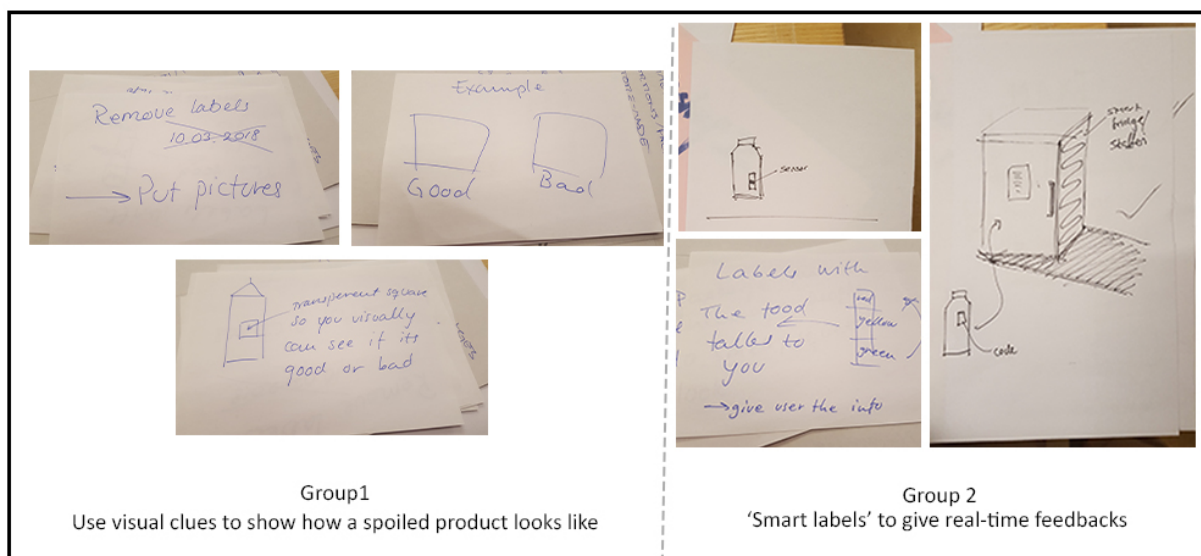


Figure 8. Some of the labelling design concepts generated in the design workshops.

## 5.2 Final design prototype

A mobile digital prototype was developed based on the Augmented Reality (AR) technology with the consideration that: (i) The use of AR technology can transfer the information attributes presented on packaging from 2-Dimension to 3-Dimension. Under the topic of this particular study, this feature can be used by food manufacturers and retailers to tell consumers how a spoiled product might look, smell, or taste like through enhanced augmented 3D modelling and the descriptions associated with the models, thus to enable users to assess the

quality and safety of the food products through making comparison with the augmented models. (ii) The image mark can extend the food information attributes from the printed packaging to consumers' personal digital devices, thus solve the packaging space limitation that industry participants concerned out. Therefore, various packaging information including the differences between 'Best-before' and 'Use-by' date, detail storage guidance regarding the particular food product, the manufacturing information of the food products, food and packaging disposal guidance, and recommended recipes, can be compressed in image marks and presented in an AR scene in consumers' mobile devices through scanning the specific product packaging.

Consumer interaction process with the app are as the following: 1). Install the app on their mobile devices. 2). Start the app and use the device default camera to scan the particular image marks on food packaging. The image mark is designed to contain the specific product's date and storage related guidance with an augmented 3D model of the food product. Note that the image mark can be designed in different sizes, patterns, colors, and layouts to fit different product packaging. 3). The specific food model, date and storage information then will be presented on the app interface. 4). Users can select the particular date and view the sensory related information and visualization of the augmented food products. The texture of the augmented food model, suggestions in terms of the best storage condition and suitable ways to handle the current food in cooking, and other alternative approaches to assess the food quality and safety, will change accordingly depending on the date that user selected (see Figure 9).

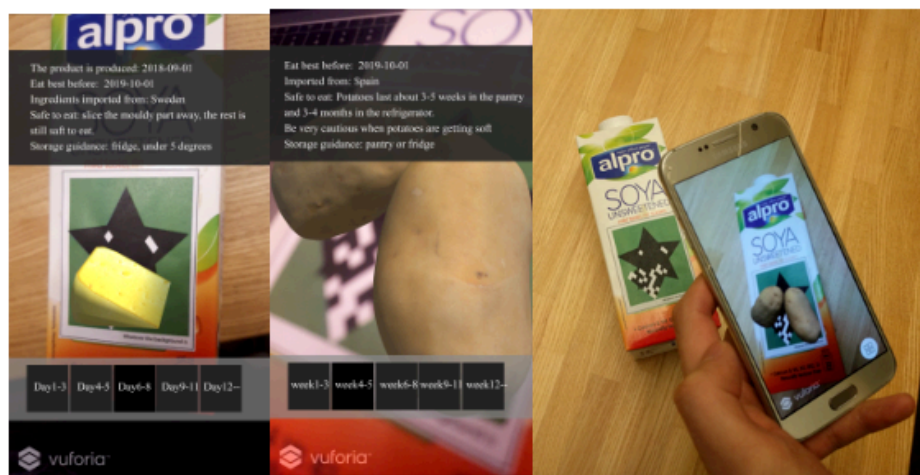
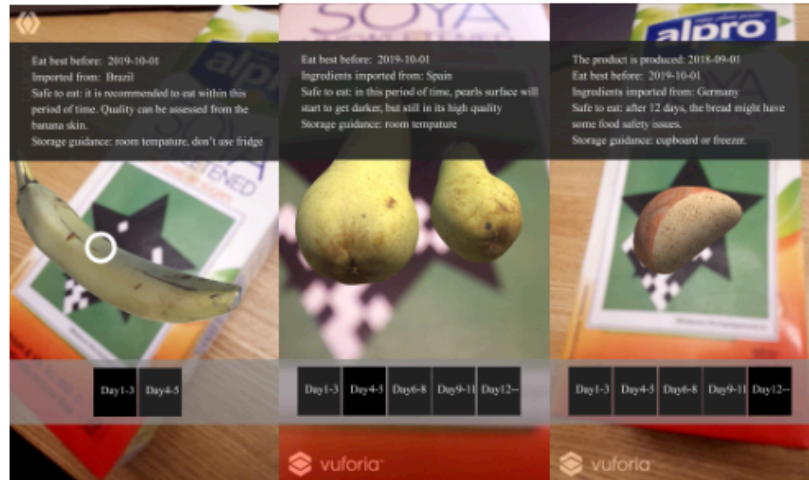


Figure 9. The AR-based mobile digital prototype developed in the present study.

The next step is to test the AR-based mobile digital prototype in consumers' real household context in a mid-term time span (1-3 weeks). We plan to conduct field observations and interviews with consumers to understand their usage of the prototype, identify potential problems, refine the design concept, and then iterate the final design.

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