Understanding and attitude regarding the shelf life labels and dates on pre-packed food products by Belgian consumers

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ABSTRACT

Based on an on-line survey using questionnaires, information on Belgian consumers (n = 907) regarding their understanding and attitude towards shelf life labels and dates was collected. 80.1% of the respondents were familiar with the terminology of the label use by and best before while 69.6% indicated to know the difference between the meaning of the two labels. Judging edibility of food products at home occurs mainly by a combination of checking visually and smelling (82.5%), followed by looking at the shelf life date (67.5%) or tasting (50.4%). About half of the consumers is aware of and appreciates the difference between the two labels during this judgment. Most of the consumers interpret shelf life labels and dates with some flexibility, with variation depending upon the type of food product under consideration. Overall, the share of consumers willing to eat expired refrigerated products was lower than for expired products stored at ambient temperature: 19.1% for refrigerated raw products (e.g. meat and fish); 34.7% for refrigerated ready-to-eat products (e.g. deli-meat, cheese products, smoked fish); 61.0% for canned products (e.g. conserves) and drinks (e.g. beer) and lastly 69.3% for other products generally stored at ambient temperature (e.g. bread, unopened UHT milk, chocolate, cereals). Differences linked to age and gender are discussed. The suboptimal understanding and application of the EU date label framework by consumers may lead on the one hand to increased food disease burden by consuming certain expired use by products allowing growth of pathogens. On the other hand discarding food at the shelf life data in case of a best before date contributes to food waste by consumers. A better understanding of the shelf life labels use by (referring to food safety) and best before dates (referring to food quality) by consumers should be promoted.

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1. Introduction

Labeling of food products can facilitate the transfer of information from producer to consumer (Bernues, Olaizola, & Corcoran, 2003; Grunert, Wills, & Fernandez-Celemin, 2010). In particular for pre-packed food products that have been subject to a number of mild or more intense processing steps, judgment about food quality, safety and nutrition without label information may be difficult. For food products sold in EU, these labels contain information such as ingredients, quantity, nutritional value, origin, treatment (e.g. irradiation), allergens, packaging (e.g. Modified Atmosphere Packaging (MAP)) and recommendations on storage conditions and shelf life (EC, 2000).

The shelf life of a food is the period before the product becomes unacceptable for consumption from sensorial, nutritional or safety perspectives (Labuza & Fu, 1993). The EU compulsory label system as defined by Directive 2000/13 (EC, 2000) applies two types of shelf life dates on pre-packed food products: the use by date linked to predominantly food safety aspects and the best before linked to sensorial and nutritional quality aspects. Both dates are considered by governments as a major means to provide consumers a point of reference regarding guarantees on the quality and the safety of food products (DEFRA, 2011). Besides these two shelf life labels, no indications on shelf life date is required for a restricted number of pre-packed food products such as fruits, vegetables or wine. The legal specifications with regard to shelf life data and labeling are summarized in Table 1. In 2011, the European Parliament and the Council agreed on Regulation (EC) 1169/2011 on food information for consumers but this regulation (to be in force from 13 December 2014) maintains the above mentioned existing rules on shelf life labels.

One of the main pillars of the EU general food law (EC, 2002) is that the primary responsibility for food safety lies with the...
Table 1

<table>
<thead>
<tr>
<th>Shelf life label</th>
<th>Specifications</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best before</td>
<td>The date of minimum durability (best before) of a foodstuff shall be the date</td>
<td>Assignment of the type of label and shelf life length to be</td>
</tr>
<tr>
<td></td>
<td>until which the foodstuff retains its specific properties when properly stored</td>
<td>decided by the food manufacturer</td>
</tr>
<tr>
<td>Use by</td>
<td>In the case of foods which, from the microbiological point of view, are highly</td>
<td>Assignment of the type of label and shelf life length to be</td>
</tr>
<tr>
<td></td>
<td>perishable and are therefore likely after a short period to constitute an</td>
<td>decided by the food manufacturer</td>
</tr>
<tr>
<td></td>
<td>immediate danger to human health, the date of minimum durability shall be</td>
<td></td>
</tr>
<tr>
<td></td>
<td>replaced by the use by date</td>
<td></td>
</tr>
<tr>
<td>No label required</td>
<td>For a limited list of products, no shelf life label is required</td>
<td>List of products defined in legislation, e.g. fresh fruit and</td>
</tr>
</tbody>
</table>

manufacturer. Therefore, as there is no definitive list of which type of foods should have a use by or a best before date, it is the legal responsibility of the manufacturer to determine the shelf life period and which type of shelf life label is appropriate for his food product (EC, 2002). Food manufacturing companies implement labeling and can use many tools to assess the shelf life period of their specific products. These techniques can be durability studies on specific spoilage organisms (SSO’s), durability studies and/or challenge tests on microbial pathogens (e.g. Beaufort (2011) and Uyttendaele et al. (2005) for Listeria monocytogenes in ready-to-eat foods or Rajkovic, Uyttendaele, Courtois, Heyndricks, and Debevere (2006) for Bacillus cereus in potato puree), predictive modeling on pathogens (e.g. Devlieghere et al. (2001) for L. monocytogenes in cooked ham, Vermeulen et al., 2007 for L. monocytogenes in mayonnaise-based salads), predictive modeling on SSO’s (e.g. Fu, Taoukis, & Labuza, 1991 for Pseudomonas fragi in milk, Kreyschmidt et al. (2010) for lactic acid bacteria in cooked ham, Vermeulen, Daelma, Van Steenkiste, and Devlieghere (2012) for Zygosaccharomyces rouxii in sweet intermediate moisture products such as chocolate fillings), measurement of chemical parameters (e.g. Escobedo-Avellaneda, Velaquez, Torres, and Welti-Chanes (2012) for moisture measurement of vegetables), consulting literature information and smelling or tasting by trained persons in sensory panels (Murray, Delahunt, & Baxter, 2001). Often a combination of these approaches is used (e.g. Noseda et al. (2012) for Pangasius fish, Matargas, Dimitriou, Skandamis, and Drosinos (2011) for yoghurt and Pexara, Ambrosiadi, Georgakis, Genigeorgis, and Batzios (2007) for gyros). The decision by the food company on the type of shelf life label (use by/best before) and also the approach/techniques to determine the shelf life period to meet the need of obtaining a safe and market acceptable product is complex and will depend on the food processing applied by the manufacturer (e.g. heat treatment) and the intrinsic (e.g. pH, αw) and extrinsic properties of the food (e.g. temperature, packaging such as MAP).

For consumers, it is also important to understand these two types of shelf life labels, both from a food safety point of view and minimization food waste. Eating food products after the use by date implicates consuming food without food safety guarantee while discarding food products after a limited period after their best before date often is a waste of food that is still acceptable for consumption (Monier, 2010; OVAM, 2012).

In particular the latter aspect on the relation between the shelf life date and food waste receives recently a lot of attention as one of the causes of unacceptable food waste in developed countries (Gustavsson, Cederberg, Sonesson, van Otterdijk, & Meyebeck, 2011, pp. 1–29; Lundqvist, De Fraiture, & Molden, 2008; Monier, 2010). Furthermore during recent discussions on sustainability in the European Parliament the shelf life date was identified as a key issue (EP, 2012). The debate takes as one of the basic elements a study by Monier (2010) that estimated food losses in EU (from processing to household, losses during agriculture not included) at 89 million tons or 179 kg/capita. The study proposed five policy options among one was related to the clarification and standardization of current EU mandated food date label application. This requires dissemination of the information to the public, the food industry and enforcement agencies to increase awareness of food edibility criteria, thereby reducing food waste due to date label confusion or perceived inedibility (Monier, 2010).

In the current article, the results of a survey of Belgian (Dutch speaking) consumers on the understanding and application of shelf life labels and dates on a range of food products are presented. The objectives of this study were i) to assess the share of consumers that are familiar with the EU shelf life labeling system for pre-packed food products and understand it; ii) to determine the relative importance of ways of how consumers judge edibility of food products and iii) to assess the expressed willingness of consumers to eat expired food products. The results give insights in the relation between shelf life dates on pre-packed food products and consumption by consumers. Implications for food safety and food waste are discussed.

2. Materials and methods

2.1. Research population

In order to obtain a view on the attitude and understanding of Belgian consumers of the system of shelf life dates best before and use by, a survey was conducted between February 2012 and April 2012. A questionnaire was developed and posted on several websites: the author’s institution website (www.foodscience.Ugent.be; www.cdo.ugent.be), an information source media (www.bodytalk.be), the Belgian consumer organization Test-Aankoop (www.Test-aankoop.be) and an information website for senior persons (www.seniorennet.be). Besides this, invitations to complete the questionnaire were sent to Master students of Ghent University, and further passed to their respective research and social network.

2.2. The questionnaire and statistical analyses of the data

The survey (in Dutch) contained closed end questions with answering categories based on preliminary literature review and in-house expertise of the Food Safety and Quality Department. The specified food product categories (related to eating after shelf life) were based upon Uyttendaele, Jacxsens, De Loy-Hendrickx, Devlieghere, and Debevere (2010), pp. 1–123. Covariable information of the respondents was collected on gender and age. Three sets of questions were asked, with each set linked to one of the objectives of this study. Related to the understanding of shelf life labels three questions were asked: i) ‘Do you know the labels use by and best before’ (answering categories: (a) yes, both, (b) only use by, (c) only best before, (d) neither of the two), ii) ‘Do you know the difference between the shelf life labels use by and best before’ (answering categories: (a) yes, (b) no), iii) ‘Do you take this difference into account when judging
edibility? (answering categories: (a) yes, (b) no). Related to the objective on weighing the ways consumers judge edibility of food products, the following question was asked: ‘When you don’t know the shelf life date of a product or when the product is already opened, how do you judge whether the product is still fit for consumption?’ Six answering categories (listed in Table 3) and an option to add other categories were provided. The third objective related to the willingness of consumers to eat expired food products. The following question was asked: ‘Imagine, you are at home and you have different food products stored. Which products would you still consume knowing that the shelf life date has passed? With other words which products do you not throw away knowing that the shelf life date has passed (one to multiple days after the shelf life date)?’ The list of food products is presented in Table 4.

2.3. Statistical analyses of the data

The obtained data set was statistically analysed using SPSS 19 for Windows and Stata/MP 12.1 (StataCorp, 2009). Logistic regression analysis was used to evaluate the strength of the association with the covariables age and gender. A polytomous nominal regression was performed for the question ‘Do you know the labels use by and best before?’; where different answers were possible. For the merged groups of food categories (refrigerated raw products, refrigerated ready-to-eat products, drinks & canned products and other products stored at ambient temperature), Chi square analyses were used to evaluate the strength with the covariable age and gender. A p-value <0.05 was retained as significant.

3. Results

3.1. Research population

In total, 908 respondents participated to the survey. One respondent’s questionnaire was rejected because of missing answers, leaving 907 questionnaires for analysis. 896 respondents shared information on their age and 899 on gender. The average age is 42.4 years with the youngest and oldest respondents aged 18 and 92 years. The group of the young adults (18–30 years), the middle age group (31–65 years) and older people (65+) represented respectively 32.2%, 59.5% and 8.6% of the respondents. For comparison, the Belgian population in the age group 18–99 years contained on January 2012 8.6 million persons and was demographically distributed among the young adults, the middle age group and older persons as 19.2%, 60.3% and 20.7%, respectively (FOD Economie, 2013). The share of women (59.4%) who participated to the survey was about 20% higher than the share of the men (40.6%). The overrepresentation of women in voluntary food related surveys is a phenomenon that is often observed (Grunert et al., 2010; Sampers et al., 2012).

3.2. Understanding by consumers of the shelf life labels use by and best before on pre-packed food products

Table 2 shows that the majority (80.1%) of respondents indicated to be familiar with both the shelf life label concepts use by and best before while about 10% declared to have heard of one of both and the other 10% did not know any of these labels. The level of significance was set at p < 0.05. The older people (65+) were

<table>
<thead>
<tr>
<th>Table 2</th>
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<tr>
<td>Understanding (%) of the shelf life labels by Belgian consumers.</td>
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<table>
<thead>
<tr>
<th>All (n = 907)</th>
<th>Age (years)</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18–30 (n = 286)</td>
<td>31–65 (n = 533)</td>
</tr>
<tr>
<td>Do you know the labels use by and best before?</td>
<td>80.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>75.5&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>only use by</td>
<td>1.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.3&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>only best before</td>
<td>8.6</td>
<td>11.2&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>neither of the two</td>
<td>10.3</td>
<td>12.9&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup>, <sup>b</sup> Entries within the same row and co-variable (age or gender) having the same letter are not significantly different (p < 0.05); a>b > b>c > c.
3.3. Assessment of the edibility of food products

At the point where consumers decide whether to eat or discard a food product, several factors will interplay in their judgment. From a list with pre-defined categories, the respondents were asked how they judge at home the edibility of a food product, multiple answers were allowed. The results are presented in Table 3. Inspecting the food product visually combined with smelling (82.5%) was the most cited approach to judge the edibility. Also checking the shelf life date of a food product (67.5%), followed by tasting (50.4%) were important approaches. These approaches can occur in a combined way to judge the edibility of food products and as one of the respondents commented in the survey, "will depend on the type of food product, for example meat will not be judged in the same way as a cookie". The reliance on own judgment by looking, smelling and tasting food products was significantly dependent on the age with the younger the age, the higher the reliance on these senses. For the above mentioned three categories (appearance & smelling, shelf life date and tasting), significant differences were only observed between men and women regarding the judgment of edibility via checking of the shelf life date, being more common for women than for men (71.9% versus 60.8%).

Many respondents (38.4%) freeze food products and consider this technique as a good guarantee for preserving quality and freshness of the food products and thus not taking the shelf life date into account anymore. This practice was significantly more selected by the older persons compared to the young adults (75.6%). Among the older respondents, no significant differences were observed with respect to gender.

Table 4 presents the expressed willingness of consumers to eat expired food products at home.

| Table 4 | Willingness of consumers [%] to eat expired food products at home. |
|---|---|---|---|
| | Shelf life group* | All (n = 907) | Age (years) | Gender |
| | | 18–30 (n = 286) | 31-65 (n = 533) | >65 (n = 77) | Women (n = 534) | Men (n = 365) |
| Refrigerated raw products (groups a-b) | | | | | |
| a. Fish intended to cook (e.g. salmon, caub) | 1 or 2 | 19.1 | 18.7* | 18.7* | 23.4* | 15.2b | 24.8* |
| b. Meat intended to cook (e.g. chicken, beef) | 1 or 2 | 14.2 | 15.4* | 13.1* | 18.2* | 11.4b | 18.4* |
| Refrigerated ready-to-eat products (groups c-j) | | | | | |
| c. Mayonnaise based deli-salads (e.g. thuna salads, egg salads) | 1, 2 or 3 | 17.4 | 20.6* | 16.6ab | 10.4b | 15.2b | 20.5* |
| d. Deli-meat (e.g. cooked ham, sliced chicken meat) | 1, 2 or 3 | 24.7 | 23.4* | 25.7* | 23.4* | 20.4b | 31.2* |
| e. RTE meals (e.g. lasagna) | 1 or 2 | 24.7 | 28.7* | 23.8ab | 15.6* | 22.3b | 28.2* |
| f. Fruit juices (cooled) | 3 | 28.7 | 27.3* | 30.5* | 20.8* | 25.3b | 33.4* |
| g. Pre-cut vegetables and fruits | 1 or 2 | 29.1 | 31.8* | 28.5* | 23.4* | 27.7* | 30.7* |
| h. Smoked fish (e.g. salmon, halibut) | 1 or 2 | 35.0 | 24.8b | 38.8* | 45.5* | 31.1b | 40.8* |
| i. Cheese products destined for bread | 1, 2 or 3 | 56.6 | 54.5* | 57.1* | 61.0* | 56.4* | 56.2* |
| j. Yogurt and other dairy desserts | 2 or 3 | 61.1 | 57.3* | 65.2* | 46.8* | 65.9* | 54.0* |

*shelf life categories: 1 – use by products for which food safety parameters restrict the shelf life date, 2 – use by products for which quality parameters restrict the shelf life date, 3 – best before products. Italics: the shelf life categories 1, 2 or 3 (first column) were put in italic to make it easier for the reader to see immediately the differences with the first column. Bold: the four rows in bold represent each date and tasting, significantly more selected by the young adults (75.5%). From those who knew only one date label, the best before label was best known by the young adults and middle aged persons while the use by was best known among the older respondents. No significant differences were observed with respect to gender.

Significantly more familiar with both shelf life labels (85.7%) compared to the young adults (75.5%). From those who knew only one date label, the best before label was best known by the young adults and middle aged persons while the use by was best known among the older respondents. No significant differences were observed with respect to gender.

Related to the understanding of the labels, 69.6% of the respondents declared to know the difference between the labels use by and best before. This degree of understanding was not significantly different between men and women but depended on the age with the young adults knowing less the difference (56.6%) compared to the middle aged persons (75.6%) and older persons (79.2%) but with no significant difference between the middle aged groups and older persons. In practice, about half of the consumers (49.3%) took the difference between the two types of labels into account when judging edibility of foods. This attitude is also dependent of the age: the share of consumers taking this difference into account was more than two-fold larger among the older persons compared to the young adults (Table 2).
already bought and stored in their house. Most of the consumers interpret shelf life dates in a flexible way in function of the type of food product. Overall, the share of consumers willing to eat expired refrigerated products lies lower than for expired products stored at ambient temperature: 19.1% for refrigerated raw products (fish and meat), 34.7% for refrigerated ready-to-eat products (e.g. deli-meat, cheese products, smoked fish), 61.0% for canned products (e.g. conserves) and drinks (e.g. beer) and lastly 69.3% for other products generally stored at ambient temperature (e.g. cookies, chocolate, unopened milk).

With respect to the co-variable age, among the eighteen food categories tested, for ten food product categories (fish intended to cook, meat intended to cook, deli-meat, fruit juices, pre-cut vegetables and fruits, cheese products, beer, conserves, chocolate and dry cereals), no significant differences were observed between the age groups. For eight food product categories there was at least one significant difference in willingness to consume expired food products between two age groups. For three of these eight categories, a significant proportion of young adults were more prepared to consume expired food products relative to the other two age groups. This was the case for the product categories soda drinks, bread and cookies. For mayonnaise-based deli-salads and ready-to-eat meats there was a significant difference between the young adults (being prepared to consume more after the shelf life date) and the older group but not with the middle age group. The preparedness to not respecting the shelf life date of smoked fish was highest for the older and middle age people and significantly different from the young adults. Consuming expired UHT milk and dairy products is significantly highest among the middle aged group compared with the two other groups. Overall, for all eighteen product categories, the older aged persons are significantly less prepared to consume expired products (43.2%) compared to the young adults and the middle aged group (47.7%, 47.1% respectively).

With respect to the co-variable gender, for eight food product categories (pre-cut vegetables and fruits, cheese products, UHT milk, soda drinks, bread, cookies, chocolate and cereals & rice) out of eighteen there were no significant differences. Among the refrigerated products, eight categories showed significant differences with for seven (fish and meat intended to be cooked, mayonnaise-based deli-salads, deli-meat products, ready-to-eat meals, cooled fruit juices and smoked fish) the men significantly more willing to consume expired products compared to the women while for one, the yoghurt and dairy desserts (e.g. pudding), women were more prepared to consume after shelf life date compared to the men. In the category canned products/drinks, significantly more men are willing to consume conserves and beer of products while for the other products stored at ambient temperature (unopened UHT milk, bread, cookies, chocolate, dry cereals or rice products), no significant differences were observed. Overall, for all eighteen food categories, the men (49.7%) were significantly more willing to consume expired food products than the women (45.1%).

4. Discussion

From the moment a food is produced, its properties will evolve. Deterioration of a food product can take different forms: chemical deterioration (e.g. rancidity due to oxidation of fatty acids), microbial deterioration (e.g. gas, acid, slime and ethanol formation due to growth of spoilage organisms) or physical deterioration (e.g. softening due to moisture uptake) (Int Veld, 1996). But besides spoilage, growth of pathogenic microbes such as cold tolerant L. monocytogenes in the food product until unsafe levels can be another reason why food is no longer acceptable for consumption (Havelaar, Nauta, & Jansen, 2004).

To increase information exchange on food quality and safety in respect of the shelf life, an EU framework was developed using the two dates best before and use by. The best before date relates to food quality, including flavor, texture, aroma and appearance, while use by dates relate to guarantees for food safety. The best before date is a quality indication used by the manufacturer to indicate that the food will be, assuming appropriate storage conditions have been respected, at or above the minimal sensorial quality as defined by the manufacturer. A food which has past its best before date is expected to be still safe to eat, but may not be at its best sensorial quality after this date. For perishable foods, during the storage time, the outgrowth of bacteria, yeasts and molds may lead to either food spoilage or food poisoning. In the latter case, a use by date should be used. This framework is important to be understood both by the manufacturer but also by the consumer (Monier, 2010).

This survey shows that the intended purpose of the shelf life label framework is not thoroughly understood by Belgian consumers: 30.4% of the respondents declares not to know the difference of the meaning between the best before and use by date and only about half of the respondents indicated to use the type of label (difference between the labels) for assessing the edibility of a product. The limited understanding and application of this framework can be considered as a lack of food safety knowledge. Because, it was not asked to explain the concepts (only asked ‘do you know the difference?’), the real proportion of consumers not understanding these concepts will probably be higher because consumers tend to overestimate their practical self-knowledge in surveys (Levy, Choiniere, & Fein, 2008; Redmond & Griffith, 2003).

In EU, a report on consumer empowerment by the European Commission highlighted that 18% of the respondents could not identify the best before date on a pack of cereals (EC, 2011). The number of more detailed studies by EU member states on consumer insight on shelf life labels is limited but studies in UK and Ireland indicate that there is a widespread misinterpretation of the date labels on food products, although the degree of misinterpretation varies (Brook Lyndhurst, 2008; FSAL, 2009). Brook Lyndhurst (2011) reports that in UK around half of consumers are able to correctly identify the best before date as a quality guideline and the use by date as a safety indicator. The above mentioned findings combined with the results from our survey suggest a suboptimal functioning of the EU label system.

The way consumers define the acceptability of food products relates to more factors among which the shelf life date serves as an anchor point in conjunction with other data (Brook Lyndhurst, 2011; Wansink & Wright, 2006). As such an interplay occurs between the use of shelf life dates and other perceptions of the food such as appearance, aroma and flavor (Brook Lyndhurst, 2008). This observation was also found in our survey where consumers mention to mainly judge visually and olfactory (82.5%) edibility of food but combined with other factors such as shelf life date (67.5%) and tasting (50.4%) to decide to consume the product or not.

Food products are produced intended to be consumed before expiry of the shelf life date because during the shelf life period both food safety and optimal sensorial properties (flavor, texture, ...) as defined by the manufacturer (if products are stored and used under recommended conditions) are guaranteed. However, for several reasons (e.g. bought too much in the supermarket), it occurs that consumers have products stored in their home with expired shelf life (Parfitt, Barthel, & Macnaughton, 2010). When asked to define which type of expired food products consumers would be willing to consume (if the product is stored at home), it follows that consumers tend to interpret the shelf life date in a flexible way according to food category.

It is important to highlight that several food categories used in this study will contain food products with a use by label but will
contain in the same category also products that carry a best before label. The decision on assigning a use by or best before date will mainly depend on the possibility of outgrowth of micro-organisms (e.g., *L. monocytogenes*, *B. cereus*) leading above a certain level to an unsafe product. This potential outgrowth is specific for a product produced by a certain manufacturer and will depend on the applied food processing technique (e.g., heating, high pressure, irradiation), type of packaging (e.g., MAP), product formulation, storage conditions and microbial ecology (Uyttendaele et al., 2009).

The shelf life period of a specific food product is defined by the manufacturer who takes into account food safety parameters (food safety risk) and/or quality parameters (microbial, chemical and physical spoilage potential) as limiting factors. Depending on which of these two factors is predominant for restriction of the shelf life length, we classified the use by products into two groups (group 1 and group 2) and the best before products in one group (group 3). This classification is presented in Fig. 1. For use by products of group 1, the limiting factor will relate mainly to the food safety risk linked to outgrowth of pathogenic micro-organisms but in some particular cases also to the outgrowth of spoilage organisms (e.g., fresh fish). The growth of these micro-organisms may lead to human illness either by infection or intoxication. For quality reasons, it is also possible that the manufacturer limits the shelf life of use by products to a shorter period than was deemed necessary from a food safety point of view (use by products from group 2). Indeed, spoilage organisms are often proliferating much quicker and exceeding the threshold for sensorial spoilage before any of the identified food safety hazards are exceeding acceptable levels. The third group of food products presented in Fig. 1 contains products with best before labels whose shelf life is limited by a defined minimal quality level. For each specific food category, based on the expertise of the authors, it was assessed whether these categories can contain products of group 1, 2 or 3 (Table 4).

Among the raw refrigerated products fish and meat, respectively 14.2% and 23.9% of consumers said to be prepared to consume these highly perishable products after the shelf life date. Microbial proliferation can occur in these rich nutrient matrices and render the product spoiled (the higher the storage temperature, the more rapid these deterioration processes proceed). Consumption of spoiled fish can lead to fish poisoning due to biogenic amines such as histamine or cadaverin. This is a foodborne chemical intoxication caused by eating spoiled, or bacterially contaminated fish. The fish are harmless when fresh and after they have become toxic they may still have a normal appearance and odor. No available method of preparation, including freezing, canning and smoking will destroy the causative toxin (Hu, Huang, Li, & Yang, 2012; Lehane & Olley, 2000). Formation of biogenic amines in meat can also lead to food safety problems (Shalaby, 1996). In both fresh fish and meat, there is a risk for outgrowth of pathogenic bacteria to unacceptable levels (Lambert, Smith, & Dodds, 1991).

In the category of the refrigerated ready-to-eat products, a substantial proportion of consumers were prepared to consume products after the shelf life date such as deli-meats (24.7%), mayonnaise-based deli-salads (17.4%), ready-to-eat meals (24.7%) and smoked fish (35%). During storage there is a risk of outgrowth of pathogens among which the most of concern are psychrotrophic *L. monocytogenes* (Farber & Peterkin, 1991) but also others such as psychrotrophic *B. cereus* (Baker & Griffiths, 1993) and psychrotrophic *Clostridium botulinum* (Bean et al., 2012). As there is a relationship between the number of pathogens and the probability of disease, this potential outgrowth is a crucial factor (Stringer, 2005). This risk will differ for each product in these categories and depend on several factors such as initial contamination, product formulation, processing and recommended storage conditions, meaning that some specific products should have a use by while others should carry a best before date. For mayonnaise-based deli-salads, cooked meat and smoked fish, a study by Uyttendaele et al., 2009 using data on prevalence and challenge tests of Belgian products showed that in general with respect to supporting growth of *L. monocytogenes*, the mayonnaise-based products and

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**Fig. 1.** Classification of pre-packed food products according to whether food safety and/or quality parameters limit the shelf-life date.
cooked meats can be considered as intermediate risk product, while smoked fish products can be considered as high risk. For example, some mayonnaise-based deli-salads may (use by label) or may not (best before label) support growth of L. monocytogenes, depending on the level of acetic acid to prevent the outgrowth of pathogens (Vermeulen et al., 2007).

As mentioned above, among refrigerated use by products, the shelf life period may have as limiting factor either the food safety risk (group 1) and/or spoilage risk (group 2) and this is defined by the manufacturer. Because the consumer does not know which of both was the limiting factor, they have no guarantee on food safety after this date. Hence, they should not eat expired use by products because then they expose themselves possibly to unacceptable food safety risks. The behavior of consumers prepared to consume these products after the shelf life should also be one of the elements to be taken into account during microbial risk assessment e.g. for the establishment of microbiological criteria intended to confirm a food safety objective (FSO).

For shelf stable products (group 3) such as cereals, dry rice, chocolate and cookies, 85% or more of the consumers indicate to be willing to consume the food after the shelf life. Bread on the other hand appears not be acceptable anymore for about half of the people and also 39% would discard unopened UHT milk. Discarding the latter types of products because strict following up of the shelf life date represents a waste of food that is often still acceptable from a food quality point of view and present no threat for food safety.

Our findings indicate that that an increase in the understanding of date labels by consumers is needed. Food safety authorities have set up several initiatives to increase this understanding on the shelf life labels (FAVW, 2012; FSA, 2013). However, the success of information campaigns depends on a whole range of elements such as consumer knowledge, socio-cultural factors and use of the appropriate communication media (Jacob, Mathiasen, & Powell, 2010). Besides this, it is also important to increase harmonization of application of shelf life labels by food business operators (Monier, 2010).

Supporting guidelines for operators are becoming more and more available (FSA, 2010; New Zealand Food Safety Authority, 2005).

Regarding the refrigerated products, it is likely that consumers are confused because in practice apparently identical products such as mayonnaise-based deli-salads or sliced meat carry a use by label or a best before label. A hypothetical way to simplify this would be to assign all refrigerated products a use by label (and the communication that use by products are unsafe to consume after the shelf life date and that for best before products the edibility can be judged by the consumer continued). Although it is difficult to predict the outcome of this simplified approach, there are advantages to be expected with respect to food safety and a mixed outcome with respect to food waste. The simplified approach would make communication more easy (do not eat expired refrigerated products) and may result in reduced consumption of expired use by products with subsequent smaller food safety risk. With respect to food waste, this more clear communication may lead to a better understanding of the best before date and subsequently less disposal of expired best before products. On the other hand several refrigerated products such as yoghurt, cheeses and others that are currently assigned a best before date (and in the hypothetical simplified approach converted to use by) may be discarded while still safe to consume.

In conclusion, via an on-line survey, it was shown that the shelf life date on pre-packed food products represents an important anchor point for the Belgian consumer in the complex process of deciding the acceptability of consuming food products. Consumers interpret the shelf life data and label in a flexible or more strict way, depending on the type of food. A better understanding of the shelf life labels use by (referring to food safety) and best before dates (referring to food quality) by consumers should be promoted via e.g. governmental information campaigns. Increased understanding and corresponding consumer behavior in respecting shelf life dates and labels should lead in due time to reduced food safety risk but also reduced food waste and thus contribute to a more sustainable food supply chain.

References
