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The Effect of Expiration Indicators on Consumer Acceptance and Food Waste Reduction

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Abstract

Assessing microbiological quality of perishable products is a difficult process for consumers, since quality is highly dynamical. Expiration dates, prescribed by the government give a static indication of the freshness of a product. Dynamic indicators are proposed to tackle the inaccurateness of these dates, in an attempt to reduce food waste. The aim of this study is to explore how consumers evaluate expiration of perishable products, how this affects their product acceptance, and to what extent real-time indication would influence this acceptance, and thereby reduce food waste. By using a computer-based questionnaire spread, among student, consumer assessment of quality, influence of dynamic indicators on behaviour and the effect on frames in this process are explored. Results show an increase in perceived quality and food acceptance of products provided with a dynamic indicator compared to a static indicator. Besides, results indirectly show acceptance of nano-technology applied to expiration labels. Furthermore, using a best-before (gain) or use-by date (loss) influences the quality perception of food in the current situation. Concluded, it therefore can be said that using a dynamic indicator provided with a gain-framed expiration probably would be best to decrease food waste in the society.

Keywords: Nano-technology, Expiration Dates, Food Acceptance, Perishables, Freshness Indicators, Food Waste

Preface

This is it, it is completed: my Master's thesis to obtain my double degree at Wageningen University and Technische Universität München. I have thoroughly enjoyed studying the MSc Management, Economics and Consumer Behaviour with the focus on Marketing and Consumer Behaviour at Wageningen University. I also loved my time in Munich where I followed the Masters of Consumer Affairs focussing on 'Consumer, Technology and Innovation' and 'Sustainable Consumption'. In this thesis the theories, methods and skills that I learned at both universities are combined. Conducting a consumer behaviour research concerning food and sustainability represents Wageningen University. The Technische Universität München is represented by the focus on consumer behaviour towards a new technical innovation.

I could not have accomplished this report without the useful insights of my supervisors. Despite his busy agenda, Prof. Van Trijp always provided useful, if sometimes confusing and thought-provoking, feedback and recommendations. Many thanks also to Van Giesen who provided guidance, and help whenever necessary, with her critical questions during meetings with Prof. Van Trijp proving to be particularly useful. Last but not least, I also would like to thank Prof. Roosen of the TUM for her help during the first stage of the research in which she provided much food for thought.

This thesis has been a pleasure to complete, however it was not without difficult moments. Throughout the process I learned that I should have the confidence to make my own decisions and be more confident about these decisions, a lessons that I will take into account in the future.

Enjoy reading my Master's thesis.

Eleonore Schut
Wageningen, August 2013

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Summary

It is difficult for consumers to assess the microbiological-related quality of perishable products. Quality is a multidimensional concept, differing between product categories and handling methods, and it is to a large extent a 'credence attribute' for consumers. Currently, static indicators provided by the government are used in the form of expiration date indicators. The expiration dates placed on products contain a safety margin to capture deviations from handling and individual products. However, these static indicators are inaccurate and often confuse the consumer, what leads to food wastage. The accuracy of safety margins could be improved by providing dynamic (real-time) indicators, which provide information on the actual status of the microbiological-related quality of the product.

Introduction

The aim of this research is to explore how consumers evaluate the quality of perishable products, how this effects their product acceptance, and to what extent real-time indicators would influence this acceptance and thereby reduce food wastage. We argue that expiration dates influence food acceptance differently, depending on their presentation in the form of a best-before date (gain frame) or a use-by date (loss frame). In addition, it was found that the type of technology used to monitor the microbiological quality would probably influence the level of acceptance amongst consumers. Real-time indication can be conducted by using nano-labels or RFID-tags. Nano-labels, based on nano-technologies, struggle for consumer acceptance in comparison to RFID-tags however give more precise information as to the microbiological quality of the product. RFID-tags therefore will be used as a 'baseline' to study if dynamic indicators would decrease food waste, and to study the perceived risk, and acceptance, of nano-labels. Since dynamic indicators give consumers the possibility to choose for themselves, personal empowerment, or the rise of uncertainty, is taken into account.

Method

An experiment, with a 2 (Best-Before x Use-By) by 3 (Static indicator x Nano x RFID) design, is conducted to test the developed theoretical model. 178 Respondents participated in the experiment, in which three situations were sketched. Respondents respectively had to evaluate a beefsteak based on a static indicator and one based on the dynamic indicators (randomly first a Nano- or RFID-label). Data was collected using an online questionnaire filled in at the university or at home.

Results

An effect of the type of expiration date on the perceived quality of a product was found, with a lower perceived quality by using a use-by date compared to a best-before date. Furthermore, the type of expiration indicator influenced the perceived quality and food acceptability of the product. With perceived quality and food acceptability being higher when using a dynamic indicator (nano- or RFID label) compared to using a static indicator (expiration date). Food acceptability gradually decreased when a dynamic indicator was used, while it decreased more suddenly in the situation of a static indicator. It can be said that a nano-label as expiration indicator is accepted, since consumers do not perceive a high risk. However compared to a RFID-label it is perceived as more risky. An indication without technology, static indication, is perceived as less risky. Finally, dynamic indication is found to influence acceptance of the food due to empowerment, because of the higher importance but also because of the rising certainty due to the use of a dynamic indicator.

Conclusion and discussion

Using a nano-label, to provide a dynamic insight into the deterioration process of perishable products, is a great innovation to provide customers with necessary information to reduce food waste, in a time in which sustainability must become the status quo. Further research can be done with regard to dynamic indications on different product categories, influence on behaviour during purchase, influence on different target groups and the effect of trust.

1. Introduction

Having a real-time insight into the quality of perishable products is an important but problematic situation for consumers due to a variety of reasons. Firstly, quality is a heterogeneous and multidimensional concept consisting of inferences related to the product's (microbiological) safety (Tsiros and Heilman, 2005; Ravn Jorgensen et al., 1988; Gram et al., 2002; Velthuis et al., 2010), its sensory attributes (e.g. Taste), its nutritional characteristics or healthfulness (Velthuis et al., 2010), it's convenience and the production process used (Brunso et al., 2002). Secondly, quality in relation to microbiological status is a highly dynamic concept. The speed and amount of microbiological changes differ per product category and handling of the product along the supply chain, for example products deteriorate faster stored under high temperatures (Timmermans, 2012; Pereira de Abreu et al., 2012). Thirdly, microbiological quality is influenced by preservation techniques. Preservation techniques make it able to: 1) Manage the amount of microorganisms, for example by canning, pasteurisation or airtight packaging 2) Avoid the growth of microorganisms, for example by irradiation. Preservation techniques make it difficult for the consumer to use basic knowledge about expiration since the lifespan of a product is extended. Finally, quality is largely a matter of credence confidence (Brunso et al., 2002), which cannot be verified before and even after use (Nelson, 1970, 1974; Darby and Karni, 1973) unless there is an extreme lack of freshness, which manifests itself in experience and search cues such as deterioration of taste, visual (e.g. colour) and olfactory (e.g. smell) characteristics of the product.

To guarantee public health and allow consumers to make an informed choice, the issue of microbiological-quality is regulated (NVWA, 2013). Food producers are required to provide information about the expected microbiological-related quality on the packaging (WEL, 2013) either in the form of a "best-before date" as an optimal quality guarantee or a "use-by date" as an indication for minimal quality guarantee (Yngfalk, 2012).

However, these indicators have a considerable safety margin included to capture deviation from optimal handling in the supply chain. This safety margin is needed since both expiration dates are static indicators based on an expectation of microbiological status at any moment in time, a batch average, and in the case of long lasting products it is a comparison of expiration dates of similar products on the market, to meet consumers' expectations (Timmermans, 2013; Pereira de Abreu et al., 2012; Yngfalk, 2012).

1.1 Problem definition

In the wake of the discussions on sustainability, particularly concerning food waste, concerns have been expressed about the unnecessary food wastage that these safety margins cause

(Timmermans, 2013; Soethoudt et al., 2012). In Europe, about 34 per cent of the food is wasted by consumers (food still edible for humans), which is around 95 kg/year per capita (Gustavsson et al, 2011). This food wastage must be reduced in order to increase levels of sustainability in the food chain (Soethoudt et al., 2012).

The issue of inflated safety margins, causing food waste, could be dealt with by providing consumers with real-time indications for quality, which can provide a real-time insight into the microbiological status of the product (Soethoudt et al., 2012). For example, using technologies like nano-technology or RFID-tags in real-time indicators can make it possible to provide information on the actual status of microbiological-related quality, and thereby capturing the factors that create differences between individual products within a product category. Additionally to this, real-time indicators are more accurate in providing information about the quality compared to expiration dates (Silvestre, et al., 2011) and confusion amongst consumers about the actual expiration of a product will be decreased (Tsiros and Heilman, 2005). However, it must be taken into account that technology such as nanotechnology is still struggling for consumer acceptance, with many consumers seeming to associate negative connotations with this technology as such (Bieberstein, et al., 2012; Marette et al., 2009; Vandermoere et al., 2009; Stampfli et al., 2010).

1.2 Aim

The aim of this study is to explore how consumers evaluate expiration of perishable products, how this affects their product acceptance, and to what extent real-time indication would influence this acceptance, and thereby reduce food wastage. This was approached by answering the following research questions:

- How does the evaluation of microbiological-related quality, by using expiration dates, influence the product acceptance of perishable products?
- What influence do dynamic indicators have on the acceptance of perishable products?

In doing so, we build on three streams of literature and an empirical-based research. First, the consumer behaviour literature on consumer assessment of product quality, in relation to microbiological status, and the indicators used for this assessment is examined. Second, the literature on the influence of dynamic indicators on product acceptability will be looked at, and especially the influence of the perceived risk caused by nano-technology. Finally, the literature on message framing is used to link the previous two literature streams. Specifically, we will argue that the two expiration indicators can be positioned in terms of gain (best-before) versus avoiding loss (use-by), and thereby influence the consumers' food acceptability. We argue that the best-before date emphasizes a maximum quality (gain), while

the use-by date emphasizes the minimum quality (reduction of loss). Advice for food waste reduction will be presented based on the results from the different designs tested in the model.

This thesis extends on previous literature since it focuses on product acceptance and perceived quality when using dynamic indication, based on nano-technology, compared to static indication for expiration which is not done in previous studies. Previous research was focussed on willingness to pay for dynamic indication (Fortin et al., 2009; Latvala and Kola, 2004), acceptance of food labelled with an expiration date (e.g. Harcar and Karakaya, 2005; Tsiros and Heilman, 2005; Gimenez et al., 2008) and acceptance of nano-technology as such (e.g. Marette et al., 2009; Vandermoere et al., 2010; Bieberstein et al., 2012). This research is unique since it takes the influence of using t use-by or best before date on food acceptance into account.

Besides being scientifically relevant, this thesis will also be socially relevant because money can be saved when less food is wasted thanks to using a dynamic indication. Furthermore, supermarkets and food producers will benefit, since having insight in the course of a products' expiration could enable them to react, for example by supplying faster spoiling products first.

The current need for sustainability makes this research highly interesting. Besides, saving money is a welcome added advantage in times of economical crisis.

2. Theoretical background

Food is wasted when the consumers no longer accept the food. This acceptance of the food is strongly depending on the perceived microbiological quality of the product, which the consumers base on the freshness and durability of the product. Information about this freshness and durability is for a major part gathered by using expiration indicators. Currently these indicators are expiration dates, a use-by or best before date, which influence perceived quality due to the frames used, respectively a loss and a gain frame.

Dynamic indicators, using a nano- or RFID-label, can also provide the expiration indication. Using dynamic indication will probably increase the perceived product quality, raise food acceptability and therefore reduce food waste. Though, using dynamic indication based on (nano-) technology could increase the perceived risk, due to negative associations with the technology, what could influence food acceptability. On the other hand, dynamic indication could raise empowerment and lower uncertainty, which increases food acceptability. All these effects are possibly affected by personal characteristics such as the knowledge level of expiration, technophobia and uncertainty avoidance.

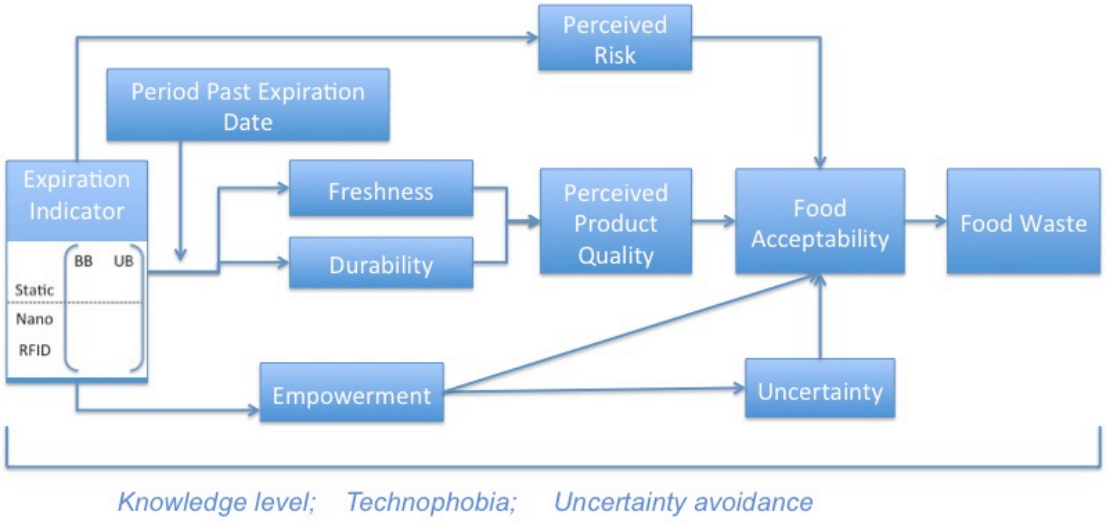

Figure 1: *Theoretical model of this research*

2.1 Consumer assessment of expected product quality

Since microbiological status determines the quality, and especially safety quality of the food, it is used as an important cue for the expected eating quality and safety of a product (Steenkamp et al., 1986). The ability to determine the quality of a product is limited since the microbiological quality is not visibly obvious in the first stages of deterioration (Latvala and Kola, 2004; Dabri and Karni, 1973; Lewis, 2002). Nevertheless, it is important for the

consumer to gather information about the microbiological-related quality of a product to avoid negative experiences due to deterioration (Tsiros and Heilman, 2005).

The consumer collects information by making inferences about the quality of a product, based on cues, heuristics, arguments, prior knowledge and information of others (Kardes, 1993 in Kardes et al., 2004; Kruglanski & Webster, 1996; Mitra et al., 1999). Prescribing expiration dates as government enables the consumer to assess expected microbiological-related quality of products, when it is not yet visible. It is therefore not surprising that the expiration date is an important cue to access quality when buying or eating food (Tsiros and Heilman, 2005; Nurliyana, et al., 2011; Harcar and Karakaya, 2005; Terpstra et al., 2005).

There are two kinds of expiration dates that are prescribed by the European regulation: the best-before date (BB) and the use-by date (UB). We argue that these two different kinds of expiration dates influence the consumer behaviour due to the framing used, since positive or negative framing has an influence on consumer evaluation (Lee and Aaker, 2004; Park 2012). In short, it is an issue of perspective: i.e. the same message can be delivered in different ways: e.g. 50% will survive versus 50% will die.

The best-before date "indicates the date after which a product is no longer of its "best" quality" (Tsiros and Heilman, 2005: 115). The best-before date is a quality guarantee, generally present on preserved products, dry groceries and frozen products. The best-before date focuses the consumer on gains (desirable end state) the product provides and it therefore can be seen as a gain frame (Lee and Aaker, 2004). People will focus on the positive outcomes and therefore be promotion focused. Promotion-focused persons emphasize the pursuit of gains and will be eager to use the product for its benefits (Higgens, 2000).

The use-by date is present on highly perishable food products, which can directly cause a health risk (Soethoudt et al, 2012), such as eggs, meat, vegetables and dairy products (Tsiros and Heilman, 2005). This date gives an indication of safety: after this date the product is perceived as dangerous according to article 14 (paragraph 2-5, nr. 178/2002) of the European Regulation and the Labelling Regulation (Soethoudt et al, 2012). A focus directed towards losses (undesirable end state) of the product is encountered. The use-by date can be seen as a loss frame (Lee and Aaker, 2004). People will focus on the negative aspects and therefore will be prevention focused. Prevention-focused persons place an emphasis on the negative aspects of a product and will be vigilance i.e. in checking the expiry date has not passed (Higgens, 2000).

In other words: the best-before date gives the consumer an indication of the quality of the product, whilst the use-by date provides boundaries of guaranteed safety to the consumer. The

best-before date and use-by date can respectively be seen as an indicator of an optimal quality guarantee (gain) and an indication for minimal quality guarantee (reduction of loss).

The expectation is that consumers reject use-by products faster since it focuses them on the negatives and risks that the product could bring when consumed. This causes a reduction in the perceived quality causing the consumers to exhibit increased vigilance. On the other hand, best-before products have an emphasis placed on quality and therefore on the positives of the product, causing consumers to have a more favourable disposition to the product. To test this thought the following hypothesis is established:

H_1: A use-by date (as a loss frame) compared to a best-before date (as a gain frame), will decrease perceived quality and therefore lower food acceptability

2.2 Questionable accuracy of expiration dates

The accuracy of the expiration dates as an indicator of quality can be discussed both in relation to giving insight into the product quality and changing consumer behaviour. The arguments below are reasons in favour of dynamic indicators.

2.2.1 Amount of quality insight

First of all, expiration dates suggest that deterioration of food is a static process whereas the influence of the growing amount of microbes, which cause spoilage of the food, varies among product categories (Gram et al., 2002; Adams and Moss, 2008; Lewis, 2002). The quality of some products declines linearly, while the quality of others declines in a parabolic (dynamic) course. For example, quality of milk declines from the moment it is produced and pathological microbes grow, while the quality of blue cheese first rises until a maximum after which it declines (see figure 2). In this thesis the focus is the dynamic quality course. The focus lies on this category since a dynamic indicator could follow this quality course whereas a static indicator could not. For the same reason having a dynamic indicator that can follow the quality course could give the opportunity to give the consumer the exact moment of best quality.

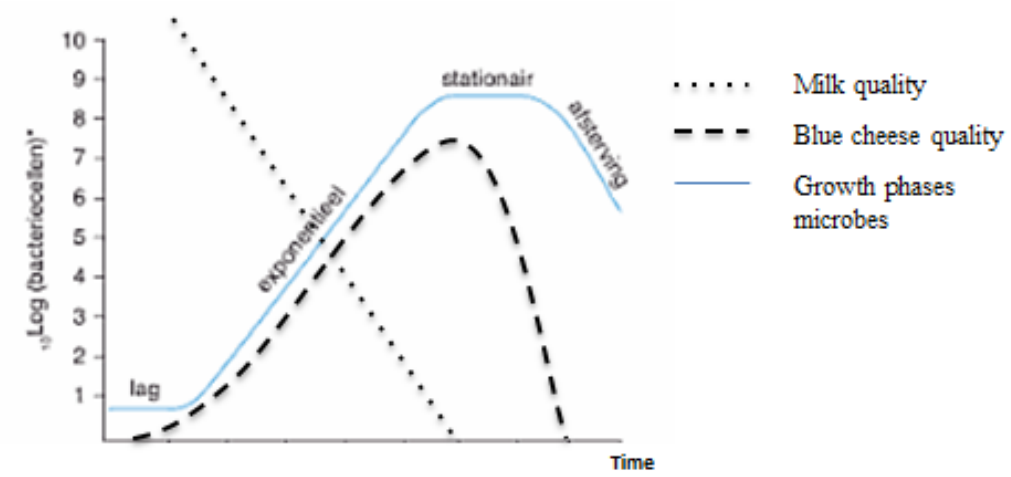

Figure 2: *Relationship quality and microbiological status*

Secondly, the quality course and deterioration speed of a product can differ within a product category due to handling, cross contamination, and preservation techniques. For example, when a product is stored under high temperature conditions the deterioration will be faster than when a low storage temperature is maintained (Lewis, 2002). The same accounts for keeping the product in the refrigerator compared to the freezer. A static indicator could not follow these changes of quality.

Furthermore, the expiration date does not reflect the quality status accurately as producers are free to choose the best-before and use-by dates (Soethoudt, et al., 2012). The choice of these dates is mostly established by predictions of the distribution and storage conditions (Silvestre, et al., 2011), risk aversion regarding health claims (Soethoudt et al., 2012), and sensory changes of the product (instead of microbiological aspects) (Soethoudt, et al., 2012; Ynkfalk, 2012). The products with a best-before date are mostly still safe to consume after the best-before date has expired (Soethoudt, et al., 2012), since real conditions regularly differ (Silvestre, et al., 2011) and producers are mainly focused on the best quality and sensory experience for the consumer and avoiding health claims (Soethoudt, et al., 2012; Ynkfalk, 2012; Hough and Garitta, 2012). Most products with a best-before date only lose a bit of their sensory quality after the date has passed, but are not bad for the health of the consumer (Yngfalk, 2012). Applying dynamic indication enables to apply a precise indication of spoilage and quality.

2.2.2 Influence on consumer behaviour

Research shows that the different messages of the two expiration dates create confusion for consumers, and could increase food wastage since consumers do not know how to use the date (Tsiros and Heilman, 2005; Soethoudt et al, 2012; Sen and Block, 2009). Using a

dynamic indicator could give a direct indication, and also provide security since most consumers for example do not know that the use-by date ceases to apply after opening (Terpstra et al., 2005).

A stigma created around products with expired dates influences consumer behaviour. Food that has not passed its expiration date is accepted; whilst food that has reached its expiration date is thrown away without smelling or tasting. Consumers encounter fear and disgust, and believe that perishable food has a consistent level of quality until the expiration date, after which it is perceived to be directly spoiled (Kerley and colleagues, 2008; Wansink and Wright, 2006; Harcar and Karakaya, 2005; Voedingscentrum, 2011; Zorba and Kaptan, 2011; Westerhoven and Steenhuisen, 2010; Rozin and Fallon, 1980). Products not spoiled after expiration of the date will not be stigmatized when using a dynamic indicator.

Final, expiration dates also enlarge food waste before purchase, since consumers tend to choose the product with the longest expiration date, even when the consumer's intention is to consume it before the shortest expiration date is expired anyway (Tsiros and Heilman, 2005; Soethoudt et al., 2012),

Concluding, since quality is highly dynamic and expiration dates influence behaviour it is important to have a dynamic indicator, which adjusts to provide accurate information about the microbiological quality of a product.

2.3 Behaviour in relation to dynamic indicators

Previous research already indicated different reasons in favour of dynamic indication. First of all, consumers see dynamic expiration information to provide advantages in terms of product safety and product freshness. In addition, research suggests that consumers indicate a dynamic indicator to be useful at home (Fortin et al., 2009). Secondly, general research concerning dynamic information shows that dynamic information can give consumers the opportunity to match this more specific information to their own personal preferences regarding food quality (Ariely, 2000). For example, people with a higher risk of getting sick could lower the risk of getting sick by using their own discretion regarding food quality, a performance that is limited with static indicators. These consumers then have the ability to see the product being (almost/already) spoiled before the expiration date (Fortin et al., 2009). Moreover, the costs are no counter argument since research showed that consumers are willing to pay more for extra quality information on products (Fortin et al., 2009; Latvala and Kola, 2004).

It is expected that the quality perceived by the consumer will change when a dynamic (real-time) indicator is used. For a real-time indicator, the expiration date is not a static point on the microbiological graph anymore but instead adjusts to the microbiological status of the product (Pereira de Abreu et al., 2012). This gives the consumer insight into the actual quality status of a product. It could be possible that a product that would otherwise have been indicated as spoiled based on the expiration date now is indicated as still edible by the dynamic indicator. It is not clear how consumers will react to this differing information. Therefore the following hypothesis is established:

H_2: Dynamic, as opposed to, static indicators will increase perceived quality, which will increase the level of food acceptability

Furthermore, in the case of the static indicator the product is perceived to be safe to consume one day, and then spoiled the next (Kerley et al., 2008), as opposed to a dynamic indicator, which would show the gradual deterioration of the product. When using a dynamic indicator it is therefore likely that the product acceptance will decline more gradually when time past the expiration date increases. This thought will be tested in the next hypothesis:

H_3: Perceived product quality will decrease with time following expiration, resulting in lower food acceptability, but this decline will occur gradually in the case of dynamic indicators and suddenly in the case of static indicators.

2.4 Nano-technology to provide dynamic indication

For a number of years nano-technology has been in the food packaging industry (Silvestre, et al., 2011; Pereira de Abreu, et al., 2012). “Nanotechnology involves creating and manipulating organic and inorganic matter at the nano scale.” (Mehta, 2004). Nanotechnology enables atoms to be organised into previously impossible structures, making a number of different properties and applications possible (Roosen et al., 2011).

Nanotechnology provides a number of advantages in packaging, such as extending shelf life of products, provision of detailed information to the consumer or producer, as well as an increasing security of food chain processes. The latter two are realised by nano-sensors that provide information about the condition of the food during transport and storage, and can for example determine if the product is still fresh (Silvestre, et al., 2011; Pereira de Abreu, et al., 2012). Silvestre and colleagues (2011) distinguish three main applications of nano materials for food packaging: improved (improvement of the package properties, such as temperature

stability), active (dynamic packaging interacting with the food and environment, such as removing substances) and intelligent packaging. The focus of this thesis will be on intelligent packaging. Intelligent packaging is packaging which can monitor and communicate the condition of packaged food or the environment surrounding the food (Silvestre, et al., 2011). These nano devices can provide information about the real-time status of food freshness, for example the amount of toxins produced by microorganisms can be detected (Silvestre, et al., 2011). It could give consumers a good insight into the freshness and safety of a product, as well as providing information about the conditions and treatment during the production, transport and storage of the product. Freshness is indicated with a colour change of the indicator tag due to the presence of bacteria (Silvestre et al., 2011). Existing examples of nano-labels included a barcode that became increasingly black so that it could not be sold anymore (Metzger, 2009), and a sticker whose colour changed from green to red (Smolander, 2009).

2.5 Consumer acceptance of nano-technology smart packaging

Consumers have not had much exposure to nano-technology (Silvestre, et al., 2011), so the application of nano labels will be perceived as a new technology and still has to go through the acceptance process. Ronteltap and colleagues (2007), and also Siegrist (2008) stated the importance of perceived risk for acceptance of new food technologies.

The risks and uncertainties the consumer encounters with regard to nano-technology are investigated in a number of studies (e.g. Marette et al., 2009; Vandermoere et al., 2010; Silvestre et al., 2011; Bieberstein et al., 2012). Consumers face a lot of perceived risk and uncertainty concerning nano-technology since they have limited knowledge about the technology. Herein health is an important issue (Marette et al., 2009). Vandermoere and colleagues (2010) found that around 80% more people would see health risks rather than health benefits. The use of nanoparticles has been found to create the perception of a higher health risk due to fear of negative health risks associated with nanoparticles migration (Silvestre et al., 2011). The studies of Marette and colleagues (2009) and Bieberstein and colleagues (2012) show a reluctance towards acceptance of nanotechnology applications.

Contradictory, other research shows that nano-technology, when used for information labels, is perceived to be less risky than e.g. nano-technology used in food itself (Stampfli, et al., 2010; Siegrist et al., 2008) since the modified part is not ingested (Siegrist et al., 2008). Since consumers perceive the proposed application to be less risky, acceptance of the technology will be more likely in the case of nano-labels. Furthermore, also research of Marette and

colleagues (2009) indicated a higher acceptance when the technology is further away from ingestion. However, whether the use of nano-labels has enough distance from ingestion must be examined, since food is mentioned as an area of reluctance (Marette et al., 2009).

Besides the unknown level of acceptance of food provided with a nano-technology label it is also an aim to investigate the influence of dynamic indication in general. To be able to test this affect (H2) when nano-technology is not accepted another technology will be tested in addition: RFID. Radio Frequency Identification (RFID) is a technology based on a chip. This technology could also monitor the freshness of a product approximately by means of a colour change of the label (Wageningen UR, 2013). Compared to the nano-technology is RFID a less direct measure, where indication is based on temperature changes and age of the product. RFID is chosen since it a more accepted technology by consumers compared to nano-technology (Gupta et al., 2012), and could provide the same monitoring, however more indirect. Using RFID as a baseline also gives the opportunity to measure acceptance of products with nano-technology labels.

H_4: Products containing a dynamic indicator based on nano-technology will enjoy lower acceptance compared to products containing a dynamic indicator based on RFID, since perceived risk is higher by using nano-technology

2.6 Empowerment

Besides characteristics of the product also individual differences play an important role in the acceptance difference by using dynamic indication. The dynamic indicators could give consumers a feeling of more control over their decisions and actions concerning the edibility of the product. This process of increasing control is called empowerment (Nutbeam 1998) and is in the case of dynamic indication especially influenced by two factors: locus of control and perceived self-efficacy/behavioural control (Koelen and Lindström, 2005).
Locus of control represents expectations of the relationship between an individual's behaviour and the outcome of that behaviour the consumer has (Rotter, 1966 in Rotter, 1990). In the current situation where expiration dates are used, control is more external (it is a result of chance or under control of others), while in the case of dynamic indication it would be more internal (an outcome of the individual's own behaviour) (Rotter, 1990). Using dynamic indication will give the consumers more information about possible influences of the product on their health, and if the deterioration level deviates from the expiration date. For example, whether the food would lead to sickness due to spoilage can be predicted. The control therefore shifts from external to internal.

Perceived behavioural control is, in the context of dynamic indication, the belief how easy or difficult it is to evaluate the freshness based on the indicator (Ajzen and Madden, 1986). When people are able to base their evaluation on the dynamic indicator they encounter behavioural control and therefore will be empowered to evaluate the edibility of the product by themselves.

However a person's character will also influence the degree of empowerment. Some people will feel empowered if they get the chance to decide for themselves, whilst others find it a nightmare. On the other hand, research of Taylor and Brown (1988) showed that people evaluate the self as more positively compared to others. In the case of dynamic indication it therefore would probably occur that people also think they can better evaluate the expiration themselves instead of relying on the evaluation of someone else in the case of a static indication. The expectation that dynamic indication will lead to empowerment therefore rises. When people are empowered to use the dynamic indicator food waste, caused by the static indicators, could be reduced.

Expected is that dynamic indication would influence empowerment. However when empowerment is not aroused it probably will lead to uncertainty about what to do with the product indicating for example 'almost spoiled'. Furthermore, a switch of control over the situation from the packaging/producer to the consumer will then raise uncertainty since responsibility for hazards caused by the products switches from the producer to the consumer (Yngfalk, 2012; Soethoudt, et al., 2012). In line with these thoughts the following hypothesis is developed:

> H_5: Dynamic indicators will influence empowerment, in comparison with static indicators, and therefore raise food acceptability, although uncertainty could be raised since the responsibility shifts to the consumer.

Furthermore individual characteristics, such as technophobia, uncertainty avoidance and level of knowledge about expiration, could moderate the effects of e.g. a dynamic indicator. These will be described in the next paragraph.

2.7 Moderating effects of technophobia, uncertainty avoidance and level of knowledge

2.7.1 Technophobia

Technophobia can be described as people's feelings of aversion or anxiety towards technologies and technology-related products (Sinkovics et al., 2002). Technophobia could lead to avoidance of technology and will lead to a higher rejection of the products provided with a technology label provided in the empirical study.

2.7.2 Uncertainty avoidance

Uncertainty avoidance can be defined as: "the extent to which people feel threatened by ambiguous situations and create beliefs and institutions that try to avoid these" (Hofstede and Bond 1984, p. 418 in Erdem et al., 2006). When people are uncertainty avoidant it could moderate the effect of the dynamic indicator since people will still tend to rely on the expiration date since they do not want to take the risk of deciding themselves.

2.7.3 Knowledge level

Knowledge is indicated as having an influence on the behaviour towards technology (Ronteltap et al., 2007). In their review Siegrist and Colleagues (2007) quote a research, which found that a majority of the US respondents "is convinced that benefits outweigh the risks" (Siegrist et al., 2007: p.459; Cobb and Macoubrie, 2004), but also write that Europeans are less optimistic. This can be declared by the fact that Americans probably have more knowledge since products with nano-technology are already present in their supply (Pereira de Abreu, et al., 2012; Vandermoere et al., 2010). When having more knowledge about the technologies acceptance of products with a label containing technology therefore will probably be higher than for consumers having no or few knowledge about the technology.
Besides when having more knowledge about the expiration of a product a higher willingness to use dynamic indication could be possible, because they probably know the dynamics of expiration.

As the presented literature showed, it is important to investigate the effectiveness of dynamic indication since the current provided expiration dates are questionable in their accuracy, which leads to food wastage. Besides, it is interesting to study the acceptance and influence of dynamic indication (especially based on nano-technology) on food acceptance in an empirical research, since this could open possibilities of using nano-technology in combination with food.

3. Method

3.1 Demarcation

Some research demarcations are set. First of all perishable products is a broad concept, there are perishables with a long or short durability and perishables with static of dynamic quality courses. In this research one perishable product is chosen as stimulus: beefsteak (see paragraph 3.4).

Secondly, quality is a broad concept. In this research microbiological quality will be taken into account since this concept is important in the context of expiration. Furthermore, tasting and smelling will not be taken into account so that these variables are kept constant and the focus lays on the use of the expiration date. Consumers use the term freshness to refer to the microbiological-related quality. It therefore will be used as synonym for microbiological-related quality in this paper (Becker, 2000).

Third, evaluation of expiration differs at the moment of purchase and at the moment of consumption. This study will focus on the consumption since the purpose is to see what happens with food if the date is expired, and an additional label indicates that the product is still good to eat. The moment of purchase will be less important since food in the supermarket is normally not out dated.

Last but not least, the influence of graphical design of the dynamic label will not be taken into account. For example, the influence of the change of colour from green to red instead of white to black could influence perception. It will not be taken into account since it would be another dimension and therefore kept constant in this research.

3.2 Research population

178 Respondent participated in the experiment, not completed questionnaires (17) and vegetarians (11) are excluded. A total of 150 respondents, 76 respondents in the use-by condition and 74 in the best-before condition, are used in the analysis. The population consisted of 90 female and 60 male, ranging in age from 18 until 29 years (M=22, SD: 2.03). An overview can also be found in Table 1.

Table 1: *Population description*

	Gender		Total	Age	
	Male	Female	N	Mean	SD
Use-by	34	42	76	22	1.842
Best-before	26	48	74	22	2.221
Total N	60	90	150	22	2.031

3.3 Research design

For this research a 2 between (BB x UB) by 3 within (Static indication x Nano x RFID) design is used to test the different combinations of expiration dates and type of indication (see Table 2). A new technology is combined with an expiration date (UB or BB) since the expiration dates are legally prescribed and therefore need to stay on the product. Respondents in the first condition saw products with a best-before date and respondents in the second condition saw products with a use-by date. Within the conditions both groups first got a situation without technology, in which they only had the expiration dates as an indicator. This static indication condition is followed by showing the technology situations, RFID or nano-technology, successively in a random order.

Table 2: *Research design*

	Best-before date	**Use-by date**
Static indication	BB-date	UB-date
Indication based on a Nano-label	BB-date and Nano-label	UB-date and Nano-label
Indication based on a RFID-label	BB-date and RFID-label	UB-date and RFID-label

3.4 Stimulus material

3.4.1 Product category

In this research the product beefsteak represents highly perishable products. Beefsteak is chosen since research shows that safety is important (Becker, 2000) and consumers are careful with storing meat (Terpstra et al., 2005). An indicator would be useful (Fortin and colleagues, 2009).

3.4.2 Representation of the expiration indicators

The beefsteak will, depending on the condition, contain a BB or UB date in combination with a nano-based label or RFID-based label. In the static indication condition the beefsteak will only contain a BB or UB –date. Picture 1a shows an example of a beefsteak package used in the UBxNano-label condition. Picture 1b shows an example of a product with a best-before date in combination with a RFID-label. The characteristics of the packaging are changed, and thereby kept neutral, this to exclude influence of preference for a store or brand.

Picture 1a: *beefsteak in condition UB x NANO*

Picture 1b: *beefsteak in condition BB x RFID*

3.4.3 Operation of the dynamic indicators

How the label works is explained by showing picture 2 (Yanko Design, 2008) accompanied with the text: "Nano-labels are based on nano-technology. Nano-technology consists of very small (nano) particles. These particles can convert and translate information about the amount of micro-organisms as a colour change of a label on a product." and "When the label is white it indicates that the product is still fresh, a darker (grey) label indicates that the product must be eaten now and a non-visible barcode means do not eat".

Picture 2: *Nano-based freshness indictor (Yanko Design, 2008)*

For explaining the RFID label picture 3 is used, which is based on a design of Insignia Technologies (2013). The RFID-label was explained by the following text: "RFID can give an approximation of the expiration, it can monitor e.g. temperature changes in the environment. When a high temperature is detected expiration of the product goes faster, what will be taken into account. This change is indicated by means of colour change of the label." and "When the middle of the label is light blue it indicates that the product is still fresh, a darker blue label indicates that the product must be eaten now and a darkest blue indicator means do not eat."

Picture 3: *RFID-based freshness indictor (based on Insignia Technologies, 2013)*

3.4.4 Technology advantages and disadvantages

The information about the technologies was described as emotionally neutral as possible with similar advantages and disadvantages (tested in the pre-test, see appendix I and II). The advantage of nano-technology is described as: ”An advantage of nano-labels is that it can help you indicate the expiration of a product, since it can monitor the amount of micro-organisms in a product.” The advantage of RFID is described as: “ An advantage of the chip-based technology RFID is that it can give a approximation of the expiration, since it can monitor e.g. temperature changes in the environment.

The disadvantage of nano-technology is described as: “A disadvantage of nano-technology is that not much is known about the effects of the nano-particles on human health.”, in line with the description used in the article of Vandermoere et al. (2010). The disadvantage of RFID is described as: “A disadvantage of RFID is that not much is know about radiation emission, and its effects on human health.”, in line with thoughts people expressed in the research of Reicher and colleagues (2007)

3.5 Measures

3.5.1 Perceived product quality

The perceived product quality is measured using five seven-point items based on the scale of Sprott and Shimp (2004) (α=0.878). The end poles of the item regarding the safety are labelled as very unsafe and very safe. The end poles of the items concerning appearance, freshness, quality and overall quality of the beefsteak, are respectively labelled as looking very bad and looking very good, lacking freshness and very fresh, very poor and very good and poor and excellent.

3.5.2 Food acceptability

Food acceptability, for a product one day past the expiration date of 31-07-13, is measured asking the consumer three dichotomous items (no/yes) based on the scales of Peryam and

Pilgrim (1957), Fennis (2003), Fennis and Baker (2001) and Tavassoli and Lee (2003). Namely 'I would try the beefsteak', 'I would use the beefsteak in my meal tonight' and 'I would throw away the beefsteak' (α=0.784; Kuder-Richardson-20). I would throw away the beefsteak is recoded to the opposite for data analysis.

3.5.3 Food acceptability over time

Food acceptability over time is measured using a dichotomous scale (no/yes), namely 'Would you use the beefsteak when the use-by date is…' in combination with an expiration date which lies two, four or eight days before the imaginary date of 31-07-13. Also the food acceptability after 1 day, as in paragraph 3.5.2, will be taken into account.

3.5.4 Perceived risk

Perceived risk is measured using four, seven-point scales based on Cambell and Goodstein (2001), regarding concern, importance, worry and risk associated with the type of expiration label in the condition (α=0.617), for which the end poles are respectively labelled as highly concerned and not at all concerned, very unimportant and very important, very worried and not worried at all, and very risky and not risky at all. The item concerning importance has been removed to improve the Cronbach's alpha (α=0.749).

3.5.4 Empowerment

Empowerment is measured using four seven-point scale items (α=0.701), with end poles labelled totally disagree and totally agree. Empowerment is reflected by behavioural control and locus of control. Behavioural control is measured using a two, seven-point scale based on Nysveen, Pederson and Thorbjornsen (2005), regarding knowledge 'I can decide by myself whether the beefsteak is expired' and means available to decide upon expiration 'I have the necessary means and resources to evaluate the expiration of the beefsteak'.
Locus of control is measured using a two, seven-point scale based on Oliver (1997) and Wagner and colleagues (2009), regarding taking conclusions based on the expiration information 'I conclude expiration of the product based on my own judgement; totally agree/disagree' or own judgement 'I conclude expiration of the product based on my own judgement'. The item for basing conclusions on expiration information is reversed by analysing the data.

3.5.5. Uncertainty

Uncertainty is measured using one seven-point scale item based on Urbany and colleagues (1989), regarding being sure to be able to latterly make the decision based on the label (Not sure at all/totally sure).

3.5.6. Moderators

Finally, three moderators are measured. Knowledge level is measured using one, seven-point scale item originally used by Coulter and colleagues (2005) and Micu, Coulter, and Price (2009), regarding the amount of knowledge about expiration, with the end poles labelled as not very much and a lot). Uncertainty avoidance is measured using three seven-point scale items, with the end poles totally disagree and totally agree, of Erdem and colleagues (2006), regarding desire to be safe, certainty of being safe, avoiding risk and importance of safety (α=0.849). Technophobia is measured using three seven-point scale items, with the end poles labelled as totally disagree and totally agree, of the technology anxiety scale of Meuter and colleagues (2003), regarding feeling afraid using technology, willingness to try new things and avoidance of the unknown (α=0.754). In the data analysis the scale of the item 'I like to try new and different things' is recoded since a high score indicates no technophobia while the other two do the opposite.

An overview of the questions, and total questionnaire, can be found in appendix III.

3.6 Procedure

Respondents were mainly recruited at Wageningen University by handing out flyers and personally approaching people. Additional respondents were recruited via the personal (online) network of the researcher. The additional respondents filled in the online questionnaire, developed using the online survey platform Qualtrics, at any moment in time. Respondents were seated in a computer room while filling in the survey and received a sweet snack in return for participation. Respondents were randomly assigned to the BB or UB condition. The questionnaire took approximately ten minutes.

A brief explanation about the research and researcher was given at the beginning of the questionnaire, after which a question excluded vegetarian respondents and directed them to the end of the questionnaire.

The other respondents continued with the explanation of the experiment scenario. The scenario consisted of a situation in which they had to use the beefsteak in a meal they prepare for themselves that day. Information about the current date, 01-08-13, (which they have to

imagine) and the expiration date of 1 day before, 31-07-13, was given. It was explicitly told whether it concerned a best-before or a use-by date and what it meant, so that the respondent would noticed it. In the static indication condition (first situation in both questionnaires) no further information was provided.

In the following situations, where technology was used, a description of the technology was given followed by showing and describing how the indicator works. After the information, in each situation, food acceptability, perceived quality and perceived risk were measured. Furthermore also acceptability over time was measured per situation by giving new expiration dates of respectively 30-07-13, 28-07-13 and 24-07-13, for which they had to indicate whether or not they would use the product.

Finally, empowerment and the moderating characteristics were measured, and general questions, concerning age and gender, were asked. In appendix III questionnaire for the UB condition can be found.

Finally, the respondents were thanked and debriefed. In the debriefing respondents are told that the technology is not used in The Netherlands yet, but that it is a technological development.

4. Results

4.1 Data

The collected data is analysed by using the program "SPSS 19" in order to extract statistical conclusions. The data is first tested using a F-test to detect overall differences between the groups. Following, a Generalized Linear Mixed Model (GLMM) is conducted to compare the means of the experimental groups to see if there are significant differences and to get insight in the processes. A mixed model analysis is used since respondents answered questions for all three situations (expiration date only, combination with nano-technology and combination with RFID-technology). Besides, the influence of expiration is measured between two groups. Furthermore, a Regression Analysis is used to test the mediation effects.
Finally, by using a one-way-ANOVA and a Regression Analysis the effect of the moderators is tested. Groups for these moderators are created based on the median of the variable.

To prepare the data for analysis cases with missing values are deleted. One respondent was deleted because of an unlikely response pattern. No response tendencies and coding failures were found. Furthermore, assumptions of multivariate analyses and regression analyses are checked, which showed no remarkable findings except from food acceptability. Therefore, the variable food acceptability has to be treated with care.

4.2 Analysis of the hypotheses

In this paragraph the data analysis conducted to answer the hypotheses are described. The results will be explained per hypotheses.

4.2.1 Use-by or best-before date

Using a one-way-ANOVA revealed a significant effect of type of expiration date on perceived quality ($F(1, 445)= 4.707$, $\rho= .031$, $\omega = .09$), and amount of certainty to decide upon expiration ($F(1, 445)= 4.028$, $\rho= .045$, $\omega = .08$). With people perceiving a higher quality and being surer when it comes making decisions with regard to products with a best-before date (see Table 3).
No significant effects were found of the type of expiration on perceived risk ($F(1, 445) =0.088$ $\rho= .767$), food acceptability one day past the expiration date ($F(1, 445) = 1.294$, $\rho= .256$) and acceptability after 2 days ($F(1, 445) = 0.004$, $\rho= .948$), 4 days ($F(1, 445) = 0.006$, $\rho= .939$) and 8days ($F(1, 445) = 0.787$, $\rho= .375$) past the expiration date (see Table 3).

Table 3: *F-test effect of type of expiration date*

	UB	BB	Total	F	Sig
Perceived risk	4.84	4.87	4.85	0.88	.767
Perceived quality	5.45	5.62	5.53	4.707	.031*
Food acceptability	.918	.941	.929	1.294	.256
Certainty	5.07	5.32	5.20	4.028	.045*
2 days	.835	.837	.836	0.004	.948
4 days	.404	.400	.402	0.006	.939
8 days	.120	.148	.134	0.787	.375

* $\alpha < 0.05$

The GLMM revealed that while expiration dates do have an influence on the perceived quality, this influence is outweighed by the introduction of dynamic indication. The regression analysis confirms this effect by showing a significant effect of expiration date on perceived quality when a static indicator is used ($t(1, 147)=.2143$, $\rho =.034$) and no effect when a nano-label ($t(1, 147)=.710$, $\rho =.479$) or RFID-label is used ($t(1, 147)=.975$, $\rho =.331$). The hypothesis, that a use-by date (as a loss frame) compared to a best-before date (as a gain frame), will decrease perceived quality and therefore lower food acceptability, can partly be accepted. The type of expiration date indeed leads to a difference in perceived quality. What can be stated is that a loss frame leads to significant lower perceived quality, compared to using a gain frame (see Table 3). The effect of expiration dates, mediated by perceived quality, on food acceptation is not proven.

Table 4: *Regression analysis testing the influence of the type of expiration date on the perceived quality*

Predictor	Dependent	Effect	t	Sig	R^2	F	Sig.
Expiration date	Perceived quality						
Static indicator		.342	.2143	.034*	0.03	4.59	.034*
Nano-label		.085	.710	.479	.003	.505	.479
RFID-label		.107	.975	.331	.006	.951	.331

* $\alpha < .05$

4.2.2 Dynamic versus static indication

Using a one-way-ANOVA revealed a significant effect of type of expiration indicator (Static indicator', 'Nano-label' and 'RFID-label') on perceived quality ($F(2, 444)= 38.213$, $\rho < .001$, $\omega = .38$), food acceptance ($F(2, 444)= 9.237$, $\rho < .001$, $\omega = .19$), and food acceptability after two days ($F(2, 444) = 16.812$, $\rho < .001$, $\omega = .26$), four days ($F(2, 444)= 26.946$, $\rho < .001$, $\omega = .32$) and eight days ($F(2, 444)= 7.532$, $\rho = .001$, $\omega = .17$) past the expiration date. With a higher perceived quality and a higher acceptance when using the dynamic indicators, both

RFID and Nano. A 90%-significance of indicator type is found on perceived risk (F(2, 444)= 2.837, ρ = .060, ω = .09). With a higher perceived risk for a Nano-label.

No significant effect was found of type of indicator on being sure (F(2, 444) =1.826 ρ= .162) (see Table 5 for the means).

Table 5: *F-test effect of type of indication*

	Static indicator	Nano-label	RFID-label	Total	F	Sig
Perceived risk	4.68[a]	5.00[b]	4.88[ab]	4.85	2.837	.060+
Perceived quality	5.07[a]	5.74[b]	5.80[b]	5.53	38.21	.000***
Food acceptability	.870[a]	.953[b]	.966[b]	.929	9.237	.000***
Certainty	5.03[a]	5.27[a]	5.30[a]	5.20	1.826	.162
2 days	.698[a]	.906[b]	.906[b]	.836	16.81	.000***
4 days	.174[a]	.516[b]	.516[b]	.402	26.94	.000***
8 days	.047[a]	.181[b]	.174[b]	.134	7.532	.001***

+ α <0.10 ** α <0.01 *** α <0.001

A Bonferroni Post-Hoc test revealed a significant difference between a static and dynamic indicator, e.g. for perceived quality (ρ < .001). Between the dynamic indicators (Nano and RFID) no differences are found (e.g. perceived risk ρ= 1.00). Also no difference between the static indication and RFID-indication for perceived risk is found (ρ= .406). It shows that the nano-label is perceived as significantly higher than the static indicator, and that perceived risk of the RFID-indicator lies between them.

The GLMM, using Greenhouse-Geisser (since Sphericity cannot be assumed), confirms a significant influence of type of expiration indicator on perceived quality (F(1.448, 212.88)=108.16, ρ <.001, ω = .424) and food acceptance (F(1.448, 212.88)= 13.267, ρ <001, ω = .083). However this conclusion must be taken carefully since the Greenhouse-Geisser estimate was not perfect. Using contrast it can be concluded that perceived quality is significantly higher in the Nano (F(1,147)= 105.245, ρ <.001, ω = .417) and RFID (F(1,147)=147.020, ρ <.001, ω = .500) situation compared to the expiration-date only situation. The same accounts for food acceptability ((F(1,147)= 11.657, ρ =.001, ω = .073; (F(1,147)=17.149, ρ <.001, ω = .104) (See Table 6). Besides a pairwise comparison shows no difference between the dynamic indicators nano and RFID for perceived quality and food acceptance (respectively ρ =. 347; ρ = .549).

Table 6: *GLMM contrast effects expiration indicator*

		F	Sig	Effect size
Perceived quality	Nano vs. Exp.-only	105.245	.000***	0.417
	RFID vs. Exp.-only	147.020	.000***	0.500
Food acceptability	Nano vs. Exp.-only	11.657	.001**	0.073
	RFID vs. Exp.-only	17.149	.000***	0.104

** α <0.01 *** α <0.001

The effect is more visible in the plots given in figure 3a and 3b.

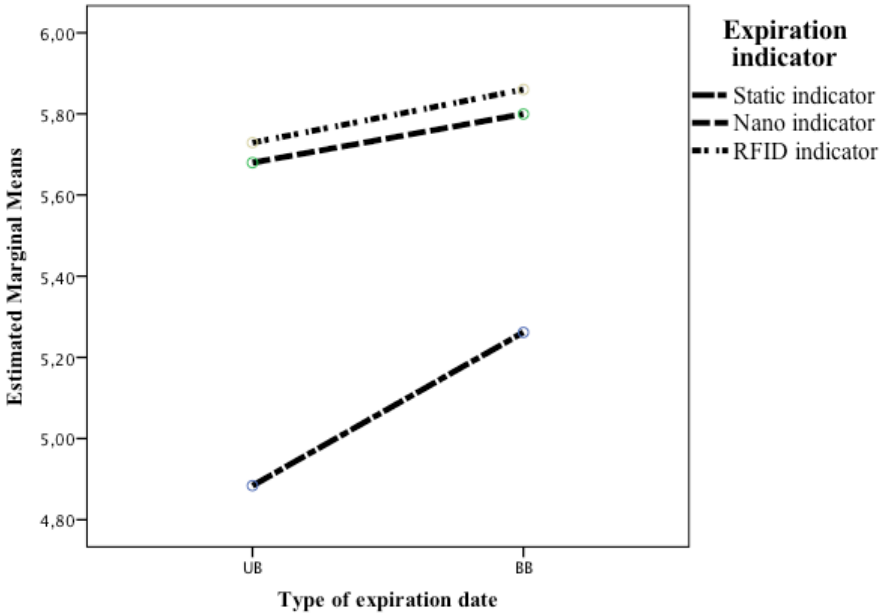

Figure 3a: *Estimated Marginal Means of perceived quality*

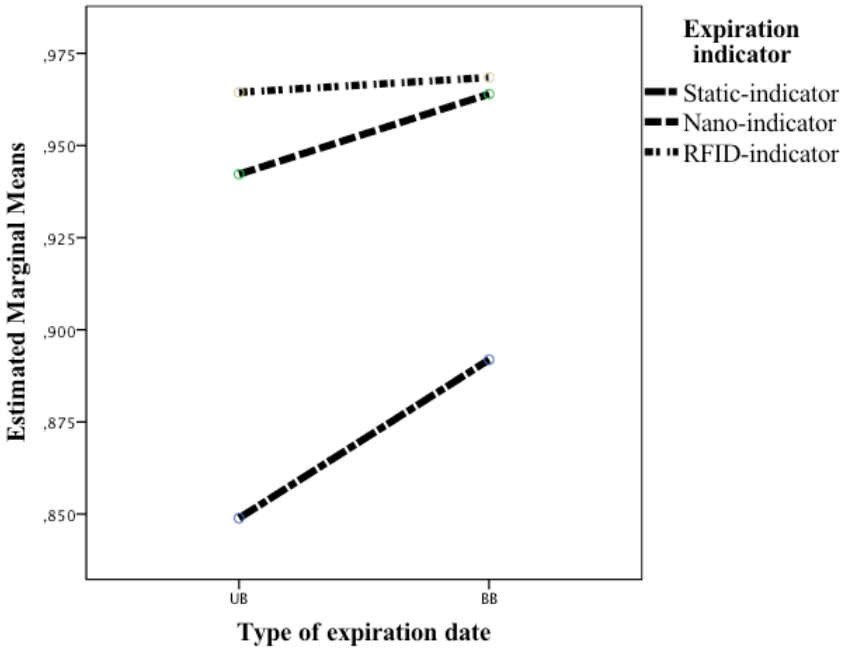

Figure 3b: *Estimated Marginal Means of food acceptability*

To examine how perceived quality acts as a mediator for predicting food acceptability a regression analysis is the next step. The regression analysis showed that there is full mediation of perceived quality on food acceptance, (see Table 7). The indirect effect size, calculated by the Sobel product of Coefficients Approach (B_2*B), is 0.04234.

Table 7: *Regression analysis testing the influence of expiration indicator and perceived quality on food acceptability*

Predictor	Dependent	Effect	t	Sig	R^2	F	Sig.
Expiration indicator	Food acceptability	.048	3.96	.00***	0.034	15.68	.00***
Expiration indicator	Perceived quality	.365	7.730	.00***	0.118	59.75	.00***
Perceived quality	Food acceptability	.118	11.54	.00***	0.231	133.31	.00***
Expiration indicator * Perceived quality	Food Acceptability	.006	.494	.621	.231	66.66	.00***
		.116	10.66	.00***			

*** α <0.001

Concluding, it can be said that hypothesis 2 can be accepted: dynamic indicators, as opposed to static, indeed increase perceived quality and thereby increases food acceptability.

4.2.3 Food acceptability over time

In hypothesis 3 the expectation was raised that a higher amount of days (period) past expiration will decrease perceived product quality and lower food acceptability, but that decline will occur gradually in the case of dynamic indicators while sudden by using static indicators. First of all a one-way-ANOVA reveals that the amount of days past expiration significantly effects acceptability (ρ <.001) (See Table 8).

Table 8: *F-test acceptability over time*

	Two days M=.836		**Four days M=.402**		**Eight days M=.134**	
	t	Sig	t	Sig	t	Sig
One day	5.723	.00***	22.391	.00***	43.365	.00***
Two days			18.493	.00***	32.449	.00***
Four days					12.793	.00***

*** α <0.001

Another one-way-ANOVA reveals a significant change in means among the days for static and dynamic indication. E.g. the post-hoc test showed a significant difference is found between the 'difference' between 1 and 2 days for static versus dynamic ($F(2, 444)=6.079$, $\rho =.002$, $\omega = .15$). The acceptance of food drops by 0.17 while the acceptance of the food in the nano situation drops (0.047) (see Table 9). Between the nano and RFID indication no difference is found.

Table 9: *F-test decline course of acceptability over time*

Acceptance	Static	Nano	RFID	F	Sig	Effect size
1 days - 2 days	-0.172[a]	-0.047[b]	-0.060[b]	6.079	.002**	0.15
2 days - 4 days	-0.523[a]	-0.389[b]	-0.389[b]	3.678	.026*	0.11
4 days - 8 days	-0.127[a]	-0.335[b]	-0.342[b]	11.835	.00***	0.22
1 days - 8 days	-0.823[a]	-0.771[b]	-0.791[b]	0.665	.515	0.04

* α <0.05 ** α <0.01 *** α <0.001

There is a higher drop in acceptance for nano compared to static in the 4 days compared to the 8 days situation. By looking at the means (see Table 10), it can be said that this is caused by an already low acceptance of food 4 days past the expiration in the expiration date only situation, while this acceptance is mediate in the dynamic indication situation. Therefore, acceptance can still drop dramatically in the dynamic indication situation. This also underlines the hypothesis, in which is said that the acceptance of food in the nano condition would decline more gradually, while acceptance using static indication will drop highly directly after expiration.

Table 10: *Average food acceptance over time*

Acceptance	1 day	2 days	4 days	8 days
Static	.870	.698	.174	.047
Nano	.953	.906	.516	.181
RFID	.966	.906	.516	.174

The conclusion is also supported by the graphical representation in Figure 4, where it can be seen that the lines of the dynamic indicators are more linear, while the static indicator rises quickly to rejection between 2 and 4 days. Using Figure 4 could also give an indication of the difference in acceptance over time. There could be said that food provided with a dynamic indicator is accepted two days longer than food provided with a static indicator, when the product is indicated as still good by the dynamic indicator.

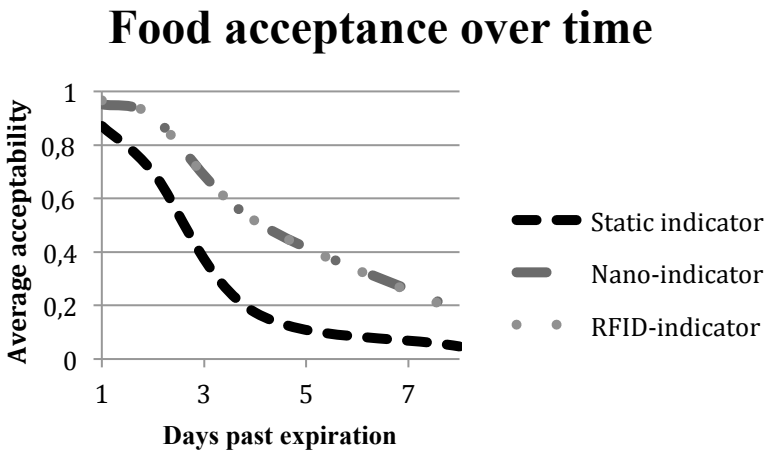

Figure 4: *Average food acceptance over time*

4.2.4 Acceptance of food containing a Nano-indicator

The fourth hypothesis was: "Products containing a dynamic indicator based on nano will enjoy lower acceptance than products containing a dynamic indicator based on RFID, since perceived risk is higher by using nano-technology". Information used in paragraph 4.2.2 already showed that using a dynamic indicator based on nano-technology does not lead to a significant higher perceived risk compared to RFID based labels (ρ= 1.00), but it does compared to static indication (ρ= 0.057) (See figure 5). The GLMM shows no effect of the type of expiration indicator multiplied by perceived risk on food acceptability (F(2, 290)=0.863, ρ =.423 ω = .006), same as the regression analysis (F(1, 446)=2.226, ρ =.136).

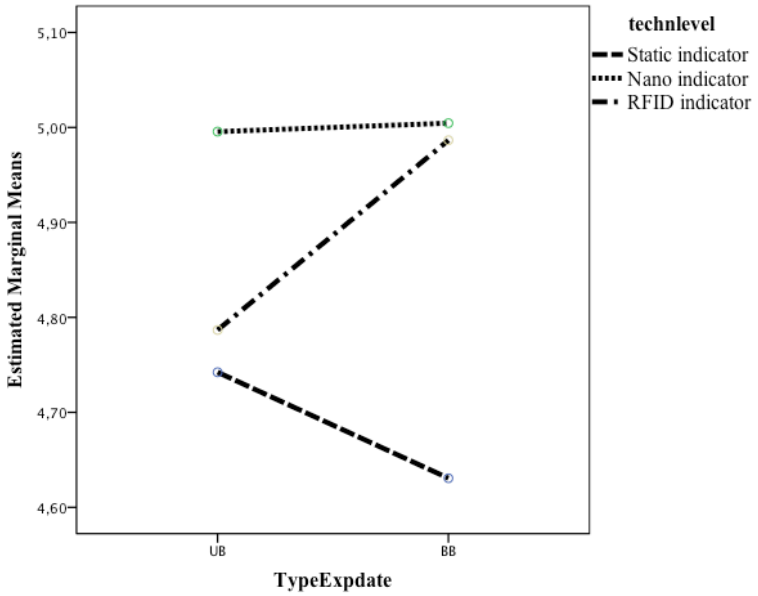

Figure 5: *Perceived risk per expiration indicator*

Concluding, it cannot be said that products provided with a RFID-indicator enjoy higher acceptance compared to products provided with a Nano-indicator. Though, results showed that risk is perceived significantly higher while using a nano-indicator compared to using a static indicator.

4.2.5 Empowerment or uncertainty by using dynamic indicators

The last hypothesis (H_5: Dynamic indicators will influence empowerment and therefore raise food acceptability, although consumers can face uncertainty) will be answered step by step. First of all, the extent to which respondents were sure they could make the decision about expiration themselves differs while using static or dynamic indication, is investigated. Information in Table 5 in paragraph 4.2.2 already showed a lower mean for certainty in the static indication compared to dynamic indication situation. A Post-Hoc test however reveals that this difference is not significant ($F(2, 444)=1.826$, $\rho =.162$). On the other hand, the regression analysis shows a significant influence of indicator type on food acceptability, partial mediated by certainty (see Table 11a). The indirect effect size, calculated by the Sobel product of Coefficients Approach (B2*B), is 0.00187.

Secondly, the influence of empowerment is looked at, which is analysed by threating it as a moderator, since it is measured as an overall characteristic in the questionnaire. The results show a significant ($t(3, 443)=2.767$, $\rho =.006$) positive moderating effect of empowerment ($\sigma =.037$), which means that the higher the empowerment among respondents, the more important a dynamic, as opposite to a static indicator, is for determine acceptance (see Table 11b). So, for people with a higher empowerment using a dynamic indicator is more important than for people with a lower empowerment.

Finally, the overall hypothesis is investigated. The regression analysis showed that the type of expiration indicator, moderated by empowerment, significantly ($t(3, 443)= 2.653$, $\rho =.008$) influenced the food acceptability. Certainty about the expiration does not have a significant effect ($t(3, 443)= 1.248$, $\rho =.213$) (see Table 11c).
Concluding, it can be said that the type of expiration indicator positively influences certainty significantly on a 90%-significance level, which influences food acceptability. Besides, the higher the empowerment, the more important a dynamic indicator, as opposite to a static indicator, is for determine acceptance. We therefore can conclude that dynamic indication will influence acceptance of the food due to empowerment, because of the higher importance but also because of the rising certainty due to the use of a dynamic indicator.

Table 11a: *Regression analysis testing the influence of type of expiration indicator on food acceptability, mediated by certainty*

Predictor	Dependent	Effect	t	Sig	R^2	F	Sig.
Expiration indicator	Food acceptability	.048	3.96	.00***	0.034	15.68	.00***
Expiration indicator	Certainty	.134	1.735	.083+	0.007	3.012	.083+
Certainty	Food acceptability	.016	2.196	.029+	0.011	4.824	.029+
Expiration indicator * Certainty	Food Acceptability	.046	.3.802	.00***	0.042	9.713	.00***
		.014	1.910	.057+			

+ α <0.1 * α<0.05 ** α <0.01 *** α <0.001

Table 11b: *Regression analysis testing the effect of the type expiration indicator on food acceptability, moderated by empowerment*

Predictor	Dependent	Effect	t	Sig	R^2	F	Sig.
Empowerment	Food acceptability	-.029	-2.699	.007**	0.066	10.361	.00***
Expiration indicator		-.048	-4.018	.00***			
Expiration indicator * Empowerment		.037	2.767	.006**			

** α <0.01 *** α <0.001

Table 11c: *Regression analysis testing the effect of the type expiration indicator on food acceptability, moderated by empowerment and mediated by certainty*

Predictor	Dependent	Effect	t	Sig	R^2	F	Sig.
Expiration indicator *Empowerment	Food acceptability	.035	2.653	.008**	.069	8.170	.00***
Expiration indicator		.047	3.902	.00***			
Empowerment		.027	2.436	.015*			
Certainty		.009	1.248	.213			

* α<0.05 ** α <0.01 *** α <0.001

4.2.6 Testing the moderating effects

Knowledge level

A one-way-ANOVA reveals a significant difference in food acceptance using a static or dynamic indicator for consumers without knowledge about the expiration of meat (F(2, 138)= 8,927, ρ <.001). The food acceptance while using a static or dynamic indicator does differ on a 90% significance level for people with knowledge about the expiration (F(2, 303)= 2.390, ρ =.093). The Bonferroni Post Hoc test shows that the food acceptance significantly differs in the situation of static indication compared to a situation in which a nano-label or an RFID-label is used. With acceptance being higher in the case of a dynamic indicator compared to a static indicator.

Another one-way-ANOVA reveals a significant difference in food acceptability in the static indicator situation for people with, compared to people without, knowledge (F(1,147)= 3.631, ρ =.059). In which people without knowledge having a lower acceptance level (M=0.891) compared to people with knowledge (M=0.902).

Table 12: *F-test food acceptance split by knowledge level of expiration*

Knowledge	Technology	M	SD
No	Expiration date	0.891[a]	0.36
N=47	Nano-label	0.957[b]	0.13
	RFID-label	0.985[b]	0.06
	Total	0.914	0.24
Yes	Expiration date	0.902[a]	0.26
N=102	Nano-label	0.951[b]	0.15
	RFID-label	0.957[b]	0.16
	Total	0.936	0.19

Looking at the moderating effect of knowledge, by using a regression analysis, shows a significant moderating effect of knowledge level on food acceptability (t (3, 443)=.2.188, ρ = .029) (see Table 13).

Table 13: *Regression analysis of moderating effect of knowledge*

Predictor	Dependent	Effect	t	Sig	R^2	F	Sig.
Knowledge	Food acceptability	.008	.972	.332	0.046	7.182	.00***
Expiration indicator		0.048	3.979	.00***			
Expiration indicator * Knowledge		-.022	-2.188	.029*			

+ α <0.1 * α<0.05 *** α <0.001

Concluded, it can be said that the level of knowledge about the expiration of meat does have a moderating effect on the food acceptance of food provided with a static or dynamic indicator. Besides having knowledge about the expiration of meat leads to a higher acceptance of the food while using a static indicator. So when people without knowledge have the opportunity to use an additional dynamic indicator, this will rise their acceptability since they will rely on that indicator.

Uncertainty avoidance

A one-way-ANOVA reveals no difference in food acceptability in the case of a dynamic indicator compared to a static indicator for people who do not avoid uncertainty (F(2,198)= .470, ρ = .625). On the other hand, for people who avoid uncertainty the food

acceptability does differ when using a dynamic indicator compared to a static indicator (F(2, 243)=11.00, ρ <0.001). The Bonferroni Post Hoc test reveals that when using a static indication the food acceptability is significantly lower, compared to the situation in which a nano-label or RFID label is used (see Table 14).

Table 14: *F-test food acceptance split by uncertainty avoidance*

Uncertainty avoider	Technology	M	SD
No	Expiration date	0.975[a]	0.08
N=67	Nano-label	0.965[a]	0.10
	RFID-label	0.980[a]	0.07
	Total	0.906	0.09
Yes	Expiration date	0.784[a]	0.37
N=82	Nano-label	0.943[b]	0.17
	RFID-label	0.955[b]	0.17
	Total	0.894	0.27

Looking at the moderating effect of uncertainty avoidance on the food acceptance by using a regression analysis shows a positive mediation effect of 0.049 of technophobia, which means that the higher the technology level (so dynamic indication as opposite to static indication), the more important the uncertainty avoidance is for determine acceptance (t(3,443)= 22.967, ρ <.001) (see Table 15).

Table 15: *Regression analysis, moderating effect of uncertainty avoidance*

Predictor	Dependent	Effect	t	Sig	R^2	F	Sig.
Uncertainty avoidance	Food acceptability	-.045	-5.374	.00***	0.135	22.967	.00***
Expiration indicator		.048	4.174	.00***			
Expiration indicator * uncertainty avoidance		.049	4.753	.00***			

*** α <0.001

Concluded, it can be said that uncertainty avoidance significantly influences food acceptability as a moderator of the type of expiration indicator. With people avoiding uncertainty having a lower food acceptance in the case of a static indicator, but having a same acceptance in the case of a dynamic indicator. So, it can be said that a dynamic indicator indeed leads to less uncertainty, in line with the result that certainty rises as found in paragraph 4.2.5.

Technophobia

A one-way-ANOVA reveals a significant difference of food acceptance in the case of a dynamic indicator compared to a static indicator for non-technophobe respondents ($F(2, 207)= 8.785$, $\rho<.001$). The food acceptance of technophobe respondents does significantly differ on a 90% level between the type of indication used ($F(2, 234)= 2.767$, $\rho=.065$). The Bonferroni Post Hoc test shows food acceptance significantly differs among static indication and dynamic indication. With food acceptance being higher in the situation of a dynamic indicator compared to when static indication is used (see Table 16).

Table 16: *F-test food acceptance split by technophobia*

Technophobe	Technology	M	SD
No	Expiration date	0.881[a]	0.28
N=70	Nano-label	0.985[b]	0.06
	RFID-label	0.990[b]	0.05
	Total	0.952	0.18
Yes	Expiration date	0.860[a]	0.31
N=79	Nano-label	0.924[b]	0.18
	RFID-label	0.945[b]	0.18
	Total	0.910	0.23

Looking at the moderating effect of technophobia on the food acceptance by using a regression analysis shows that technophobia has no effect on food acceptability of food provided with a static or dynamic indicator ($t(3, 443)=1.1217$, $\rho =.224$) (see Table 17).

Table 17: *Regression analysis, moderating effect of technophobia*

Predictor	Dependent	Effect	t	Sig	R^2	F	Sig.
Technophobia	Food acceptability	-.002	-.161	.872	0.037	5.725	.00***
Expiration indicator		-048	3.958	.00***			
Expiration indicator * Technophobia		-.015	-1.217	.224			

+ α <0.1 * α<0.05 *** α <0.001

Concluding, technophobia does not have a moderating effect on the food acceptability of food provided with a static or dynamic indicator.

Summarizing, a use-by or best-before date influences the perceived product quality. Using a dynamic indication compared to a static indicator raises perceived product quality and food acceptability, and reduces food waste. Food acceptability decreases suddenly in the case of a static indicator, while gradually in the case of a dynamic indicator. Using a dynamic indicator raises empowerment and certainty, and therefore food acceptability. But it also raises

perceived risk, however not so far that it influences food acceptability. Finally, knowledge about the expiration of meat and technophobia do not have a moderating influence on the effects. Uncertainty avoidance does have a moderating influence.

5. Conclusion and discussion

The aim of this research was to explore how consumers evaluate expiration of perishable products, how this affects their product acceptance, and to what extent real-time indication would influence this acceptance, and thereby reduce food wastage. Literature showed that consumers strongly rely on extrinsic cues, such as expiration indicators, to evaluate the expiration of perishable products. Results concerning research question one, "How does the evaluation of microbiological-related quality, by using expiration dates, influence the product acceptance of perishable products?", show that the food acceptance is influenced by using a best-before or a use-by date. Products with a use-by date have a significantly lower perceived quality compared to products with a best-before date. Results concerning research question two, "What influence do dynamic indicators have on the acceptance of perishable products?", show that dynamic indication leads to a higher perceived quality and increased food acceptability compared to static indication. It can be stated that using dynamic indication would lead to a decrease in food wastage. Besides, by using dynamic indication the empowerment increases and uncertainty declines, what positively influences the food acceptance. A slight increase in perceived risk, in the case of using nano-technology, did not influence the food acceptance.

5.1 Use-by or best-before date

The use-by and best-before date have a different influence on the perceived quality of a product. Using a use-by date (loss frame) leads to a lower perceived quality in comparison to using a best-before date (gain frame). This influence of expiration dates was outweighed when dynamic indicators were introduced. That no influence was found on the food acceptability can be explained, since the perceived quality for 1 day passed the expiration did lead to rejection of the food. This is also in line with the statements made in the article of Park (2012) that loss frames are more likely to be effective when a highly risky situation or behaviour is paramount.

5.2 Dynamic versus static indication

It can be concluded that using a dynamic indicator leads to a higher perceived quality and thereby increases food acceptance but also increases perceived risk in the case of a nano-indicator compared to static indication. Since the risk for nano-technology is indicated as not risky, although respondents perceived a slightly higher risk, it probably did not have an influence on the food acceptance. In addition, in the process of acceptance perceived risk can be mitigated by benefits provided by nano-labels and are important to take into account (Ronteltap et al., 2007; Marette et al., 2009). Different research indicated that benefits in

relation to nano-labels are indeed paramount, which moves risk perception to the background (Siegrist et al., 2007: p.459; Cobb and Macoubrie, 2004; Fortin and colleagues, 2009). It would be interesting to study whether the benefits of the nano-label have a mitigating effect on the perceived risk of nano-technology. This would be interesting as the knowledge could be used when introducing and marketing the nano-label.
As a final result, food combined with a dynamic indicator is on average accepted 2 days longer than food combined with a static indicator.

5.3 Acceptance of food containing a Nano-indicator

It can be concluded that consumers are not reluctant towards food containing a nano-indicator, when it comes to perceived risk. As said in the previous paragraph, the results show that the consumer doses not perceive a high risk when using a nano-indicator, although the perceived risk is slightly higher compared to static indication. This is in line with the expectations based on the literature that nano-technology would probably be accepted when it is used as nano-label since it is not ingested (Marette et al., 2009; Siegrist et al., 2008; Stampfli, et al., 2010). Although it is verified that nano-technology is still less accepted than RFID, as Gupta and colleagues (2012) stated, using nano-technology in the dynamic indicator is advised. It is advised since nano-technology, perceived as just slightly riskier, can provide a direct indication of the freshness while RFID only can provide an indirect indication.

5.4 Empowerment or uncertainty by using dynamic indicators

Using dynamic indication leads to more certainty in deciding upon the expiration, which influences the food acceptability positively. Furthermore, empowerment is raised. It therefore can be concluded that dynamic indication will influence acceptance of the food due to empowerment, because of the higher importance but also because of the rising certainty due to the use of a dynamic indicator.

5.5 Methodological limitations and further research

First of all, there was a need to recruit several respondents over the Internet. As respondents could be distracted or influenced by other factors it could be discussed whether or not the results are representative. Though, this was just a small part of the respondents.

Secondly, a mixed design was used in which the influence of technology is measured within subjects. The effect of the measures for static indication could have influenced the following measures, which were randomly the nano indicator or RFID indicator. It therefore would be

interesting to test the influence of the expiration indicators between subjects. Furthermore, the influence of seeing both Nano- and RFID-based labels could be dismissed in this way. A higher difference in acceptance between the indicators is expected; because consumers will not relate their answers using a dynamic indicator to the answers they would give using a static indication. Also a higher difference in acceptance and perceived risk between nano and RFID is expected since they cannot be compared. Further research would be interesting since an even higher difference between the indicators, as expected, could give more ground for implementation.

Thirdly, while measuring the food acceptance over time the changing appearance and other sensorial aspects of the beefsteak could be taken into account. Taking this change into account will enable to standardize the results, since personal interpretations are slightly corrected. This can be important since visual factors are indicated as important while accessing meat (Becker, 2000; Acebron and Dopico, 2000). For the results this will mean that a difference can be measured between people relying on the expiration date and people relying on the sensorial aspects. In which it is expected that people using their senses would accept the product longer than people who rely on the expiration date.

Fourthly, this study was mainly consisting of students, who probably would use the beefsteak longer since they are less afraid of sickness and because they do not want to spoil a, on average, more expensive kind of meat. Research of Anderson and colleagues (2011) indeed showed that young adults are less aware of risks and taking more risk when it comes to eating potential hazardous food. Besides, monetary costs and inability to substitute the product are indicated as reasons to eat spoiled food (Sen and Block, 2009). It is expected that when older consumers would be studied less acceptance of food would be found compared to the results found in this study, because older adults are probably more relying on what they already used (the expiration dates). Besides they probably do not take any risk and go for the date on the indicator, which indicated the expiration date first. Finally, results showed that technophobia only had an influence on a small group of respondents, what is likely since young consumers are less technophobic because they mostly grew up with using technologies (Hogan, 2009). When studying older adults it is likely that more influence and a higher influence of technophobia will be found, influencing the acceptance such that it will be lower compared to the results found in this study. It would be interesting to take another target group into account in further research, and compare the results of this target group with the results of the students, since knowledge about the reaction of other groups out of society would be important when implementing the proposed nano-labels.

Fifthly, as was been said the food acceptability was measured on a dichotomous scale and therefore had to be threaten with care. Nevertheless, conclusion were based on this scale since the scale had a high Kuder-Richardson reliability and conclusions were in line with conclusion based on the perceived quality. Nonetheless, another scale is recommended for further research, because having a interval scale could improve the results. Recommended is for example a scale on which the end poles are labelled as I would not use the product and I would use you product, with trying as point in the middle.

A final point for discussion is the use of mainly Wageningen University students. Students of Wageningen are more concerned with food and the environment compared to students of other universities. Since Wageningen University is specialized in the field of food and sustainability it attracts people who also take this into account. It therefore could be possible that acceptation of food provided with a nano-label would be more accepted among students of other universities, since they could be more directed towards the convenience of such a label. Though, it could also be possible that is more accepted by Wageningen students, because they see the need to reduce the food waste. It is important to investigate this difference between students since Wageningen students probably do not reflect the society, but just a part of it.

5.6 Theoretical contributions and suggestions for further research

Some theoretical contributions can be discussed which lead to suggestions for further research. First of all, the focus was a highly perishable product, represented by using beefsteak in the experiment. In further research it could be highly interesting to study the difference in influence of the dynamic indicator between static deteriorating and dynamic deterioration products. Especially focussing on different product categories within the dynamic deterioration products would be interesting. Fruit for example matures before pathological microbes grow, after which it deteriorates quickly, while the quality of blue cheese increases thanks to growth of benign microbes. Figure 6 illustrates the quality courses of the different product examples. Further research could focus on the effect of indication, which will first indicate a growing quality of the product (e.g. fruit first matures). It could be examined in which product categories the consumer perceives a dynamic indicator as useful. Expected is that in static, as opposed to dynamic, product categories are less needed since the deteriorating could be predicted more easily. However, it would probably not be the case that a dynamic indicator on these products is perceived as useless, as the deteriorating process also differs in the static product categories due to handling in the supply chain.

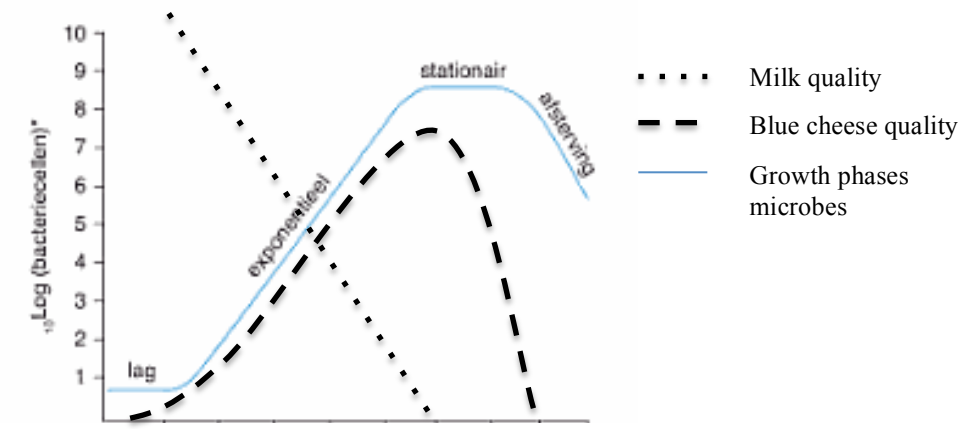

Figure 6: *Relationship quality and microbiological*

Second, an interesting point would be studying what happens when respondents see that the expiration date is not expired but the dynamic indicator indicates that the product is spoiled. Would the respondent rely on the indicator or on the expiration date? The expectation is that is this case the consumer would not use or even try the product, whereas they would have tried it when they only had an expiration date to rely on. This expectation is based on the literature about stigma's being formed when consumers have the idea that the product is not good anymore or taste at all (Kerley and colleagues, 2008). Taking into account on which label consumers rely would be important because when results show that consumers rely on the nano-label it gives more reason for implementation.

A third recommendation is taking purchase into account, since it is found that evaluation differs at the point of purchase and point of consumption. Consumers tend to choose the product with the longest expiration date, even when the consumer's intention to consume it before the shortest expiration date is expired anyway (Tsiros and Heilman, 2005; Soethoudt et al., 2012). Furthermore, research shows a rising likelihood (and therefore willingness) to eat food past its expiration date when the consumer owns the product, since consumers estimate the likelihood of getting sick lower when they own a product (Sen and Block, 2009). Besides, risk is taken when people face potential costs (spoiling the food) (Bartels et al., 2010). It is expected that also products in the supermarkets will be accepted longer when an indication is given, since it will extend the shelf-life of the product.

A fourth recommendation concerns the technology acceptance model (TAM) originally developed by Davis (1989). In this TAM ease of use and usefulness are indicated as important factors for the consumer in the evaluation and determination to use the new technology/product (Vijayasarathy, 2004). In this thesis mainly acceptance of food provided

with a technology-label is taken into account, whereby the acceptance of the technology is not looked at. Though in further research it would be highly interesting to see how the consumer rate the ease of use and usefulness of a dynamic indicator, or specifically a nano-label. It is important to take this into account since it could predict the acceptance of the label in itself. The expectation is that consumers when the consumer think the dynamic label is useful it would influence their evaluation, because they will use it for determine the freshness and durability of the product. Besides, when the ease of use is perceived high it would increase the amount of empowerment since consumers can easily assess the expiration by themselves based on this new indicator.

A final recommendation would be taking trust into account, since this is an important concept in accepting food-based technologies (Ronteltap et al., 2007; Siegrist et al., 2007). The level of trust the consumer has in the source that provides the nano-label could influence the acceptance level of the food. Expected is that results would differ when respondents heard the label was produced by the producer themselves instead of by the government. In our research the label is placed in comparison with the expiration dates, which are provided by the government, therefore the level of trust could have been higher. Besides, the level of social trust a person has could moderate the acceptance. Persons having a low social trust have a lower acceptance of the food in the case of labels provided by the government compared to e.g. labels provided by an independent organisation (Ronteltap et al., 2007).

After gathering all this knowledge, it can be stated that using a nano-label, to provide a dynamic insight into the deterioration process of perishable products, is a great innovation to provide customers with necessary information to reduce food waste, in a time in which sustainability must become the status quo.

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Appendix I Pre-test technology descriptions

Nano-technology

Nano-technology consists of little nano particles, which can detect the amount of micro-organisms in a product. An advantage of Nano-labels is that it can monitor the product freshness by means of colour change of the label. When the label is white it indicates that the product is still fresh, a darker (grey) label indicates that the product must be eaten now and a non-visible barcode means do not eat (as shown in the picture below). So, the nano-label can indicate that the product is still edible although the use-by date is expired. A disadvantage of nano-technology is that not much is known about the effects of the nano-particles on human health.

1. To what extent is this description plausible on a scale from 1 – 10, 10 standing for very plausible? Please indicate why.
2. To what extent is this description complicated on a scale from 1 – 10, 10 standing for very complicated? Please indicate why.

Results

Most respondents for the pre-test indicated the descriptions as believable, however half of them found it difficult to understand. Reasons they gave the most were: 'You do not explain the step to nano-labels' and 'It is not clear where the label will be on the product'. Based on these reactions the description is changed to the description in the final questionnaire (Appendix III).

RFID

RFID is a chip-based technology, which can detect for example temperature changes in the environment, what influence product freshness. An advantage of RFID is that it can give you approximation of product freshness based on these changes by means of colour change of the label. When the label is light blue it indicates that the product is still fresh, a darker blue label indicates that the product must be eaten now and a dark blue indicator means do not eat (as shown below). So, the RFID-label can indicate that the product is still edible although the use-by date is expired. A disadvantage of RFID is that not much is known about the effects of exposure to radiation on human health.

1. To what extent is this description plausible on a scale from 1 – 10, 10 standing for very plausible? Please indicate why.

2. To what extent is this description complicated on a scale from 1 – 10, 10 standing for very complicated? Please indicate why.

Results

Most respondents indicated the description for RFID as believable. However, most of them found it difficult to understand. The reasons they gave were: 'You do know explain the influence on temperature that well, so I do not understand the link', The terms used are a bit difficult' and 'The step between temperature differences and freshness is to quick'. Also the description of RFID is changed based on the reactions (See Appendix III).

Appendix II Pre-test similarity technology descriptions

Applying nano-technology to labels (nano-labels) is a new technology to indicate expiration. An advantage of nano-labels is that it can help you indicate the expiration of a product, since it can monitor the amount of micro-organisms in a product. Nano-labels are based on nano-technology. Nano-technology consists of very small (nano) particles. These particles can convert and translate information about the amount of micro-organisms as a colour change of a label on a product. When the label is white it indicates that the product is still fresh, a darker (grey) label indicates that the product must be eaten now and a non-visible barcode means do not eat (as shown in the picture below). So, the nano-label can indicate that the product is still edible although the use-by date is expired.
A disadvantage of nano-technology is that not much is known about the effects of the nano-particles on human health.

To what extent do you think nano-technology is beneficial?

Not beneficial -3 -2 -1 0 1 2 3 *Highly beneficial*

To what extent do you think nano-technology is disadvantageous?

Not disadvantageous -3 -2 -1 0 1 2 3 *Highly disadvantageous*

To what extent do you think nano-technology is risky?

Not risky -3 -2 -1 0 1 2 3 *Highly risky*

To what extent do you think nano-technology could be helpful?

Not helpful -3 -2 -1 0 1 2 3 *Highly helpful*

Applying Radio Frequency Identification chips to labels (RFID-labels) is a new technology to indicate expiration.
An advantage of the chip-based technology RFID is that it can give an approximation of the expiration, since it can monitor e.g. temperature changes in the environment. When a high temperature is detected expiration of the product goes faster, what will be taken into account. This change is indicated by means of colour change of the label. When the label is light blue

it indicates that the product is still fresh, a darker blue label indicates that the product must be eaten now and a dark blue indicator means do not eat (as shown below). So, the RFID-label can indicate that the product is still edible although the use-by date is expired.
A disadvantage of RFID is that not much is known about radiation emission, and its effects on human health.

To what extent do you think nano-technology is beneficial?

Not beneficial -3 -2 -1 0 1 2 3 Highly beneficial

To what extent do you think nano-technology is disadvantageous?

Not disadvantageous -3 -2 -1 0 1 2 3 Highly disadvantageous

To what extent do you think nano-technology is risky?

Not risky -3 -2 -1 0 1 2 3 Highly risky

To what extent do you think nano-technology could be helpful?

Not helpful -3 -2 -1 0 1 2 3 Highly helpful

To what extent do you think the advantages are similar?

Not similar at all -3 -2 -1 0 1 2 3 Totally similar

To what extent do you think the disadvantages are similar?

Not similar at all -3 -2 -1 0 1 2 3 Totally similar

To what extent do you think the risks are similar?

Not similar at all -3 -2 -1 0 1 2 3 Totally similar

Besides testing the descriptions for nano and RFID also the whole questionnaire is pre-tested, to be sure that it was clear for respondents to fill in. Also as a result of this pre-test only some changes were made, therefore the final questionnaire is given in the next appendix.

Result pre-test II

Most respondents indicated the nano-technology and RFID as beneficial, helpful and having no disadvantages. Besides, the disadvantages and risks of both the technologies were indicated on a same level, namely as not being risky. Overall the respondents indicated that they found the descriptions were similar in (dis)advantages and risks. Based on this pre-test no changes were made.

Appendix III Questionnaire

Questionnaire version 1

Thank you for participating in my research. For my master thesis for the Wageningen University and Technische Universität München I am looking at expiration labels on meat packages. Some questions will be asked about the existing labels and labels based on new technologies. The study will take about 10 minutes. Participation in this study is anonymous. You can stop your participation at any moment in time. For questions about the study you can contact eleonore.schut@wur.nl.

By clicking "yes" you acknowledge that you have read the above and will participate in the survey.

0 Yes

For this study meat is chosen as product, it is therefore important that you eat meat so you can evaluate the expiration. Do you eat meat ? Yes/No --> (thank you)

On the following page you will get a situation followed by some questions. These questions are on a scale from -3 to 3, by which -3 is always the negative end and 3 the positive end. When you select 0 it means you are neutral about the statement. There are no right or wrong answers, select the answer that fits you best.

Imagine it is 1st of August 2013, and you have to use the beefsteak on the picture below in a meal you are making for yourself tonight. You see that the unopened beefsteak you found in your refrigerator has an expired use-by date of 1 day. The use-by date shows the date by which the product should be used. This date can help you indicate the quality of the beefsteak.

1. This beefsteak is:

Very unsafe to eat	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Very safe to eat*
Looking very bad	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Looking very good*
Lacking freshness	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Very fresh*

2. This beefsteak has a:

Very poor quality -3 -2 -1 0 1 2 3 *Very good quality*

3. Overall, this beefsteak is:

Poor -3 -2 -1 0 1 2 3 *Excellent*

1. I would try the beefsteak: yes/no
2. I would use the beefsteak in my meal tonight: yes/no
3. I would throw away the beefsteak: yes/no

4. Would you use the beefsteak if the use-by date was 30-07-13 (2 days ago) yes/no
5. Would you use the beefsteak if the use-by date was 28-07-13 (4 days ago) yes/no
6. Would you use the beefsteak if the use-by date was 24-07-13 (8 days ago) yes/no

Please indicate the answer that fits you best.

7. An use-by label as information source of the expiration date makes me feel:

Highly concerned -3 -2 -1 0 1 2 3 *Not concerned at all*

8. The type of information provision about the expiration date is:

Very unimportant -3 -2 -1 0 1 2 3 *Very important*

9. Using a product with a use-by label regarding the expiration date makes me

Very worried -3 -2 -1 0 1 2 3 *Not worried at all*

10. I think a use-by label as the type of information provision is:

Very risky -3 -2 -1 0 1 2 3 *Not risky at all*

11. To what extent do you feel informed to decide upon the expiration?

Not enough -3 -2 -1 0 1 2 3 *Totally enough*

12. To what extent are you sure you can make the decision yourself about expiration, based on the use-by label.

Not sure at all -3 -2 -1 0 1 2 3 *Totally sure*

New technologies

New technologies for indicating the expiration date of products are available. We will introduce two of these technologies, accompanied with some questions. There are no right or wrong answers.

Nano-technology

Applying nano-technology to labels (nano-labels) is a new technology to indicate expiration.

To what extent do you feel informed about nano-technology at this moment?

No knowledge -3 -2 -1 0 1 2 3 A lot of knowledge

An advantage of nano-labels is that it can help you indicate the expiration of a product, since it can monitor the amount of micro-organisms in a product. Nano-labels are based on nano-technology. Nano-technology consists of very small (nano) particles. These particles can convert and translate information about the amount of micro-organisms as a colour change of a label on a product.
A disadvantage of nano-technology is that not much is known about the effects of the nano-particles on human health.

When the label is white it indicates that the product is still fresh, a darker (grey) label indicates that the product must be eaten now and a non-visible barcode means do not eat (as shown in the picture below). The nano-label can indicate that the product is still edible although the use-by date is expired.

The same situation occurs as before but now you can use the use-by label in combination with the nano-label: Imagine it is 1st of August 2013, and you have to use the beefsteak on the picture below in a meal you are making for yourself tonight. In the picture below you see that

the unopened beefsteak you found in your refrigerator has an expired use-by date of 1 day, but the white indicator shows that the product is still fresh.

Please indicate the answer that fits you best.

1. This beefsteak is:

Very unsafe to eat	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Very safe to eat*
Looking very bad	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Looking very good*
Lacking freshness	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Very fresh*

2. This beefsteak has:

Very poor quality	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Very good quality*

3. Overall, this beefsteak is:

Poor	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Excellent*

1. I would try the beefsteak: yes/no
2. I would use the beefsteak in my meal tonight: yes/no
3. I would directly throw the beefsteak away: yes/no

4. Would you use the beefsteak if the use-by date was 30-07-13 (2 days ago) and the indicator indicates the product is still good to use yes/no
5. Would you use the beefsteak if the use-by date was 28-07-13 (4 days ago) and the indicator indicates the product is still good to use yes/no
6. Would you use the beefsteak if the use-by date was 24-07-13 (8 days ago) and the indicator indicates the product is still good to use yes/no

7. A nano-label as information provision of the expiration date makes me feel:

Highly concerned -3 -2 -1 0 1 2 3 Not concerned et all

8. The type of information provision about the expiration date is:

Very unimportant -3 -2 -1 0 1 2 3 Very important

9. Using a product with a nano-label regarding the expiration date makes me

Very worried -3 -2 -1 0 1 2 3 Not worried at all

10. I think a nano-label as type of information provision is:

Very risky -3 -2 -1 0 1 2 3 Not risky at all

11. To what extent do you feel informed to decide upon the expiration?

Not enough -3 -2 -1 0 1 2 3 Totally enough

12. To what extent are you sure you can make the decision yourself about expiration, based on the nano-label.

Not sure at all -3 -2 -1 0 1 2 3 Totally sure

RFID

Applying RFID to labels (RFID-labels) is a new technology to indicate expiration.

13. To what extent do you feel informed about RFID at this moment?

No knowledge -3 -2 -1 0 1 2 3 A lot of knowledge

An advantage of the chip-based technology RFID is that it can give an approximation of the expiration, since it can monitor e.g. temperature changes in the environment. When a high

temperature is detected expiration of the product goes faster, what will be taken into account. This change is indicated by means of colour change of the label.
A disadvantage of RFID is that not much is known about radiation emission, and its effects on human health.

When the middle of the label is light blue it indicates that the product is still fresh, a darker blue label indicates that the product must be eaten now and a darkest blue indicator means do not eat (as shown in the picture).
The RFID-label can indicate that the product is still edible although the use-by date is expired.

The same situation occurs but this time you can use the use-by label in combination with the RFID-tag: Imagine it is 1st of August 2013, and you have to use the beefsteak on the picture below in a meal you are making for yourself tonight. In the picture below you see that the unopened beefsteak you found in your refrigerator has an expired use-by date of 1 day, but the light blue indication shows that the product is still fresh.

1. This beefsteak is:

Very unsafe to eat	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*very safe to eat*
Looking very bad	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Looking very good*
Lacking freshness	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Very fresh*

2. This beefsteak has:

Very poor quality	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*very good quality*

3. Overall, this beefsteak is:

Poor	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*excellent*

1. I would try the beefsteak: yes/no
2. I would use the beefsteak in my meal tonight: yes/no
3. I would directly throw the beefsteak away: yes/no

4. Would you use the beefsteak if the use-by date was 30-07-13 (2 days ago) and the indicator indicates the product is still good to use yes/no
5. Would you use the beefsteak if the use-by date was 28-07-13 (4 days ago) and the indicator indicates the product is still good to use yes/no
6. Would you use the beefsteak if the use-by date was 24-07-13 (8 days ago) and the indicator indicates the product is still good to use yes/no

7. A RFID-label as information provision about the expiration date makes me feel:

Highly concerned -3 -2 -1 0 1 2 3 Not at all concerned

8. The type of information source of the expiration date is:

Very unimportant -3 -2 -1 0 1 2 3 Very important

9. Using a product with a RFID-label regarding the expiration date makes me

Very worried -3 -2 -1 0 1 2 3 Not worried at all

10. I think a RFID-label as the type of provision is:

Very risky -3 -2 -1 0 1 2 3 Not risky at all

11. To what extent do you feel informed to decide upon the expiration?

Not enough -3 -2 -1 0 1 2 3 Totally enough

12. To what extent are you sure you can make the decision yourself about expiration, based on the RFID-label

Not sure at all -3 -2 -1 0 1 2 3 Totally sure

General statements and demographic questions

Some general statements will follow. Also here a -3 to 3 scale is used and there are no right or wrong answers.

General statements:

1. In general, I have the knowledge to decide whether the beefsteak is expired

Totally disagree -3 -2 -1 0 1 2 3 Totally agree

2. I have the necessary means and resources to evaluate the expiration of the beefsteak

Totally disagree -3 -2 -1 0 1 2 3 Totally agree

3. I base conclusions, about the expiration of the product, on the expiration information:

Totally disagree -3 -2 -1 0 1 2 3 Totally agree

4. I draw conclusions, about the expiration of the product, based on my own judgement

Totally disagree -3 -2 -1 0 1 2 3 Totally agree

5. I would rather be safe than sorry when it comes to expiration.

Totally disagree -3 -2 -1 0 1 2 3 Totally agree

6. I want to be sure about the safety before I eat something.

Totally disagree -3 -2 -1 0 1 2 3 Totally agree

7. I avoid risky things

Totally disagree -3 -2 -1 0 1 2 3 Totally agree

8. Being sure is an important concern in my life

Totally disagree -3 -2 -1 0 1 2 3 Totally agree

9. I feel apprehensive (afraid) about using technology.

Totally disagree -3 -2 -1 0 1 2 3 Totally agree

10. I like to try new and different things.

Totally disagree -3 -2 -1 0 1 2 3 Totally agree

11. I have avoided technology because it is unfamiliar to me

Totally disagree -3 -2 -1 0 1 2 3 Totally agree

12. How much do you know about expiration (information) of products?

Not very much -3 -2 -1 0 1 2 3 A lot

Final some demographic questions:

1. *Age:*
2. *Gender: Male/Female*

3. *Student: Yes/No*
4. *Study:*

This is the end of the survey. We like to let you know that both technology-based labels are not available on the Dutch market yet, but that they are technological developments. Thank you very much for participating in my research.

Frequently surveys are taken by the Marketing and Consumer behaviour group of Wageningen University. If there are more surveys for which we need participants, is it ok to contact you occasionally (1 time per month) by e-mail?

If yes, please write down your e-mail address
If no, do not forget to submit the questionnaire

Appendix IV Scale reliability

	Cronbach's Alpha	T-test	Mean	Standard Deviation	Measure
Perceived product quality	0.878		5.541	0.865	Seven-point scale
Food acceptability Expired one day	0.784		1.069	0.212	Dichotomous
Empowerment:	0.701		4.596	0.901	Seven-point scale
Perceived risk	0.617/0.749		5.023	0.913	Seven-point scale
Uncertainty avoidance	0.849		4.716	1.121	Seven-point scale
Technophobia	0.754		2.486	1.003	Seven-point scale

Appendix V Affidavit

Last Name: Schut
First Name: Eleonore
Date of Birth: 18-09-1989

I declare under penalty of perjury that I have produced this work independently, without unauthorized assistance of third parties and without the use of any other than the specified resources. Data and concepts, acquired directly or indirectly from other sources are identified by indicating the references. This also applies to figures, graphs, illustrations and the like, as well as, to Internet sources and unpublished sources.

The work has not been submitted previously either in this country or in another country in the same or in a similar version to any other examining body, and was not previously part of a course requirement or any other examination.

_____ _____

(Place, Date) (Signature)