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White paper

Reducing food waste and losses in the fresh dairy supply chain

Chr. Hansen impact study

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Preface

As a supplier to the food, health and agricultural sectors, Chr. Hansen (CH), a leading global producer of cultures and enzymes to the dairy industry, is working closely with its customers and partners to meet the needs of a growing population for safe, affordable and nutritious products from farm to fork. With the world's largest commercial collection of bacteria, numbering more than 20,000 strains, the medium-sized Danish company, despite its modest size, has a significant global impact and reach. Every day millions of people are in contact with CH's ingredients in daily products such as yoghurt, cheese, meat and wine.

In support of CH's business strategy, Nature's No. 1, through which the company aims to enable the wider adoption of natural ingredients and bioscience solutions to address important global challenges within food, health and agriculture¹, CH's management sees an untapped potential in developing a deeper understanding of how beneficial microbial solutions can create value in a broader societal sense. Or put differently, what is the societal value of applying natural and beneficial microbes to food, feed, health and agricultural supply chains beyond their immediate functional benefits (e.g. improved flavour or texture, improved efficiency etc.)?

As the company's stakeholders are growing increasingly concerned with global challenges such as resource scarcity, climate change and rising global health costs, CH has a unique opportunity to leverage the societal impact potential of its microbial technology platform to convey how the company is addressing important sustainable development challenges. This, however, requires documented and scientifically robust facts on how, and to what extent, beneficial microbes are adding value, not just in meeting the company's sales targets, but also in fulfilling the wider needs of customers, consumers and society at large.

For this purpose, CH has engaged QBIS to assess the socio-economic net costs and benefits of one of its strategic product areas; the development and application of bioprotection solutions to maintain and extend the shelf life of perishable foods. With this first impact study, we therefore set out to further the understanding of how beneficial microbial solutions can address the growing global challenge of food waste and losses (FWL), which was recently identified by the UN as one of the world's most pressing sustainable development priorities leading up to 2030². We hope that the study will contribute to CH's own internal understanding of the impact potential of the company's microbial technology platform. Likewise, we hope it will provide as a useful example of the value of scientifically robust and fact-based arguments in the communications and engagement with key stakeholders on global sustainability issues in agriculture, food and health.

¹ Chr. Hansen's Corporate Social Responsibility report, 2014/15

² Reduction of Food Wastage and Losses (FWL) have been identified as a key priority in the UN Sustainable Development Goals launched in September of 2015: "By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses" (source: *UN Sustainable Development Goal, goal 12*)

Executive summary

In EU-28, more than 29 million tons of dairy products go to waste every year with the majority of this waste happening downstream in private households, followed by retailers and dairy manufacturers³. Not only does this pose a significant loss from an economic and nutritional perspective, it also comes at an environmental cost as dairy products such as cheese, butter and yoghurt have a relatively high intensity of greenhouse gas emission (per unit weight).⁴

One of the main challenges in keeping dairy products fresh throughout the supply chain is contamination of yeast and mould, which are naturally present everywhere and quickly lead to untimely spoilage. To help address this challenge, CH has introduced a collection of bacterial strains called FreshQ® intended for the use in fermented milk products such as yoghurt, that make it possible to extend the shelf life by a minimum of seven days⁵.

For yoghurt, such extension of shelf life has the potential for reducing waste across all the value chain. Dairy manufacturers may use some of the extra shelf life to increase the size of their production batches (and decrease their frequency) which in turn reduces their production waste. Increased shelf life may help retailers sell more of a particular yoghurt delivery before it expires and in turn reduce wastage levels, while consumers will get more time to consume the yoghurt prior to its expiration and in turn allow less yoghurt go to waste.

It is this effect of FreshQ® - the ability to extend product shelf life - that is the focus of this study. As a starting point, the results show that there is a significant potential for reducing yoghurt waste by extending shelf life. Building on existing literature as well as collection of primary data, the study assesses that FreshQ® has a waste reduction potential corresponding to around 15% of total production across dairy manufacturers, retailers and household consumers. The potential is defined as the amount of yoghurt production that is wasted and that FreshQ® has the potential to influence, i.e. thrown away for reasons influenced by shelf life.

However, potentials for reducing food waste will only be realised if the stakeholders within the value chain have an incentive to engage in the process of food waste reduction⁶. Changes in the supply chain to prevent food waste can lead to some producers being worse off such that they are likely to disengage from food waste reduction initiatives, and this is precisely the problem in relation to reduction of yoghurt waste.

Bioprotection solutions such as FreshQ® are readily available to dairy manufacturers and their shelf life extending effects well-documented. Nevertheless, bioprotection solutions are not used to their full potential. This is mainly due to the (somewhat justified) perception by dairy manufacturers and retailers that European consumers will not readily accept longer shelf lives in their fresh dairy products. Similarly, if shelf life of fresh dairy products in the EU is extended and household

³ Global Food Waste: The Numbers Behind the Problem. FAO. <http://www.fao.org/save-food/resources/infographic/en/>

⁴ Clune, S. et. al. (2016)

⁵ From Chr. Hansen experience based on hundreds of lab trials, more than three hundred customer field trials and extensive customer feedback, we consider seven days a conservative average estimate when considering a yoghurt product produced by an average European dairy and sold in average European cold chain conditions.

⁶ Rutten, M. (2013).

consumers' waste are reduced, dairy producers and retailers will, all else being equal, sell less, unless consumers start consuming (or paying) more. As a result, dairy manufacturers and, to some extent, retailers in the EU currently do not have strong economic incentives to experiment with shelf life enhancing food technologies such as FreshQ®.

If the waste reduction potential illustrated in this study is to be fully realized, there is therefore a need to carefully consider how each of the main actors in the value chain – from dairy manufacturers to retailers and consumers – can maximize their individual gains. Consequently, the net impacts of applying FreshQ® for each of these stakeholders have been assessed by considering cost savings from waste reduction, costs of applying FreshQ®, saved household income due to less waste and lost profit due to less consumer waste.

The results indicate that all actors (dairy manufacturer, retailers and household consumers) actually can get positive net savings from reducing yoghurt waste and thereby have a financial incentive to engage in waste reduction, if either:

- Allocation of FreshQ®'s extra shelf life days favours the retailers. More specifically, if five extra shelf life days are used by retailers and just one extra shelf life day is allocated to household consumers.⁷
- Around 10% of the retailers' waste reduction savings are reallocated to the dairy manufacturers by means of existing product return agreements or by means of a benefit sharing-scheme between dairy manufacturers and retailers.

Under these circumstances, it is assessed that FreshQ® can reduce waste of yoghurt up to around 4% of total yoghurt production. In the EU-28, this corresponds to around 356,000 tons of yoghurt not being wasted each year out of a total production of nearly 9 million tons or around 430,000 tons CO2 emissions. In terms of net savings to dairy manufacturers, retailer and household consumers, it corresponds to around EUR 180 million. It is however important to emphasise that these findings are indications of the potential of reducing waste rather than hard facts given the uncertainty associated with the assessments.

Creating such financial incentives requires a maximum of between one and three extra shelf life days to the household consumers. As this is a relatively modest extension of shelf life and since there is significant variation in available shelf life days when consumers are buying yoghurt⁸, it is likely that many consumers will not even discover these one to three days and consequently, contractions in demand due to consumers' preferences for freshness might be prevented.

This assertion is supported by the findings of a mini-survey conducted among Danish consumers in connection with the study indicating that half of the respondents would consider buying yoghurt with a longer shelf life, if it enabled them to reduce waste. Thus, for half of the respondents, preference for freshness is trumped by the ability to reduce food waste. Also, the mini-survey indicated that most respondents have a preference for the yoghurt with the longest remaining shelf life when

⁷ Dairy manufacturers use all seven days to prolong the shelf life of their yoghurt, but only uses one of these seven days in the dairy.

⁸ In the UK, average available life in the shops is 13.7 days, but the minimum shelf life is zero and the maximum is 27. Lee, P., Osborn, S., & Whitehead, P. (2015), p. 16.

they purchase yoghurt, which also support the assertion that modest extension of shelf life will not necessarily conflict with consumers' preference for freshness.

This study shows that if such consumer statements turn out to be true for consumers in general and if at least three or more shelf life days are allocated to the retailers, lost profit from contraction in consumer demand as well as the costs of using FreshQ® are more than offset by savings relating to reductions in waste for dairy manufacturers and retailers. Thus, the results indicate that it is possible for all stakeholders of the yoghurt value chain to benefit from reducing their yoghurt waste.

The results also indicate that creating incentive for all of the stakeholders does not necessarily mean less waste reduction for society as a whole. If all of the available shelf life days provided by FreshQ® are used by the consumers and zero days are used by the retailers, it does not create additional benefits to society in term of more waste reduction compared to a situation, where all the available shelf life days are used by the retailers. In other words, the study estimates that the potential for reducing waste at retailers are as big as it is at the consumers in this situation.

Food waste and its causes for all of the value-chain's stakeholders have, to the best of our knowledge, not previously been studied in a comprehensive analysis aiming to determine incentives. This study is a first attempt to do just that. First of all, it demonstrates that such studies are difficult to carry out for several reasons (probably also explaining their absence). First, lack of data, studies and reports, necessitates data from primary sources. Second, part of the needed data is business sensitive requiring networking efforts to obtain and use it. Third, assessing how each stakeholders' waste will respond to waste-reduction initiatives requires behavioural knowledge often difficult to obtain without conducting (expensive) field research. Fourth, the lack of data necessitates assumptions about waste patterns being similar across different countries causing uncertainty, even though cross-referencing of waste data in different EU countries has shown comparability within a reasonable range.

Notwithstanding these challenges, such complete or near-complete value chain studies are necessary and further efforts should be a priority in the future. In her 2013 study on what economic theory tell us about the impact of reducing food losses and waste, Rutten emphasises how trade-offs occur on the demand side, where a reallocation of spending on previously wasted foods causes some producers to be worse off and some to be better off. As this might prevent food waste reduction initiatives from materialising, Rutten calls for analysis of the entire value chain in order to provide insight on how to facilitate and incentivise food waste reduction efforts.⁹

This study has tried to accommodate Rutten's call and it more than anything indicates that it is possible to create a market driven incentive for reducing food waste for all the stakeholders of the yoghurt value chain. This is a good starting point. But how will a process of extending shelf life with FreshQ® get started? Who should take the first step? Basically, it narrows down to either the politicians and legislation or the stakeholders of the yoghurt value chain, i.e. the dairy manufacturers, retailers and household consumers.

Recognising that yoghurt waste are reduced with longer shelf life, politicians could decide to create incentives for producing yoghurt with longer shelf life in order to reduce food waste. In France, newly imposed legislation makes it illegal for retailers throw away unsold food, which primarily is

⁹ Rutten, M. (2013).

expected to enable charity organisations to give out more free meals to people in need. However, to the best of our knowledge, no legislation in EU-28 target reduction of food waste. Considering that the results of this study indicate that benefits from food waste reduction can accommodate all stakeholders in a value chain avoiding passing on the costs to a single stakeholder, such initiatives need not be a burden on tax payers.

Another possibility is that yoghurt with longer shelf life becomes more in demand than regular yoghurt and this way incentivise the stakeholders of the yoghurt value chain to take the first step. Longer shelf life will enable retailers to reduce their waste and in turn save costs. This can potentially increase demand as well even prices for yoghurt encouraging dairy manufacturers to focus on yoghurt with longer shelf life. Similarly, longer shelf life could be considered superior to regular yoghurt by consumers since it enables them to reduce food waste, which is likely to be considered an attractive feature for the increasingly eco-conscious consumers. However, as demonstrated in the study, empirical evidence is weak as well as contrasting when it comes to consumers' reaction to bioprotection as a mean to prolong shelf life as well as prolonged shelf life itself. It could therefore be helpful for the food waste agenda, if further research could provide more insight into consumers' behaviour, notably the tension between food freshness and food waste.

Chapter 1

Introduction and research objectives

As the concern over global food security continues to grow, the topic of FWL has become top of mind for global policy makers, industry and civil society alike. Each year, 1.3 billion tonnes of food, about a third of all that is produced, is wasted¹⁰. If global food waste and losses were reduced by just 25%, there would be enough food to feed the more than 800 million people who currently suffer from hunger and malnutrition¹¹. Further, wasted food also inflicts a host of negative environmental impacts, including unnecessary greenhouse gas emissions and inefficient use of water and land. If food waste was a country, it would rank as the third highest national emitter of greenhouse gasses after USA and China.¹²

In response hereto, there has been a growing amount of literature in recent years which demonstrates the significant economic, social and environmental costs of global food waste and losses as well as the cost of waste to the various stakeholders in the food supply chain, including individual households, retailers, food manufacturers and agricultural producers¹³.

In one of the first major attempts to quantify the size and causes of global FWL, FAO (2011) pointed to three sector-specific intervention areas which account for the largest share of global waste. One of these intervention areas is the need to reduce food wastage in the consumption of meat and fresh dairy products in developed countries¹⁴.

Looking at the fresh dairy sector in EU alone, every year more than 29 million tons of dairy products go to waste with the majority of this waste happening downstream in private households, followed by retailers and dairy manufacturers¹⁵. Not only does this pose a significant loss from an economic and nutritional perspective, it also comes at an environmental cost as dairy products such as cheese, butter and yoghurt are relatively high contributors to greenhouse gas emissions¹⁶.

One of the main challenges in keeping dairy products fresh throughout the supply chain is contamination of yeast and mould, which are naturally present everywhere and quickly lead to untimely spoilage. To help address this challenge, CH has invested extensive R&D resources in identifying new strains of beneficial cultures to keep dairy products fresh for longer periods of time, thereby allowing dairy manufacturers to extend the shelf life of their products.

¹⁰ Gustavsson, J. et al (2011)

¹¹ Global Food Waste: The Numbers Behind the Problem. FAO. <http://www.fao.org/save-food/resources/infographic/en/>

¹² <http://insinkerator.co.uk/uk/page/global-food-waste-stats>

¹³ See e.g. Gustavsson, J. et al (2011), Quested, T. et al. (2013), Okawa, K. (2015), Lee, P. et al (2015), Rutten, M. and Verma, M. (2015), Rutten, M. (2013), Foster, C. et al (2006), Chapagain and James (2011), Buzby, J. et al (2014), Vanham, D. et al (2015), Monier et al. (2010) etc.

¹⁴ FAO highlighted three commodity specific intervention areas of the global food supply chain which account for the largest share of global FWL. These are: reduced food waste from cereal consumption in North America, Europe and North Africa; reduced food waste in consumption of meat and dairy products in developed countries; and reduced food losses from crop production in developing countries (ibid)

¹⁵ Global Food Waste: The Numbers Behind the Problem. FAO.

¹⁶ Clune, S. et. al. (2016)

While these so-called bioprotection cultures can be applied to a broad number of perishable food categories, including meat and fish, CH's biggest application area so far is within the fresh dairy sector and, more specifically, fermented milk products such as yoghurt.

While there are naturally many other ways to keep food fresh and prevent food waste and losses along the value chain - e.g. improved packaging technologies, optimal cooling facilities, heat treatment technologies or improved inventory and logistics planning tools – existing studies of such technology interventions rarely consider the socio-economic and environmental costs and benefits of implementation (i.e. societal relevance and costs), nor the underlying incentives which may, or may not, lead to their adoption¹⁷ (i.e. practical feasibility).

In this study we set out to investigate the waste reduction potential of a specific food technology intervention – bioprotection – in the fresh dairy sector. Building on existing literature as well as collection of primary data, we map the quantities and causes of waste for a specific fresh dairy value chain (yoghurt) and assess the net socio-economic impacts of applying bioprotective cultures to extend product shelf life. Finally, recognizing that adoption of new technologies with food waste reduction potential will only happen if actors within the value chain are incentivized to do so¹⁸, we consider various scenarios that may help strengthen the case for implementation.

Ultimately, the study hopes to contribute to the current debate on food waste reduction interventions and initiatives and, particularly, the importance of economic incentives in the food supply chain. Similarly, the study hopes to inspire CH's management with new knowledge and facts on the wider impact potential which can be achieved with the further adoption of bioprotection solutions in perishable foods.

¹⁷ See e.g. Rutten, M. (2013)

¹⁸ Ibid

Chapter 2

Background and context

2.1 Introduction to Chr. Hansen (CH)

CH is a global bioscience company that develops natural solutions for the food, nutritional, pharmaceutical and agricultural industries. The company owns one of the world's largest commercial collections of bacteria, numbering more than 20,000 strains, and develops and produces microbial solutions for a wide variety of foods, confectionery, beverages, dietary supplements as well as animal feed and plant protection.

In 2012/13, CH launched its new business strategy, Nature's No. 1, through which the company aims to enable the wider adoption of natural ingredients and bioscience solutions to address important global challenges within food, health and agriculture¹⁹. As the company's stakeholders are growing increasingly concerned with global challenges such as resource scarcity, climate change and rising global health costs, CH's management sees an opportunity in developing a better understanding of how its products can create value in a broader societal sense, i.e. beyond functional benefits (e.g. improved flavour, texture, etc.). It is to this end that the current study was commissioned.

2.2 Characteristics of bioprotection and FreshQ®

While CH develops microbial solutions for a wide variety of food groups, this study focuses specifically on the application of bioprotection cultures which are developed by CH to prevent spoilage in perishable food. For the purpose of this study, we define bioprotection solutions as 'the application of lactic acid bacteria (LAB) to a given food product in order to control the flora without significantly altering the sensory properties of the product'. Depending on the food category in question, bioprotection solutions generally have two main functions: 1) improving quality by delaying growth of spoilage bacteria and 2) increasing safety by inhibiting and reducing growth of pathogens²⁰.

Even though adoption rates of bioprotection cultures are still relatively modest when looking across most food groups²¹, the technology has gained increased attention in markets such as the EU in recent years. With growing trends towards natural and minimally processed foods, stricter food ingredient regulations²² as well as consumer scepticism against the use of chemical preservatives, bioprotection cultures offer a potentially attractive solution to food producers who wish to keep their products fresh without the use of conventional preservatives. This is especially the case within the

¹⁹ Chr. Hansen Communication on Progress report, 2014/15

²⁰ The latter is especially the case for meat and fish products. Source: <http://www.cmc-cvc.com/sites/default/files/files/EnhancingSafety.pdf>

²¹ Peter Thoysen, Marketing Director, dairy bioprotection, food cultures & enzymes bioprotection at Chr. Hansen.

²² As an example, the use of artificial preservatives in product groups such as yoghurt is banned by law in the EU, making bioprotection solutions the only viable alternative for dairy manufacturers who are looking to food ingredient providers for technologies that can help prevent untimely spoilage and/or extend the shelf life of their products. Source: Chr. Hansen internal interviews.

fresh dairy segment which is characterized by shorter shelf life and a high risk (and cost) of spoilage throughout the supply chain.

To assist dairy manufacturers in maintaining and possibly extending the shelf life of fresh dairy products, CH has introduced a collection of bacterial strains called FreshQ® intended for the use in fermented milk products such as yoghurt.

"Many of our customers have a strong focus on reducing waste, both for economic but also for environmental reasons. With FreshQ®, we have found a way to help our customers reduce the risk of spoilage and product recalls, enabling an extension of shelf life and delivering a fresher, higher-quality product to consumers. And they can do so without making use of chemical preservatives."

- Peter Thoeysen, Global Marketing Manager, Chr. Hansen

One of the primary shelf life limiting factors of a product like yoghurt is the natural spoilage with yeast and mould. Spoilage gradually changes the product's appearance and sensory profile and will at a certain level make the product unattractive and unconsumable. CH's FreshQ® cultures can however inhibit the growth of yeast and mould in yoghurt and other fermented milks which may benefit CH's dairy customers in several ways.

Firstly, for dairies in markets like the EU where conventional preservatives in yoghurt are prohibited, FreshQ® allows for better microbial control in the production and distribution of yoghurt by countering the effects of contaminants which may enter during processing or in the cold chain. In that sense, FreshQ® acts as an added "insurance" for dairies, protecting them against expensive product recalls from larger retailers.

In extension of these characteristics, FreshQ® also offers the added and important benefit of allowing dairy manufacturers to extend the shelf life of their yoghurt with minimum seven days²³. As we shall elaborate later in this paper, this benefit can be realized in different parts of the value chain. Dairies may for instance use some of the extra shelf life to optimize their internal processes and logistics by allowing themselves to use more time internally thereby enabling a reduction of changeovers, running larger production batches and improving picking, handling and shipping processes. Increased shelf life may likewise help retailers sell more yoghurt and reduce scrap levels while consumers will get more time to consume the yoghurt prior to disposing of it. It is this effect of FreshQ® - i.e. the ability to extend product shelf life - that preoccupies the remaining sections of this paper.

2.3 The link between extended shelf life and FWL reduction

Extending shelf life of fresh dairy products – or any food group for that matter – is not just a commercial matter; it is also a socio-economic and environmental matter. In the UK alone, approximately 80% of the yoghurt that goes to waste in private households is due to the yoghurt not being "used in time", stressing the direct correlation between food waste and shelf life²⁴. Similarly,

²³ From Chr. Hansen experience based on hundreds of lab trials, more than three hundred customer field trials and extensive customer feedback, we consider seven days a conservative average estimate when considering a yoghurt product produced by an average European dairy and sold in average European cold chain conditions.

²⁴ WRAP in the UK has studied this correlation intensely, see e.g. Quested, T. (2013) and Lee, P., Osborn, S., &

product expiration is a key cause of waste for retailers, especially in perishable food categories such as fresh dairy, meats, fruits and vegetables²⁵.

While there is limited data available on the correlation between shelf life and food waste and losses, the UK-based NGO, WRAP, has studied this relationship both at the household level²⁶ and for the grocery supply chain²⁷. Among other things, this research suggests that at a consumer level – for milk – a small increase in shelf life could lead to considerable reductions in waste, cf. chapter 4.

As such, innovative technologies that can extend shelf life of perishable foods while, at the same time, meet the commercial interests of key players in the food supply chain are important contributions to the global efforts to reduce FWL by 50% by 2030²⁸.

Whitehead, P. (2015)

²⁵ Quested, T., & Murphy, L. (2014).

²⁶ Quested, T., & Murphy, L. (2014)

²⁷ Parfitt, J., Woodham, S., Swan, E., Castella, T., & Parry, A. (2016).

²⁸ In 2015, the UN published 17 new global goals for sustainable development, one of which specifically targets the issue of food waste and losses: "By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses" (source: UN Sustainable Development Goal #12)

Chapter 3

Scope and methodology

3.1 Scope of study

This study assesses the FWL reduction potential of applying a specific strain of bioprotection cultures (FreshQ®) to the yoghurt supply chain and the net impacts to yoghurt manufacturers, retailers and consumers. The scope is defined using the WRI Food Loss and Waste Standard²⁹

Timeframe

The timeframe for the data collected is from 2006 to 2016. Even though this can seem like a long period, the data used in the study does not show and is not expected to show a lot of variation over time. For illustration, the yoghurt waste percentage measured in a 2006 study in two Swedish dairies³⁰ is quite similar to the yoghurt waste percentage stated in connection with an interview of a Danish dairy in 2016³¹. Also, the waste percentage of household consumers, which is also an important piece of data in the study, is from 2014 with the field work carried out in 2012 and 2013³². However, as household waste percentage is a result of a behavioural pattern not likely to change significantly over a short time horizon, the two year of age of these data is similarly not expected to introduce uncertainty.

The timeframe for the findings is 2012 as this is the first field study year for the mentioned household consumer study, which is vital for analysis, and since the year is roughly halfway between the study dates for much of the other data used in the study.

Definition food waste and losses

We follow the definition of food waste and losses (FWL) reiterated by FAO³³, which characterizes food losses as the decrease in edible food mass throughout the part of the supply chain that specifically leads to edible food for human consumption. Food waste occurs at the end of the food chain and thereby mainly which relates to retailers' and consumers' behaviour. For simplicity reasons we use the two concepts interchangeably in this study with either "food waste and losses (FWL)" or simply "food waste" as a shared terminology covering both occurrences.

Boundaries

The study focuses on the fresh dairy sector but takes a product-specific approach with yoghurt as the product focus³⁴. Assessing food waste and losses at a product category level can however introduce uncertainty in the study as the classification of yoghurt is not always consistent between different sources and different markets. When we have had access to granular product level data for

²⁹ Food Loss and Waste Accounting and Reporting Standard version 1.0. See: http://www.wri.org/sites/default/files/REP_FLW_Standard_July27.pdf

³⁰ Berlin, J., & Sonesson, U. (2006).

³¹ See section 4.1.

³² Quested, T., & Murphy, L. (2014).

³³ Gustavsson, J., (2011).

³⁴ Only the edible parts of yoghurt waste are considered, i.e. excluding packaging.

dairy waste and losses, we have generally opted for the broadest available categorization of yoghurt. The study uses data from WRAP, PRODCOM, dairy manufacturers and retailers. For WRAP data, yoghurt category includes yoghurt, yoghurt drinks and fromage frais³⁵. For PRODCOM data, both available yoghurt categories have been used.³⁶ For dairy manufacturers, the yoghurt category include yoghurt, sour cream, cold sauce and creme fraiche, all with multiple flavours³⁷; however, not all of the interviewed dairy manufacturers produces all of these variants. As evident, the categories are broad, but not 100% identical. This can introduce uncertainty if major yoghurt categories are included for some stakeholders of the value chain but not for others.

Due to data limitations, the main focus of the paper is only on three of the key actors in the yoghurt value chain; dairy manufacturers, retailers and households. However, as these actors are assessed to generate the biggest amount of yoghurt waste, the quantification of yoghurt waste and its causes focuses on the parts of the product life cycle where the study subject – FreshQ® – is believed to have the biggest direct impact. This also means that the study does not consider the impact of FreshQ® in reducing FWL in the pre-harvest stages or end-of-use stages of the value chain as well as distribution and food service³⁸.

Destination

While the main causes of waste at each step of the value chain are detailed in the subsequent chapters, the waste that occurs in the yoghurt supply chain goes to different destinations. However, lack of detailed mapping makes it difficult exactly to identify which destinations.

For dairy manufacturers and retailers, diversion to animal feed, food banks, composting, incineration of waste with and without energy recovery as well as landfill and sewer are among the most cited destinations in the UK.³⁹ For dairy manufacturers yoghurt waste occurs during production (e.g. a contaminated batch) and in connection with product returns from retailers. For retailers, yoghurt that is contaminated or past its shelf life is either returned to the dairy manufacturer or donated to charity, food banks or thrown out. In France, it is now forbidden by law for retailers to throw out food and consequently, it goes to food banks.

For consumers, data from the research from WRAP in the UK shows that the majority of yoghurt waste at household level is disposed of in unopened packaging and that a large share is not recycled but goes down the sewer. For the purpose of this study all the mentioned destinations are classified as yoghurt waste and included in the waste reduction potential.

³⁵ The study thus follows the classification of WRAP's product inventory for yoghurt waste at a household level (Qvested, T. et. al., 2013)

³⁶ PRODCOM, 2014, 10515241: Curdled milk, cream, yoghurt and other fermented products
10515245: Flavoured liquid yoghurt or acidified milk (curdled milk; cream; yoghurt and other fermented products flavoured or containing added fruit; nuts or cocoa).

³⁷ Berlin, J., & Sonesson, U. (2006).

³⁸ This is not to say that farmers will not be impacted indirectly by longer shelf life and less waste in yoghurt production (e.g. through reduced demand for milk) or that less yoghurt waste will not have an impact on the disposal and distribution of yoghurt waste, however, these effects are considered secondary. That said, in the environmental impact assessment (to come) pre-harvest and end-of-use are important considerations as the environmental gains associated with reduced waste in the grocery supply chain and with consumers are largely attributed to reduced inputs from farms and reduced disposal.

³⁹ Parfitt et. al. (2016).

Finally, recognizing that causes and quantities of yoghurt waste can, as mentioned differ between countries, the impact model is constructed based on FWL data and insights from four key markets which generally have better-than-average data; UK, Germany, France, Sweden and Denmark. Similar to the approach taken by e.g. FAO⁴⁰, these countries are used as a proxy to model food waste reductions achievable with FreshQ® within the EU-28.

3.2 Methodology and approach

Studies of how companies impact society – whether through a specific investment, a process or, as in this case, by developing a specific product or technology – can be conducted in a variety of ways. As an example, a growing number of companies have started to use environmental Life Cycle Assessments (LCAs) to quantify the impacts of their products on the environment from cradle to grave, while others use more qualitative methodologies focussing on social and community impacts such as socio-economic and/or human rights impact assessments, for instance when evaluating a specific project or production site. It is important to recognize that each of these methods have merits as well as trade-offs in their own rights, hence the key to a successful outcome is to choose the methodology that is most appropriate to the research objective in question.

The methodology used in this study builds, and further expands, on the basic principles of economic cost-benefit analysis (CBA) as outlined in the guidelines by the EU Commission⁴¹ and the World Bank⁴² for conducting impact assessments of public and/or private investments. The benefits of this approach is that it allows for a more holistic assessment of costs and benefits beyond “just” environmental or social factors by putting a monetary value on potential welfare gains while at the same time factoring in the costs of implementation.

In practical terms, QBIS uses the CBA methodology to provide an organisational framework for identifying, quantifying, and comparing the costs and benefits from a specific corporate investment and/or activity. In this case, we have used the methodology to measure the socio-economic net impacts of applying CH’s bioprotection solutions (FreshQ®) to a specific product value chain (yoghurt) in a specific market context (UK, Germany, France, Sweden and Denmark) as detailed in the scope section above.

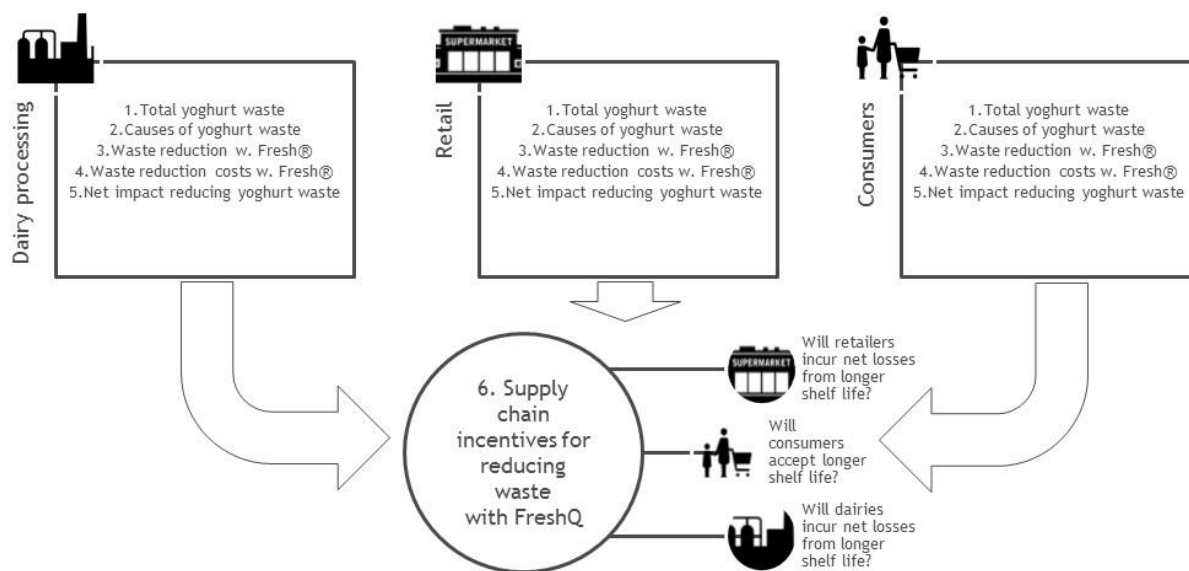
Building on an extensive review of existing data as well as collection of perspectives from industry experts, c.f. section 3.3, the study started out by mapping the yoghurt value chain in the selected EU markets “as is”, including current waste levels, causes and resulting costs and benefits to each of the main stakeholders in the value chain (Step 1 + 2). A cost benefit assessment was then developed based on the known effects of adding bioprotection solutions (in this case FreshQ®) to extend the shelf life of yoghurt (Step 3 + 4 + 5). Finally, a number of “action levers” were identified (Step 6), which may provide an incentive for all stakeholders in the yoghurt value chain to adopt FreshQ®, thereby creating a higher likelihood that the waste reduction potential identified in this study may actually be realized, cf. Figure 3.1 below.

⁴⁰ The majority of the findings for EU in FAO’s seminal quantification of food waste and losses from 2011. Gustavsson et al., (2011) was based on, or extrapolated from, UK FWL data.

⁴¹ “Guide to Cost Benefit Analysis of Investment Projects”, DG REGIO, EU Commission, 2008, http://ec.europa.eu/regional_policy/sources/docgener/guides/cost/guide2008_en.pdf

⁴² Cost Benefit Analysis in World Bank Projects, 2010, <http://web.worldbank.org/external/default/main?no-SURL=Y&theSitePK=1324361&piPK=64252979&pagePK=64253958&contentMDK=22703501>

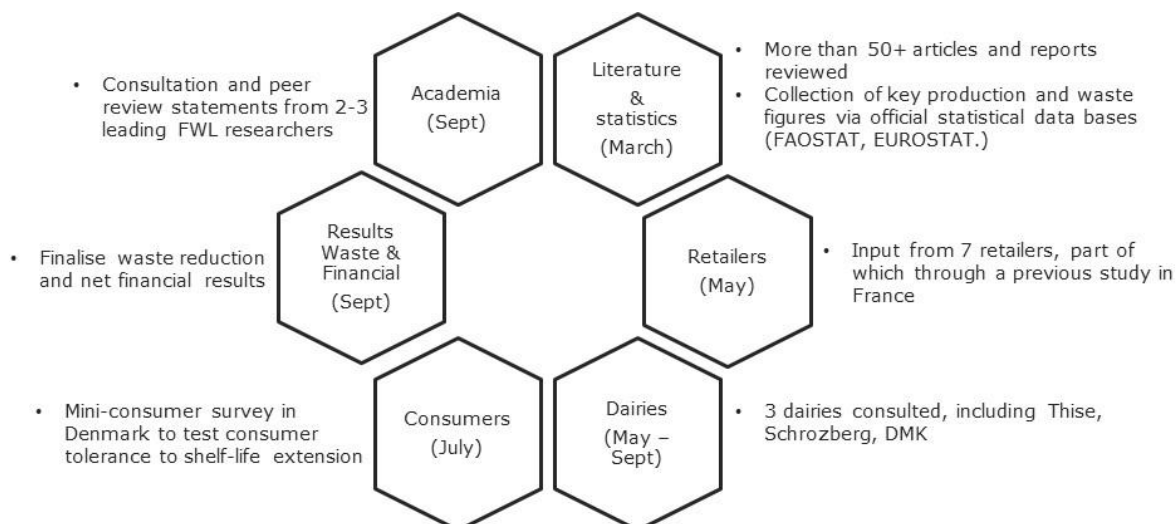
Figure 3.1: The 6-steps approach of the impact assessment



3.3 Data collection

Several data sources have been used in this impact study as illustrated in Figure 3.2 below.

Figure 3.2: Data collection and inputs



Secondary data was collected initially as well as throughout the project, in form of a review of more than 50 academic articles and reports on various aspects of causes, quantities and interventions within global food waste and losses as well as relevant statistical databases containing food production, demand and waste figures. From this review it was clear that the literature on food waste

and losses, while growing, is still in its infancy with significant discrepancies in definitions and measurement approaches as well as high fluctuations in data quality from country to country.

It was therefore determined early on that it would be necessary to collect *primary data* as well to fill the gaps identified in the existing literature and ensure practical relevance of the findings to key players in the industry. To this end, the study has collected data from the main stakeholders outlined in the value chain scope, cf. Figure 3.2 above, i.e. EU dairies, retailers and consumers. For dairies and retailers, loosely structured interviews were conducted with the main purpose of identifying waste percentages and, in the case of the dairies, current and potential waste reductions achievable with the application of FreshQ® in yoghurt production.

From experience, many companies underestimate the amount of wasted food they produce unless they measure it. In order to minimise this bias, information on waste and waste percentages provided by dairy manufacturers and retailers have only been used if the data is within reasonable distance from the typical indicated values. For instance, a dairy manufacturer indicated that their yoghurt waste percentage in production was around 0.5%. This value was not used as the typical indicated yoghurt waste percentage in production was 5%-6%. In the absence of more sophisticated methods and more comprehensive data, this primitive filter is relatively effective.

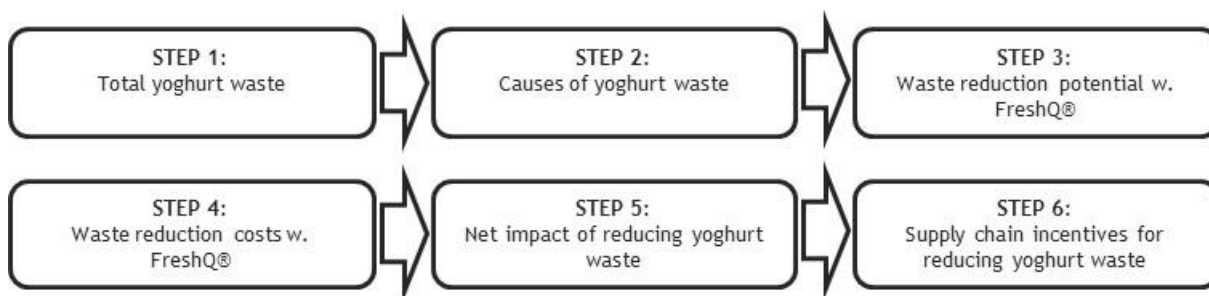
With regards to consumers, a substantial evidence base on consumer waste quantities and causes at the product level is available in the UK due to the work of the government-sponsored NGO, WRAP. Even so, limited insights exist into EU consumers' willingness and tolerance levels when it comes to extending the shelf life of perishable foods such as dairy. To this end, a small in-person survey was conducted in one of the focus EU markets (Denmark) as input for the scenario development phase. The survey⁴³, which includes reactions from 70 respondents exiting their local supermarket, provides novel insight into consumer tolerance levels and biases towards shelf life extensions of yoghurt, yet more research is needed in this space. Since what people say and what they do – especially in a hypothetical situation such as the questions asked – are not always the same, the results of the survey are subject to uncertainty and should only be used as indications of consumers' tolerance levels towards shelf life extensions of yoghurt.⁴⁴

Finally, to ensure validity of the study's methodology and invite a critical review of the findings, a number of academic experts have been consulted within various topics of the study. An overview of the feedback provided by the expert panel is included in Appendix A with the majority of the comments having been worked into the analysis and conclusions.

⁴³ Highlights from the consumer study are presented in section 0..

⁴⁴ For example, people who were actively seeking British Seasonal produce were no more or less likely to buy British Strawberries. See: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/137736/defra-stats-foodfarm-food-attitudes-report-110406-execsummary.pdf

Chapter 3

Cost-benefit analysis yoghurt waste reduction**4.1 Step 1: Total yoghurt waste**

As described in section 3.3, the literature on food waste and losses, while growing, is still in its infancy with significant discrepancies in scopes, definitions and measurement approaches as well as high fluctuations in data quality from country to country. Consequently, assessing waste of yoghurt is not possible using a single source but requires combination of knowledge and sources. While this may entail additional uncertainty in the results, cross-references of waste percentages identified by various sources in different EU countries have turned out to be comparable within a reasonable range. The impact study has used data from FUSIONS, WRAP and selected main stakeholders of the yoghurt value chain in Germany, France and Denmark. Each of these data sources is described in the following sections.

Data from FUSIONS

FUSIONS⁴⁵, a project funded by the European Commission 7th Framework Programme with the aim of reducing food waste⁴⁶, has been given the task of harmonising food waste data in the EU28 including combining data and setting up a common definitional framework and standards in order to provide baseline estimates for food waste in the EU28.

These baseline estimates have been obtained using a combination of national waste statistics and findings from selected research studies. The data were collected from contacts within EU Member States and filtered according to quality thresholds in order to ensure that retained data were aligned to the FUSIONS food waste definition and used a robust methodology.

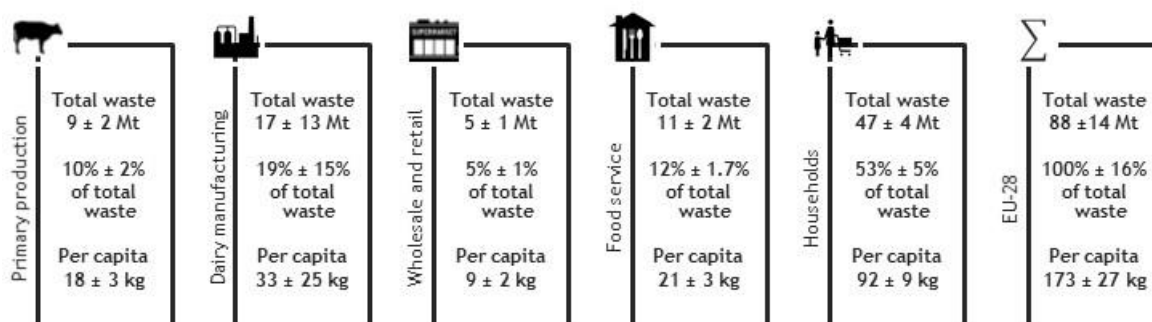
The resulting estimates show that EU-28 produces around about 87 Mt of food waste every year, and that about 45% of this is generated from households. This estimate is for 2012 and includes food waste according to FUSIONS' definitional framework. There is a relatively high uncertainty around the estimate; the approximate 95% confidence interval is ± 13.7 Mt (or $\pm 16\%$). Therefore,

⁴⁵ FUSIONS is an abbreviation for Food Use for Social Innovation by Optimising Waste Prevention Strategies.

⁴⁶ See about FUSIONS: <http://eu-fusions.org/index.php/about-fusions#wp1>

the range of results within this confidence interval is from around 74 Mt to 102 Mt, cf. Table 4.4 below.⁴⁷

Figure 4.1: Estimates of food waste in EU-28, 2012



Note: Estimates are presented with 95% confidence intervals.
Source: FUSIONS 2016.

As the FUSIONS' estimates do not provide detailed knowledge about the kind of types of food that is wasted including yoghurt, they have primarily been used to confirm, which main stakeholders of the value chain that produce the largest amount of waste and as such where the biggest return on reduction of food waste is located, i.e. processing and household consumers.

Data from WRAP

The government-sponsored NGO, WRAP, has published a range of studies investigating food waste in the UK.⁴⁸ The studies are very detailed focussing on one value chain stakeholders at the time and offer valuable insight in terms of waste percentages, waste causes as well as the potential for reducing food waste through different measures including extending product life.

WRAP's 2014 study (*Household food and drink waste, a product focus*) shows that household consumers in the UK waste around 8.8% of their purchased yoghurt and all 8.8% is assessed as avoidable, cf. Figure 4.2 below.⁴⁹ It also shows that approximately 80% of the yoghurt that goes to waste in private households is due to the product not being "used in time" placing yoghurt in the top 20 list of products being disposed of solely due to shelf life expiration⁵⁰. Also, people in the diary research undertaken by WRAP mentioned the date label as a factor for the vast majority of the waste incidents, indicating that a long shelf life (as stated by the date label) has the potential to be influential for this product category.

In addition, WRAP's 2015 study on reducing food waste by reducing product life estimates that 1.4% of yoghurt sales at the retailer level is due to date expiration causes and as such could be prevented through longer shelf life.⁵¹ As this figure stems from a survey, it could underestimate the

⁴⁷ FUSIONS (2016).

⁴⁸ See: <http://www.wrap.org.uk/>, <http://www.wrap.org.uk/content/food-waste-resource-listing>, and <http://www.wrap.org.uk/content/manufacturing-and-retail-resource-listing>

⁴⁹ Quested, T., & Murphy, L. (2014).

⁵⁰ According to Quested, T., & Murphy, L. (2014), yoghurt ranks 11th in the top 20 list of avoidable food waste which is caused by shelf life expiration. Across all food categories only 50% of avoidable waste is due to shelf life issues versus 80% for yoghurt.

⁵¹ Lee, P., Osborn, S., & Whitehead, P. (2015).

actual waste companies have a tendency to underestimate their actual waste unless they measure it, cf. section 3.3 above.

Data from universities

Berlin and Sonesson (2008) investigate the possibility of reducing waste in yoghurt production by optimising dairy manufacturers' sequence of product shifts.⁵² Their results substantiate the potential for reducing yoghurt waste at dairy manufacturers, but also provide an estimate of yoghurt waste in production as two detailed dairy case studies included in their study suggests that yoghurt waste constitutes 4.6%-6.4% of total production.

Data from main stakeholders in the yoghurt value chain

Apart from the estimates from WRAP and Berlin and Sonesson (2008), it has not been possible to find additional knowledge on yoghurt waste from existing literature. Therefore, in order to fill the gaps and substantiate existing results, additional data has been collected directly from dairy manufacturers and retailers.

Interview with a Danish dairy manufacturer confirms the estimates from Berlin and Sonesson (2008) in regard to yoghurt waste percentage in production. While Berlin and Sonesson estimate yoghurt waste to be 4.6%-6.4% of total production, the Danish dairy manufacturer estimates its waste to be 5.0%-6.0 of total production.

A field study by CH among French retailers' estimates that yoghurt waste due to expiration is around 2.0%-2.5% of total production for retailers.⁵³ The study objective was to investigate retailers' perception towards the value added of shelf life for dairy products using data from the largest French retailers⁵⁴. Since this estimate is produced through actual measurement and not interviews, it could be less biased than the corresponding WRAP estimate, cf. above. However, as it is based on a single hypermarket, it contains some uncertainty due to the small sample size.

Summary of estimates of yoghurt waste across the value chain

In summary, based on data from WRAP, universities and interviewed stakeholders of the yoghurt value chain, it has been possible to establish estimates on yoghurt waste for dairy manufacturers, retailers and household consumers, cf. Figure 4.2 below.

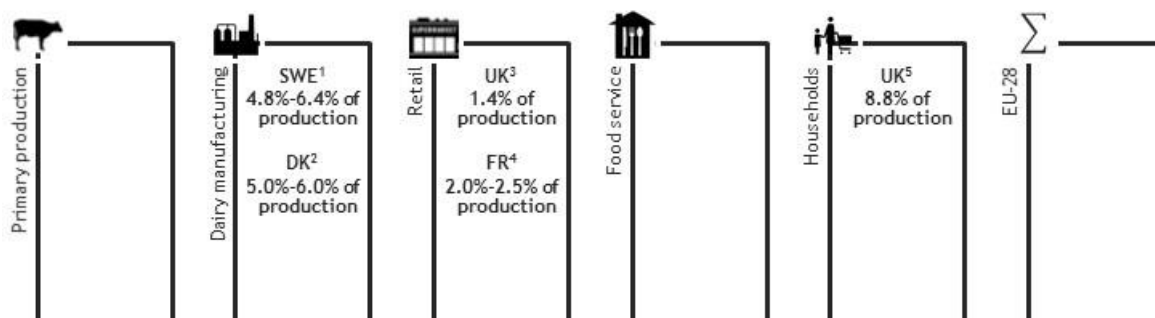
It has not been possible to estimate waste in connection with primary production and food service, which means that the assessment of yoghurt waste is not going to cover all value chain stakeholder. However, if the distribution of total waste across the value chain approximately corresponds to the distribution of yoghurt waste, FUSIONS's estimates suggest that this assessment – with dairy manufacturers, retailer and household consumers - covers around 75%-80% of total waste, cf. Figure 4.1 above.

⁵² Berlin, J., & Sonesson, U. (2006).

⁵³ Bauquis, C. (2015). The field study was carried out as an internship project with a student from ESC Rennes School of Business.

⁵⁴ Carrefour, E. Leclerc, Intermarche, Casino, Zero Gachis, Auchan and Systems U.

Figure 4.2: Estimates of avoidable yoghurt waste in different EU countries



Sources:

¹ Berlin, J., & Sonesson, U. (2008).

² Interview w. Danish dairy.

³ Lee, P., Osborn, S., & Whitehead, P. (2015).

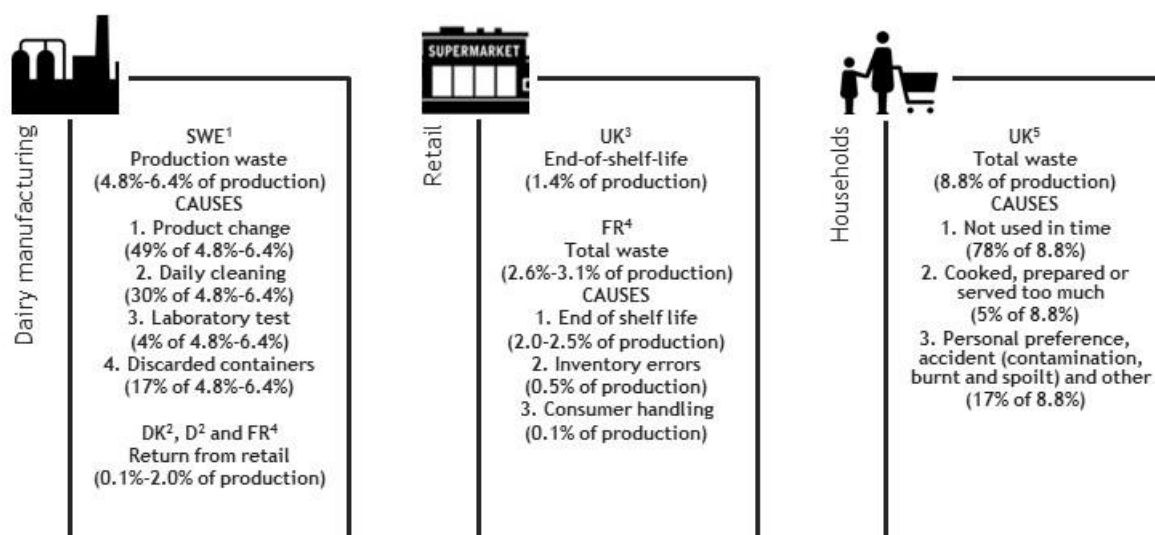
⁴ Field study of French retailers (Carrefour, E. Leclerc, Intermarche, Casino, Zero Gachis, Auchan and Systems U).

⁵ Quested, T., & Murphy, L. (2012).

4.2 Step 2: Causes of yoghurt waste

In order to determine how much of the estimated yoghurt waste that accrues from expirations and shelf life issues and in turn potentially can be reduced by using FreshQ®, the underlying causes of the estimated waste needs to be identified, cf. Figure 4.3 below.

Figure 4.3: Causes of yoghurt waste



Sources:

¹ Berlin, J., & Sonesson, U. (2008).

² Estimated on the basis of interview w. Danish dairy manufacturer (Arla) and German dairy manufacturer (anonymous).

³ Lee, P., Osborn, S., & Whitehead, P. (2015).

⁴ Bauquis, C. (2015).

⁵ Quested, T., & Murphy, L. (2014).

Dairy manufacturing

Dairy manufacturers' waste types are identified as production waste and waste due to return of yoghurt from the retailers' warehouses.

Concerning production waste, Berlin and Sonesson (2008) identify the causes as being product change, cleaning, laboratory tests as well as discarded containers⁵⁵. Cleaning must be done after a change of base, e.g. after a product containing rhubarb, after a product containing vanilla, and at the end of the working day. Rinsing is done after products containing tropical fruit (a mix of pineapple, mango, peach and passion-fruit), elderberry or honey, which are considered to have allergenic potential. Otherwise the pushing principle is used, with pale coloured products preceding dark ones.

Thus, all of the three waste causes cleaning, rinsing and/or pushing are related to the frequency and sequence of production batches, which means that if the number of production batches is reduced, so is the waste in dairy production and Berlin and Sonesson (2008) show that optimisation of the production batch sequence given in terms of bigger batches reduces the waste significantly, cf. section 3.3 below.

As bigger batches can be achieved through longer shelf life, FreshQ® can initiate similar waste reductions as achieved in the Swedish dairies. Thus, longer shelf life enables dairy manufacturers to reduce the number of production batches and in turn increase the volume of their production batches. This is because all dairy manufacturers are requested to deliver yoghurt with a certain number of available shelf life days to the retailers' warehouses. In order to achieve this number of available days, the dairy manufacturers need to operate with a certain number of production batches per week per product, e.g. three production batches per week per product. But when shelf life of yoghurt is increased, dairy manufacturers can reduce the number of production batches per week per product and still being able to deliver yoghurt with the required number of available shelf life days to the retailers' warehouses. In this way, bigger volumes in the production batches saves waste through lower production batch frequency, which is the primary waste generator.

⁵⁵ For each yoghurt product manufactured, approximately 18 filled containers (1 kg each) were discarded. The first 10 and the last five containers produced were disposed off, because the dairy wanted to eliminate the risk of substandard content.

Figure 4.4: Batch size and FreshQ® and waste reduction, a German dairy manufacturer



Source: Interview with a German dairy manufacturer using FreshQ®.

An example from a German dairy manufacturer illustrates this. After applying FreshQ®, the dairy manufacturer was able to increase its batch volumes from 6,500 litres to 17,500 litres and in turn reduce its already low production waste an additional 50%. The longer shelf life accruing from using FreshQ® also reduced the return of yoghurt from the retailers because longer shelf life meant less products above the date threshold level at the store. According to CH's market intelligence and the interviews with dairy manufacturers, such return agreements are used in markets such as Denmark, Germany, UK and France, but probably also in other EU countries.

However, product-return waste from retailers' warehouses is something that varies greatly among the dairy manufacturers. Some of the interviewed dairy manufacturers say it constitutes a significant part of their total waste, while others say it is non-existing or very small. It is therefore difficult to estimate accurately and has been set to vary between 0.1% to 2.0% of production, which are the percentages mentioned during the interviews and obtained from available non-scientific sources.⁵⁶ But the estimate has considerable uncertainty and that has implications for the findings as the percentage of return waste has a large impact on the distribution of incentives between dairy manufacturers and retailers, cf. section 0.

Retailers

According to the field study on French retailers' perception towards the value of added shelf life for dairy products⁵⁷, the causes of yoghurt waste are 1) end of shelf life (2.0%-2.5% of production), 2) inventory errors (0.5% of production) and 3) consumer handling (0.1% of production). Overall, these causes generate around 2.6-3.1% yoghurt waste out of total production.⁵⁸

The 2.0%-2.5% waste out of total yoghurt production from end of shelf life for French retailers is somewhat higher than WRAP's corresponding estimate of 1.4% for UK retailers. As both estimates have uncertainties they are assessed to carry approximately the same credibility, cf. section 4.1. The differences are therefore seen as natural variation considering differences in sampling (interview versus measurement), as well as logistics setup, legislation, retailer practices, etc. and both estimates are included in the analysis.

⁵⁶ For instance, new paper articles. For France, an article in *La Vie Eco* mentioned based on interviews with retailers and experts that return rates for dairy products were 1%-2%. <http://lavieeco.com/news/economie/les-industriels-se-plaignent-des-rup-tures-de-la-chaine-de-froid-dans-la-grande-distribution-33688.html>

⁵⁷ Bauquis, C. (2015).

⁵⁸ The right baseline is "product ordered" and not "production". However, in order to keep the same baseline, and since it has no implications for the results whether "product ordered" or "production" is used, "production" is used as the consistent baseline.

An interview with the Danish retailer Dansk Supermarked, who has around 30% of the retail market in Denmark, indicates a total yoghurt waste percentage of 2.3% of production. Assuming that the Danish retailer's yoghurt waste has the same composition as the French retailers, yoghurt waste from end of shelf life is around 1.7% of production, i.e. between the French and the UK estimate.

Since FreshQ® is able to provide longer shelf life for yoghurt, it has the potential to reduce some of yoghurt waste from end of shelf life causes estimated between 1.4%-2.5% of production.

Household consumers

According to WRAP's comprehensive study of household consumers' food waste, the causes of yoghurt waste are 1) not used in time (78%), 2) cooked, prepared or served too much (6%) and 3) Personal preference, accident (contamination, burnt and spoilt) and other (17%).⁵⁹

As the avoidable yoghurt at household consumers is estimated to 8.8% of production, cf. section 4.1, this means that 6.8% (78% x 8.8%) of household consumers' yoghurt waste is due to expiration causes and can potentially be reduced with FreshQ®. WRAP's study also shows that around 50% of the estimated yoghurt waste was thrown away in unopened packaging with another 11% in opened packaging indicating the potential from extended date limits through longer shelf life. If the date on the packaging is longer, then presumably there will be a reduction in the amount of unopened yoghurt waste and if the product lasts longer, then this – and the associated longer date – can both help the opened yoghurt wasted because it was “not used in time” to be reduced.

Summary of yoghurt waste causes

The identification of yoghurt waste causes indicates a relatively high proportion of yoghurt waste being linked to reaching its shelf life. Therefore, it is high likely that increasing the shelf life – e.g. via FreshQ® - will reduce the amount wasted.

Production induced waste at dairy manufacturers are estimated to be around 4.6%-6.4% out of total production in two Swedish dairies and around 5.0%-6.0% in a Danish dairy. The similarity of the numbers makes it plausible to take the narrower range of the Danish study. This means a theoretical maximum waste reduction potential using FreshQ® of around 5.0%-6.0% of total production for dairy manufacturers.

End of shelf life induced waste at retailers are estimated to be around 1.4% for the surveyed UK retailers and around 2.0%-2.5% for the surveyed French retailers. This means a theoretical maximum waste reduction potential using FreshQ® of around 1.4%-2.5% of total production for retailers.

Not used in time induced waste for UK households are estimated to be around 6.4%. This means a theoretical maximum waste reduction potential using FreshQ® of a similar magnitude at household consumers.

Subject to the uncertainty of having only partial estimates of waste and waste causes from four countries, this means that FreshQ® has a theoretical waste reduction potential corresponding to

⁵⁹ Quested, T., & Murphy, L. (2014).

around 15%-17% of total production across dairy manufacturers, retailers and household consumers.

4.3 Step 3: Waste reduction potential with FreshQ®

FreshQ® characteristics

FreshQ® protective cultures inhibits the growth of yeast and mould contamination in dairy products. The contaminant growth delaying effect of FreshQ® is dependent on the level of initial contamination and the quality of the cold chain from dairy to consumption.

Therefore, the number of extra shelf life days which can be obtained by using FreshQ® protective cultures is specific to each dairy and the conditions of the cold chain. In this study, it is assumed that FreshQ® will enable dairy manufacturers to extend the shelf life of their yoghurt with by seven days. From CH experience based on hundreds of lab trials, more than three hundred customer field trials and extensive customer feedback, we consider seven days a conservative average estimate when considering a yoghurt product produced by an average European dairy and sold in average European cold chain conditions.

One of the important objectives of this study is to determine the optimal allocation of these seven extra shelf life days among the key stakeholders in the yoghurt value chain, i.e. dairy manufacturers, retailers and household consumers. Optimal in the sense that the allocation of extra shelf life days provides sufficient financial incentive for all stakeholders to engage in waste reduction of yoghurt and optimal in the sense that the allocation does not discourage consumers from buying yoghurt with longer shelf life, i.e. the extension does not conflict with consumers' preferences for fresh products to such a degree that profit loss from demand reductions is bigger than the savings from reduced yoghurt waste.

Dairy manufacturers

As described in section 4.2, dairy manufacturers' yoghurt waste mainly comes from production, while waste from product return of yoghurt from retailers is more uncertain and volatile varying from less than 0.1% and up to around 2.0%.

Production waste is closely related to the number of production batches as production waste increases with the frequency of the production batches. Thus, as mention in section 4.2, each new production batch requires either cleaning, rinsing or pushing, with cleaning producing the relatively biggest amount of waste and pushing producing the relatively lowest amount of waste, cf. section 4.2.

Table 4.1: Batch frequency, shelf life and waste reduction, two Swedish dairies

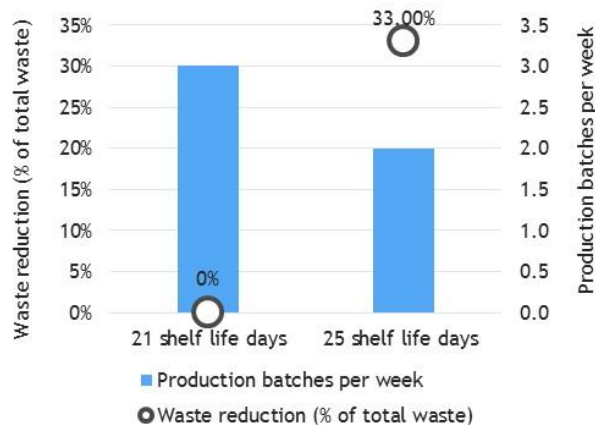
	Today	Goal A	Difference
Dairy A			
Production batches (week):	2-3	2.0	-20%
Production (tons/week):	219,000	219,000	0%
Waste (tons/week):	12,194	9,301	-24%
% waste in production:	6.7%	5.1%	-24%
Dairy B			
Production batches (week):	2-3	2.0	-20%
Production (tons/week):	182,000	182,000	0%
Waste (tons/week):	11,715	8,698	-26%
% waste in production:	5.3%	4.0%	-26%

Source: Berlin, J., & Sonesson, U. (2008).

On the basis of case studies of two Swedish dairy manufacturers, Berlin & Sonesson (2008) show that optimisation of batch sequence with the aim of reducing the number of batches per product reduces waste significantly, cf. Table 4.5. Thus, reducing the batch frequency from two to three per week to two per week reduces waste 24%-26%. In addition, Berlin & Sonesson (2008) assess that a Future A scenario also is possible, where the batch frequency is further reduced to one per week and waste is reduced more than 50%.

The results of Berlin & Sonesson (2008) are interesting as they document the relationship between batch size and frequency and waste reduction, but they do not show how batch size and frequency is related to shelf life days and as such how FreshQ® can reduce waste in connection with batch frequency. This knowledge has therefore been obtained directly from dairy manufacturers.

Figure 4.5: Batch frequency, shelf life and waste reduction, one Danish dairy



Source: Interview with Danish Dairy.

According to an interview with a German dairy manufacturer reducing the number of production batches by one per week will require a minimum of five extra shelf life days. The five days are necessary in order for the dairy manufacturer to be able to still meet retailer' shelf life days' requirements despite fewer production batches per week. How this reduction in batches will impact production waste not disclosed by the German dairy manufacturer. According to an interview with a Danish dairy manufacturer, reducing the number of production batches per week from three to two would require a minimum of four extra shelf life days and would reduce production waste by around 33%, cf. Figure 4.5.

Overall, Berlin & Sonesson (2008) and the Danish dairy manufacturer estimate that reducing batch frequency by one batch per week can reduce production waste by 33%-50%. Further, the German and Danish dairy manufacturers estimate that reducing batch frequency with one batch per week requires an extra four to five shelf life days.

Applying these estimates means that dairy manufacturers potentially can reduce their production waste from the current level of around 5.5% out of total production, cf. section 4.2, to an estimated around 2.8%-3.7% by reducing batch frequency to one batch per week through an extra four to five shelf life days.

With its ability to extend shelf life of yoghurt, FreshQ® can help dairy manufacturers achieve such waste reductions. Actually, even though dairy manufacturers need four to five extra shelf life days to reduce batch frequency, they do not use these extra days in the dairy itself. As described, dairy manufacturers primarily need the date on the yoghurt containers to be longer in order to meet retailers' requirements to available shelf life days, cf. section 4.2



According to interview with a Danish dairy manufacturer, only one of the four extra shelf life days required to reduce batch frequency will be used in the dairy itself while the remaining days can potentially benefit retailers and/or consumers.

Thus, out of the seven extra shelf life days provided by FreshQ®, one or perhaps two days are used at the dairy manufacturers, the remaining five to six days can potentially benefit retailers and household consumers. How retailers and household consumers potentially can benefit from extra shelf life days is described in the next sections.

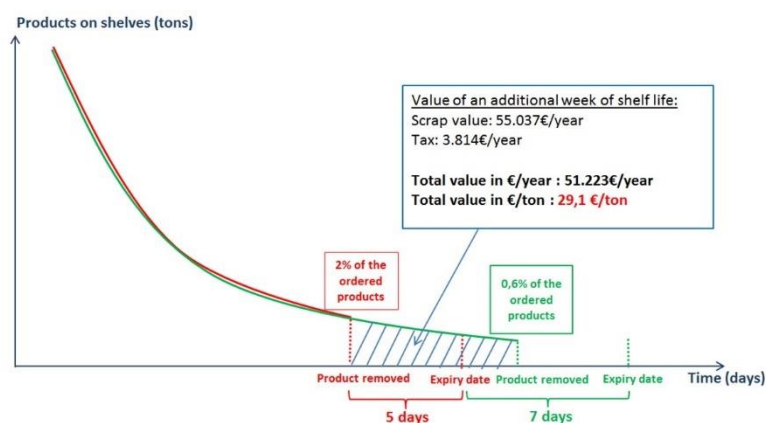
Retailers

The field study of French retailers included Carrefour, E. Leclerc, Intermarche, Casino, Zero Gachis, Auchan and Systems U.⁶⁰ The objective was to determine the possibilities and likely benefits of extending yoghurt shelf life as well as characteristics of retailer yoghurt waste such as waste causes, types of waste and current countermeasures to avoid waste.

The study includes two shelf life case studies, where the percentages of yoghurt left on the shelves were monitored for an increasing number of shelf days. The case studies show that at a certain date threshold, one retailer had 2.0% yoghurt left out of the original amount of yoghurt placed on the shelves, while another retailer had 2.5% yoghurt left on the shelves. After that threshold, the two retailers pursued different strategies for dealing with the remaining yoghurt., cf. Figure 4.6 and Figure 4.7 below.

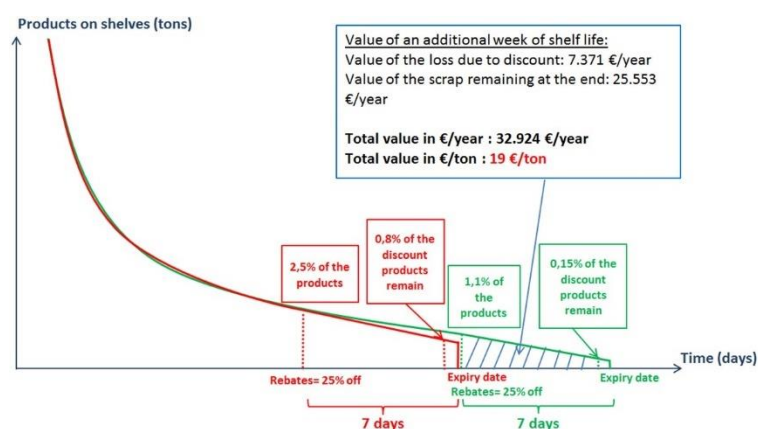
⁶⁰ Bauquis, C. (2015).

Figure 4.6: First retailer case



Source: Bauquis, C. (2015).

Figure 4.7: Second retailer case



Source: Bauquis, C. (2015).

One retailer donated the yoghurt to charity and in turn incurred 2% loss out of the original amount of yoghurt placed on the shelves.⁶¹ Even though donation to charity probably prevents the yoghurt from being wasted, it is still a financial loss for the retailer that will influence the incentives for waste reduction. According to the field study, this retailer is presumably one of the only French retailers donating to charity.

The other retailers use rebates to get rid of yoghurt with few remaining shelf life days. After the threshold date, the retailer started introducing rebates (of around 25%) and after seven more days on the shelves, around 0.8% of the original amount of yoghurt placed on the shelves remained and was subsequently thrown out as it had reached the expiration date.

The case studies provide empirical observation sets consisting of 1) percentages yoghurt left on the shelves and 2) the number of shelf days. In order to establish a tool for assessing the impact of longer shelf life days on the percentage yoghurt left on the shelf, these discrete observation sets have been approximated by a continuous linear function. This way it is possible to assess how the percentages of yoghurt left on shelf develop as one extra shelf life day is added to the total shelf life.

The continuous linear function is simple assuming that yoghurt has a constant probability (p) of being sold on each day it is on the shelf. The ex-ante probability of yoghurt being sold within day t (day t included), called $P(t)$, is given by:

$$\text{Ex ante probability for yoghurt being sold within day } x = P(t) = 1 - (1 - p)^t$$

⁶¹ In France, donating to charity triggers a tax deduction.

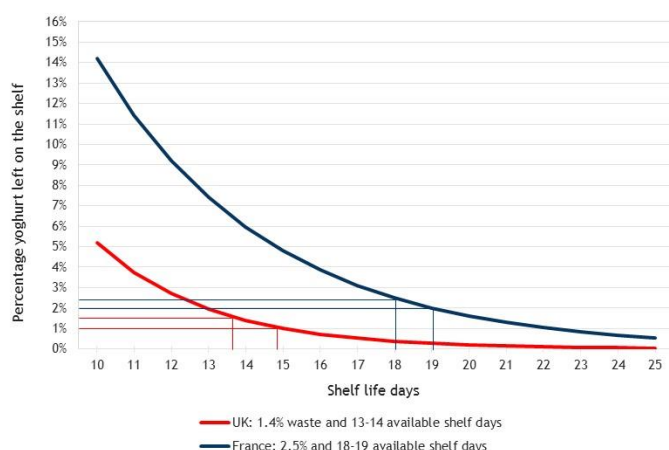
The underlying logic is that on each day yoghurt has an ex ante probability of being sold equaling p minus the accumulated probability that the yoghurt has not been sold on a previous day. It follows that the accumulated probability of a yoghurt being sold within day t (included) can be calculated as one minus the probability that the yoghurt has not been sold. On day one the ex-ante probability of the yoghurt not being sold is $1-p$. The probability of the yoghurt not being sold on day two either is $(1-p) * (1-p)$, which by rearranging leads to the accumulated probability of the yoghurt being sold as stated in the equation above.

As there for each day is an increased probability that the yoghurt has been sold, the ex-ante probability that the yoghurt will be sold on day t diminished as t increases. From section 4.2, it follows that that 1.4% – 2.5% of the yoghurt will not be sold within the expiration date and given a distinct shelf life, the daily probability of the yoghurt being sold can be calculated. Assuming that the waste rate is given by a percentage w and that the total shelf life is n , the daily probability can be calculated as:

$$(1 - w) = 1 - (1 - p)^n \Rightarrow p = 1 - \sqrt[n]{1 - (1 - w)}$$

By assuming that p is a function of store design, filling of shelves etc., the waste reduction (measured in percentage points) from increasing shelf life from t to $t+x$ can then from p be calculated as $P(t+x) - P(t)$. This way of modelling the effect on retail waste from increasing the shelf life generates a continuous linear approximation to the discrete observations on the two retailer cases, cf. Figure 4.6 and Figure 4.7 above.

Figure 4.8:



Source: Interview with Danish Dairy.

The probability (p) is determined from 1) the percentage of yoghurt left on the shelves out of the original amount of yoghurt placed on the shelves and 2) the available shelf life days for the yoghurt. In UK, these set of numbers are assessed to be around 1.4% waste⁶² and 13.7 shelf life days⁶³ and in France, they are assessed to be around 2.0%-2.5% waste⁶⁴ and 18 shelf life days⁶⁵. Based on these sets of observations, it is possible to assess how yoghurt waste develops as additional shelf life days are added to the available shelf life, Figure 4.8.

This flexibility is then used when assessing the optimal distribution of the additional shelf life days provided by FreshQ®.

⁶² See section 4.2.

⁶³ See Lee, P., Osborn, S., & Whitehead, P. (2015), p. 19.

⁶⁴ See section 4.2.

⁶⁵ Bauquis, C. (2015).

Household consumers

In 2013, WRAP published a study on simulating household consumers' food waste.⁶⁶ The study uses a so-called milk model developed to simulate waste of milk at home as a function of consumer behaviour given in terms of shopping and consumption patterns. Depending on the amount of milk purchased in the supermarket and the probability of drinking milk at meals and in between meals, the model estimates households' waste of milk using discrete event simulation.

As milk and yoghurt shares many similarities, the milk model has been adapted to fit the shopping and consumption patterns of yoghurt in order to estimate household consumers' waste of yoghurt. The adaptation of the milk model to yoghurt includes changing shopping patterns to less top-up shopping and extension of average shelf life from 8.1 to 13.7 days⁶⁷. The consumption pattern was also changed with the primary probability being in the morning, cf. Table 4.2 and Table 4.3 below.

Table 4.2: The milk model (original)

Milk Purchasing			
Total amount purchased in main shop (litres)	4	...bought as	2 bottles
Total amount purchased in top-up shop (litres)	4	...bought as	2 bottles
Is the fridge checked and a shopping list made?	No	Trigger for top up shop	1 litres
If so, purchased quantity can vary in step sizes of: (litres)	1		
Average shelf-life of milk	8.1	Once opened use within	3 days
Standard Deviation	1.9		

Milk demand					
	Tea/Coffee	Cereal	Cooking	Drinking	Total
No. opportunities to consumer (per day)	16	4	2	4	
Probability of consumption for each occasion	0.5	0.5	0.15	0.35	
Amount consumed on each occasion (ml)	20	150	600	150	
Average number of consumption events (per day)	8.0	2.0	0.3	1.4	
Average consumption (litres per household per day)	0.16	0.30	0.18	0.21	0.85
Average consumption (litres per household per wk)	1.12	2.10	1.26	1.47	5.95

Table 4.3: The yoghurt model (adapted)

Yoghurt Purchasing			
Total amount purchased in main shop (litres)	2	...bought as	2 bottles
Total amount purchased in top-up shop (litres)	0	...bought as	0 bottles
Is the fridge checked and a shopping list made?	Yes	Trigger for top up shop	1 litres
If so, purchased quantity can vary in step sizes of: (litres)	1		
Average shelf-life of yoghurt	13.7	Once opened use within	5 days
Standard Deviation	3		

Yoghurt demand					
	Tea/Coffee	Cereal	Cooking	Drinking	Total
No. opportunities to consumer (per day)	1	1	1		
Probability of consumption for each occasion	0.319	0.74	0.1		
Amount consumed on each occasion (ml)	150	200	100		
Average number of consumption events (per day)	0.3	0.7	0.1	0.0	
Average consumption (litres per household per day)	0.05	0.15	0.01	0.00	0.21
Average consumption (litres per household per wk)	0.33	1.04	0.07	0.00	1.44

As it has not been possible to find documentation to substantiate yoghurt shopping and consumption behaviour from e.g. consumer research, the chosen shopping and consumption patterns in the adapted yoghurt model are purely layman work based on personal knowledge and experience.

However, with the illustrated setup, the adapted yoghurt model generates 6.8%-7.3% waste out of total production, which approximately correspond to WRAP's 6.8% estimate of yoghurt waste at the household consumers, cf. section 4.1.

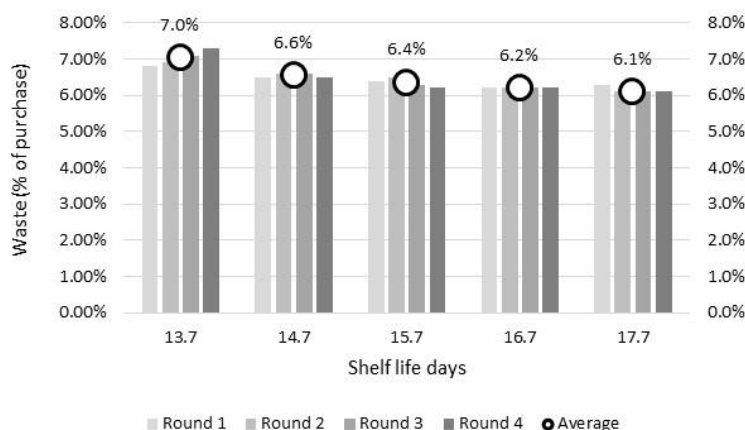
With this setup functioning as today's situation (in UK), the adapted yoghurt model was then used to estimate how household consumers' waste develops as the average number of shelf life days of yoghurt increases one day at the time. This way the model could illustrate the impact of longer shelf life enabled by FreshQ® on household consumers' waste.

The adapted yoghurt model generates relatively stable results. After four model simulations, where the number of yoghurt shelf life days is gradually increased by one day at the time, the model had a standard deviation between 0.05% and 0.19% in its waste percentage estimates for each extra shelf life day added, cf. Figure 4.9 below.

⁶⁶ Quested, T. (2013).

⁶⁷ Average available shelf life of yoghurt in shops are 13.7 days. Lee, P., Osborn, S., & Whitehead, P. (2015), p. 16.

Figure 4.9: Households' yoghurt waste as a function of shelf life days



Source: Adapted version of WRAP's model for estimation of milk waste as a function of shelf life days and consumption pattern. The model has been adapted to yoghurt by changing the number of shelf life days and consumption pattern to fit yoghurt.

With one extra shelf life days, the corresponding reduction in yoghurt waste goes from average 7.0% of purchases wasted to 6.6% of purchases wasted. As evident, the reduction in yoghurt waste is getting smaller as the number of extra shelf life days increases. Adding the first extra shelf life day reduces yoghurt waste 0.4 percentage point (7.0%-6.6%), while adding the next shelf life day only reduces yoghurt waste 0.2 percentage points (6.6%-6.4%), cf. Figure 4.9.

It is however important to emphasise that these results are model results with simplifications compared to real households. For instance, a mechanism for households to use up more yoghurt as it comes up to its date is not present. Also, the model does not use actual consumption or purchasing data for yoghurt. Therefore, this is a very rough approximation to link waste. Subject to this reservation, the adapted yoghurt model is used to estimate the reduction of household consumers' waste of yoghurt as shelf life days gradually increases one by one.

Summary of waste reduction potential with FreshQ®

In order to illustrate the potential impact of FreshQ®, methods have been developed to estimate the reduction in yoghurt waste as shelf life days increase. In section 4.5 and 0, these methods are used to find the optimal allocation of FreshQ®'s seven of extra shelf life days among the dairy manufacturers, retailers and household consumers. By optimal we refer to a situation where the allocation of extra shelf life days provides sufficient financial incentive for all stakeholders in the yoghurt value chain to ensure successful adoption of FreshQ® or equivalent solutions. Similarly, there are behavioural aspects to consider as the waste reduction potential will require consumers in the EU to accept yoghurts with longer shelf life, or, put differently: the adoption of FreshQ® must not conflict with EU consumers' preferences for fresh products to such a degree that profit loss from demand reductions exceeds the savings from reduced yoghurt waste.

This is a relevant focus, but also a narrow focus that excludes other aspects such as the value from helping consumers reduce their waste e.g. by increased loyalty to a retailer or brand.

4.4 Step 4: Waste reduction costs with FreshQ®

An important first step in determining the net financial incentive for investing in reducing yoghurt waste with FreshQ® is to assess whether dairy manufacturers will benefit or lose from such investment. Dairy manufacturers are the stakeholders that shall initiate the waste reduction by applying FreshQ® in their production and are therefore a gatekeeper to change. If they stand to lose, it is difficult to imagine FreshQ®'s waste reduction potential materialising.

Dairy manufacturers' net return has been investigated by estimating the potential cost savings from lower production batch frequency and comparing them to the costs of applying FreshQ®.

CH states that the average costs of FreshQ® is 0.017 EUR per kg of yoghurt. The estimated savings from applying FreshQ® to reduce batch frequency is 1.8%-2.7% of production, cf. section 4.3. Using the market knowledge and experience of CH sales staff to roughly assess retail profit margin and dairy manufacturing profit margin as well as annual reports to determine production costs out of revenue for selected dairy manufacturer, the 1.8%-2.7% waste reduction can be translated into production cost savings of 0.015-0.022 EUR per kg of yoghurt cf. Table 4.4 below.

Table 4.4: Estimated costs of reducing yoghurt waste for dairy manufacturers

No.	Prices, costs and savings	Low	High	Calculation
1.	Price, consumers, EU-28 - weighted across both types of yoghurt, (EUR/kg)	1.375 ¹	1.375 ¹	
2.	Mark-up, retail to consumers, (% of consumer price)	30% ²	30% ²	
3.	Price, manufacturer to retail, (EUR/kg)	0.963	0.963	1. * (1 - (2.))
4.	Production costs out of revenue, manufacturing, (% of revenue)	83% ⁴	83% ⁴	
5.	Production costs, manufacturing, (EUR/kg)	0.801	0.801	4. * (1 - (5.))
6.	Waste reduction savings, (% of production)	1.8% ⁵	2.7% ⁵	
7.	Waste reduction savings, (EUR/kg)	0.015	0.022	6. * 7.
8.	Production costs minus waste reduction saving, (EUR/kg)	0.786	0.779	6. - 8.
9.	Costs of FreshQ®, (EUR/kg)	0.017 ⁶	0.017 ⁶	
10.	Production costs minus waste reduction saving plus FreshQ®, (EUR/kg)	0.803	0.796	9. - 10.
11.	Net difference, (EUR/kg)	-0.002	0.005	6. - 11.

¹ PRODCOM, 2014, 10515241: Curdled milk, cream, yoghurt and other fermented products
10515245: Flavoured liquid yoghurt or acidified milk (curdled milk; cream; yoghurt and other fermented products flavoured or containing added fruit; nuts or cocoa).

² Assumption based on interviews with Chr. Hansen's sales staff and dairies.

³ Assumption based on interviews with Chr. Hansen's sales staff and dairies.

⁴ Calculated on the basis of annual reports from Danish dairies Arla and Thise.

⁵ See section 3.3.

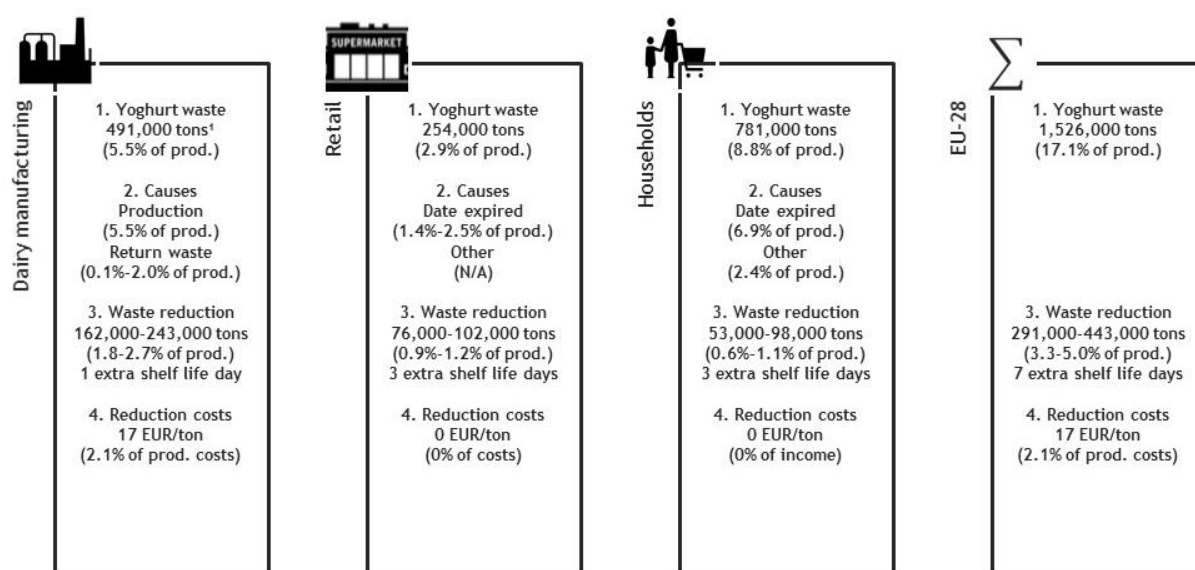
⁶ CH.

As illustrated in Table 4.4, only if production waste is reduced 2.7%, i.e. the high estimate, will dairy manufacturers get a net positive return from using FreshQ® to reduce their production. The financial incentive for dairy manufacturers is therefore not necessarily present from the beginning. Whether this is also the case for retailers and household consumers is discussed in the next section.

4.5 Step 5: Net impacts of reducing yoghurt waste

In previous step 1-4, yoghurt waste and potential for reducing yoghurt waste have been estimated for dairy manufacturers, retailers and household consumers. These estimations indicate that the avoidable waste of yoghurt is 17.1% of total yoghurt production, cf. Figure 4.10 below.

Figure 4.10: Overview of step 1-4



In EU-28, the 2012 estimated annual production of yoghurt was 8.9 Mt.⁶⁸ This means that the estimated waste percentage of 17.1% corresponded to 1,526,000 tons of yoghurt in 2012.⁶⁹

Since the estimates are based on data from France, Germany, UK, Denmark and Sweden, applying an EU-28 level naturally introduces further uncertainty. However, an EU-28 level illustrates the total EU potential and is therefore presented despite the underlying uncertainty. In any case, it is important to emphasise that it is the waste percentages that are essential results and they suggest a significant waste reduction potential.

Figure 4.10 illustrates that the 17.1% yoghurt waste can be reduced by 3.4-4.8 percentage points corresponding to 291,000-443,000 tons across EU-28 in 2012 by applying the extra seven shelf life days from FreshQ®. Of the extra seven shelf life days, one day has been allocated to dairy manufacturers, cf. section 4.3, while the remaining six days as a starting point have been equally divided between retailers and household consumers. The resulting waste reductions have been estimated using the methods developed in section 4.3.

⁶⁸ PRODCOM, 2012, see: <http://ec.europa.eu/eurostat/web/prodcom>.

10515241: Curdled milk, cream, yoghurt and other fermented products

10515245: Flavoured liquid yoghurt or acidified milk (curdled milk; cream; yoghurt and other fermented

⁶⁹ The 2012 estimate has been used because 1) WRAP's estimate of household consumers' yoghurt waste is from 2012 and 2) the dairy manufacturers' waste estimates seem somewhat constant with Berlin, J., & Sonesson, U. (2006) and estimate from Danish dairy being approx. similar, cf. section 4.1.

However, even a significant potential does not materialise unless the responsible stakeholders have sufficient incentive. Bioprotection solutions such as FreshQ® are readily available to dairy manufacturers and their shelf life extending effects well-documented. Nevertheless, bioprotection solutions are not used to their full potential. This is mainly due to the (somewhat justified) perception by dairies and retailers that European consumers will not readily accept longer shelf lives in their fresh dairy products. Similarly, if shelf life of fresh dairy products in EU is extended and household consumers' waste are reduced, dairy producers and retailers will, all else being equal, sell less, unless consumers start consuming (or paying) more.

As a result, dairy producers and, to some extent, retailers in the EU currently do not have strong economic incentives to experiment with shelf life enhancing food technologies such as FreshQ®. If the waste reduction potential illustrated in this study is to be fully realized, there is therefore a need to carefully consider how each of the main actors in the value chain – from dairy manufacturers to retailers and consumers – can maximize their individual gains.

Consequently, the net impacts of applying FreshQ® for each of these stakeholders have been assessed by considering cost savings from waste reduction, costs of applying FreshQ®, saved household income due to less waste and lost profit due to less consumer waste. As a starting point, one extra shelf life day has been allocated to dairy manufacturers while the remaining six shelf life days have been equally divided between retailers and household consumers. The results are illustrated using yoghurt prices and volumes for EU-28, but can just as easily be calculated for a single country, cf. Table 4.5 below.⁷⁰

Table 4.5: Net impacts of reducing yoghurt waste with FreshQ® in EU-28 – the baseline scenario

		Manufacturers		Retailers		Consumers		Total	
		Low	High	Low	High	Low	High	Low	High
Waste reduction	(% of prod.)	1.8%	2.7%	0.9%	1.2%	0.6%	1.1%	3.3%	5.0%
Waste reduction	(1,000 tons)	162	243	76	102	53	98	291	443
CO2	(1,000 tons)	178	267	95	129	67	123	341	520
Waste reduction savings	(million EUR)	130	195	73	99	0	0	203	293
Costs of FreshQ	(million EUR)	-152	-152	0	0	0	0	-152	-152
Saved income	(million EUR)	0	0	0	0	100	183	100	183
Lost profit	(million EUR)	-10	-18	-30	-55	0	0	-40	-73
Net savings	(million EUR)	-32	25	43	44	100	183	111	251

Source: Qbis.

A first observation is that consumers and society will benefit significantly from reducing yoghurt waste. Even though consumer only get three extra shelf life days, they benefit significantly through saved income. Also, since shelf life is only extended with three days, it is quite likely that consumers will not notice the extension, which in turn can prevent consumers from substituting away from yoghurt and a subsequent drop in demand.

⁷⁰ Yoghurt prices and volumes are available at PRODCOM. See: <http://ec.europa.eu/eurostat/web/prodcom>

A second observation – and perhaps more surprising – is that retailers also will benefit from reducing yoghurt waste. Even though they lose profit due to declining demand caused by reduced household consumer waste, the cost savings from reduction of their own yoghurt waste more than offsets the lost profit. This is however not necessarily the case for the dairy manufacturers. Even though they save more costs from reduction of their waste than retailers, the costs of FreshQ®, which they alone bear, can result in negative net savings. However, as illustrated below, if some of the retailers' costs savings are passed on to the dairy manufacturers by means of less product return, the net impacts change rapidly.

A third observation is that there are huge environmental benefits from reducing yoghurt waste. The total CO₂ emissions from producing, distributing and storing one kilo of yoghurt is around 1.2 to 1.3 kilo CO₂ depending on type of yoghurt.⁷¹ This means that the potential waste reduction of 291,000-443,000 tons in turn can reduce CO₂ emissions by 341,000-520,000 tons.

In summary, the only value chain stakeholder that does not necessarily benefit from reducing yoghurt waste is the dairy manufacturers. Since they are the ones that shall initiate the waste reduction by applying FreshQ® in their production, this is critical both from an economic as well as an environmental perspective. However, there are a number of reasons why the above baseline assessment might not be the most likely situation to materialise. This is discussed in the next section.

4.6 Step 6: What it takes to create financial incentives for dairy manufacturers, retailer and consumers

Baseline: Consumers and retailers get 3 more shelf days each

As just described, the baseline assessment does not provide financial incentives for all stakeholders as the medium estimate (average between high and low estimates) suggests a net loss of EUR 3 million from the waste reduction provided by FreshQ®, cf. Baseline figure below.

Lever 1: Consumers get one extra shelf life day and retailers get five extra shelf life days

One way to create financial incentive all stakeholders including dairy manufacturers is to chance the baseline's split with three extra shelf life days to both retailers and household consumers. If less than three shelf life days are allocated to the household consumers, the lost profit due to declining demand caused by reduced household consumer waste will be reduced and in turn improve the financial incentives for retailers and dairy manufacturers. By varying the allocation extra shelf life days across the value chain stakeholder, it is evident that it is necessary to allocate five extra shelf life days to retailers and just one extra shelf life day to household consumers in order to achieve positive net savings for all stakeholders, cf. Lever 1 below. This new allocation actually increases the overall waste reduction percentage slightly from 4.1% to 4.2% out of total production, which means that financial incentive can be created without impairing overall waste reduction for society. This is due to the analysis' assessment of a more modest reduction in yoghurt waste for

⁷¹ Research Institute of Organic Agriculture (FiBL), see: https://www.fibl.org/fileadmin/documents/de/oesterreich/arbeitschwerpunkte/Klima/Presentation_Schader_Biofach_1002.pdf and Ministry of Environment and Food of Denmark, see: https://naturerhverv.dk/fileadmin/user_upload/NaturErhverv/Filer/Tvaergaende/Foedevarenes_klimaaftak_tabel_1.pdf

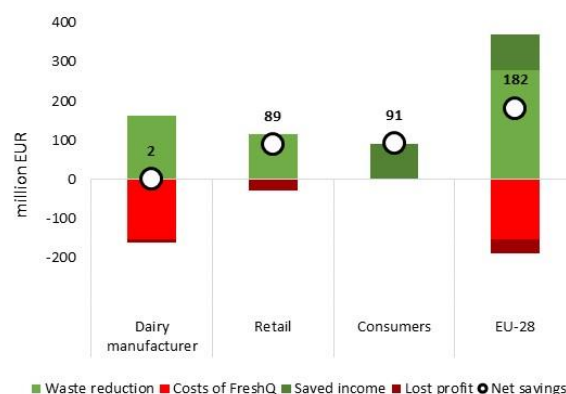
household consumers than retailers when given more shelf life days, cf. section 4.3. As this assessment is subject to uncertainty, the status quo result for society can easily change to a situation with less overall waste reduction.

Baseline: Consumers and retailers get 3 more shelf life days each (4.1% waste reduction)



Source: Qbis

Lever 1: Consumers get 1 more shelf life day and retailers get 5 more shelf life days (4.2% waste reduction)



Source: Qbis

Lever 2: 10% of the retailers' waste reduction savings are reallocated to the dairy manufacturers

In addition to changing the allocation of extra shelf life days, another factor might also change the distribution of the net savings among the value chain stakeholders in the baseline estimation. According to interviews with CH sales people and dairy manufacturers, waste due to product return to dairy manufacturers from retailers' warehouses seems to be quite common in UK, France, Germany and Denmark, even though the waste generated from this arrangement varies greatly corresponding to around 0.1%-2.0% of total yoghurt production.

It is therefore possible that reallocating of some of the retailers' savings from waste reduction to the dairy manufacturer can improve the financial incentive of dairy manufacturers. The analysis shows that if just 10% of the retailers' waste reduction savings are reallocated to the dairy manufacturers in the baseline assessment corresponding to 0.1% of total yoghurt production, the dairy manufacturers will have a positive net saving from using FreshQ®, cf. Lever 2 below.

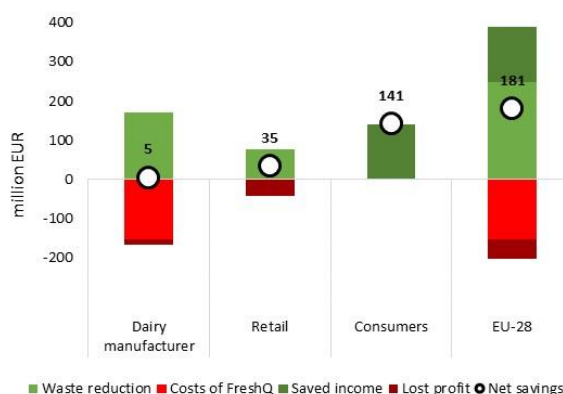
Lever 3: Maximum waste reduction for consumers with 6 more shelf life days

Will creating financial incentive for all stakeholders mean a loss for society in terms of less than optimal waste reduction from FreshQ®? This issue has been addressed by allocating all off the six available extra shelf life days to consumers and zero days to retailers. While this allocation increases consumers' saved income from EUR 141 million to EUR 238 million and reduces retailers' waste reduction saving to zero, it does not create additional benefits to society. Actually, the overall net savings are reduced from EUR 181 million to EUR 154 million, cf. Lever 3 below.

This is because consumers waste reduction savings are assessed to have a relatively modest progression as extra shelf life days are added to their yoghurts' total shelf life, cf. section 4.3. As this progression is predicted by the adapted milk model and as such is the result of model simulations

rather than real life measurements, the result can turn out to be inaccurate in which case creating financial incentives for all stakeholders can result in a price for society in terms of less than optimal waste reduction from FreshQ®.

**Lever 2: 10% product return arrangements in baseline
(4.1% waste reduction)**



Source: Qbis

**Lever 3: Maximum waste reduction for consumers with 6 more shelf life days
(3.7% waste reduction)**



Source: Qbis

What about prices?

When demand changes, it is important to investigate what happens to prices. However, probability of higher prices is assessed as low because the mini-consumer survey and existing market experience suggest that consumers will not be willing to pay higher prices for yoghurt with longer shelf life. Similarly, the probability of lower prices is also assessed as low given the above scenarios consider situations with one or three extra shelf life days to consumers. Thus, with one extra shelf life day, demand is expected to be reduced 0.3%-0.8% and with three extra shelf life days, demand is expected to be reduced 0.6%-1.1%. I.e. both very modest demand reductions. In addition, it has not been possible to find studies of demand price elasticities for yoghurt in the European markets. The closest is a 2010 US study estimating price elasticities to -0.16 for refrigerated yoghurt and -0.60 for drinkable yoghurt.⁷² This would in turn mean very low price reductions. Finally, considering price mark-up is assessed 10% for dairy manufacturers and 30% for retailers, the corresponding profit loss is a tenth and a third of the price reduction. On the basis of these considerations, price reactions have not been included in the analysis. It will however be important to include price reactions, if demand changes more than anticipated in the above scenarios or if other waste reduction measures are investigated.

Summary of supply chain incentives for reducing yoghurt waste

The objective of the further development of the baseline assessment is to illustrate what it will take to create financial incentive for all value chain stakeholders including dairy manufacturers when using FreshQ® to reduce yoghurt waste as well as to investigate a possible trade-off of creating fi-

⁷² See: http://ageconsearch.umn.edu/bitstream/139041/2/Davis_41_2.pdf

nancial incentive. It shows that extra shelf life days to retailers and fewer to the household consumers or 10% product return from retailers to dairy manufacturers both will improve the net savings for dairy manufacturers sufficient to create financial incentive for all value chain stakeholder.

Hopefully, these further developments of the baseline assessment can bring new perspectives and lead to new discussions about the feasibility of reducing yoghurt waste among dairy manufacturers, retailers and also consumers. Such discussion with value chain stakeholders would also be valuable in the sense that they would test the validity of the underlying estimations and assumptions in the study and as such substantiate or alter the findings. Also, such discussions could lead to new scenarios as the four presented in no way cover the many possible outcomes when reducing yoghurt waste.

Assumptions and uncertainty factors in the analysis and results

When using the results, it is important to do so with caution. The analysis and its results are based on a number of assumptions and generalisations that will generate uncertainty, notably:

- Data is not complete and it has been necessary to assume that waste percentages and waste causes observed at stakeholders in one country also are valid for other stakeholders in other countries. For instance, household consumers' waste percentages and waste causes in the UK are assumed representative for household consumers in other EU countries. Similar generalisations have been applied to dairy manufacturers' and retailers' waste percentages and waste causes.
- Apart from dairy manufacturers, assessment of the value chain stakeholders' response to longer shelf life days is based on studies from just one country. For the retailers' response to longer shelf life days, it is a case study from France and for the household consumers' response to longer shelf life days, it is a behavioural model from the UK.

These factors will lead to uncertainty and it is therefore important to use the findings as indications of the potential of reducing waste rather than hard facts given the uncertainty associated with such assessments.

4.7 Results of the mini-consumer survey

In addition to financial incentives, consumer preferences can be important barriers to reducing yoghurt waste with longer shelf life. As mentioned, dairy manufacturers and retailers are often convinced that European consumers will not readily accept longer shelf lives in their fresh dairy products as this implies reduced freshness. Consequently, extending shelf life with three days as proposed could risk reducing demand simply due to consumer preferences for perceived freshness and in turn undermine the potential positive net savings. Alternatively, the fear of this happening could prevent dairy manufacturers from even considering reducing yoghurt waste via longer shelf life.

It is therefore paramount to test consumers' preferences for freshness generally as well as specifically in the light of the potential for reducing their food waste. Such testing would ideally require measuring waste and purchases before and after a change in shelf life. This is unfortunate outside the scope of this study, but in order to provide at least some sort of indication of consumers' preferences, a mini-survey has been carried out. It was conducted in Denmark, where preferences for freshness generally are ranked high among consumers, and the approach was simply to ask consumers a number of questions regarding yoghurt before entering one of the shops of three of the biggest retailers in Denmark.⁷³ A total of 70 respondents participated in the survey and they could answer by agreeing or disagreeing with different statements. The levels of agreement and disagreement went from one to ten with one being in full agreement and 10 being in complete disagreement.

Question 1 was whether consumers always try to find the yoghurt with the longest remaining shelf life when buying yoghurt. The answers to that questions were relatively unambiguous with 53 answers in agreement (1-5) out of a total of 63 answers, cf. Question 1 below.

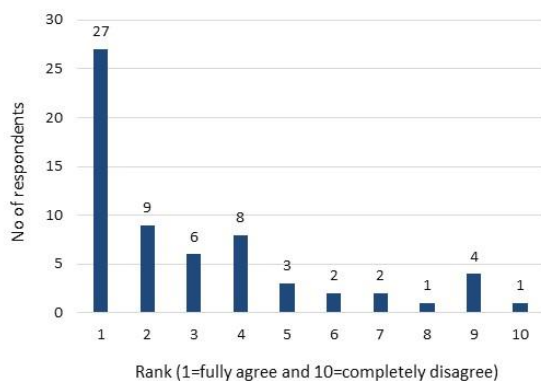
Question 2 was whether consumers always would buy a yoghurt longer shelf life than their normal yoghurt, if they could save money. Consumers were evenly divided to that question with approx. one half being in agreement (1-5) and the other half being in disagreement (6-10), cf. Question 2 below.

Question 3 was whether consumers wanted to buy yoghurt with longer shelf life than their normal yoghurt, if it enables them to reduce food waste. Similar to question 2, consumers were evenly divided to that question with approx. one half being in agreement (1-5) and the other half being in disagreement (6-10), cf. Question 3 below.

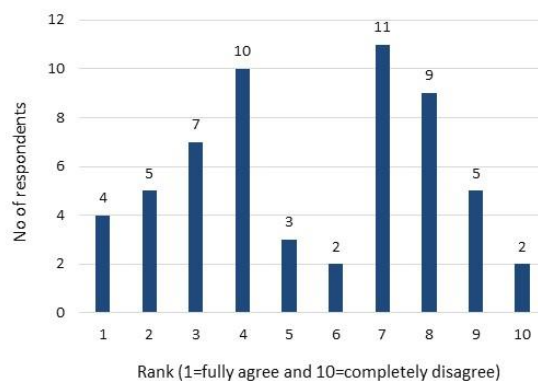
Question 4 was whether it was important to consumers that their yoghurt is natural, and does not include artificial additives (E-numbers) to prolong shelf life. Similar to question 1, the answers were relatively unambiguous with 49 answers in agreement (1-5) out of a total of 67 answers, cf. Question 4 below.

⁷³ The shops were Netto and Føtex (owned by Dansk Supermarked w. approx. 30% market share) and Superbrugsen (owned by COOP w. approx. 42% market share).

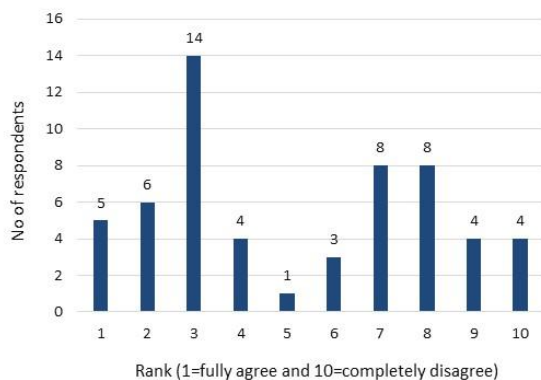
Question 1: When I've decided what kind of yoghurt, I'll buy, I always choose the yoghurt with the longest remaining shelf life



Question 2: I want to buy a yoghurt with longer shelf life than my normal yoghurt, if I can save money in my household

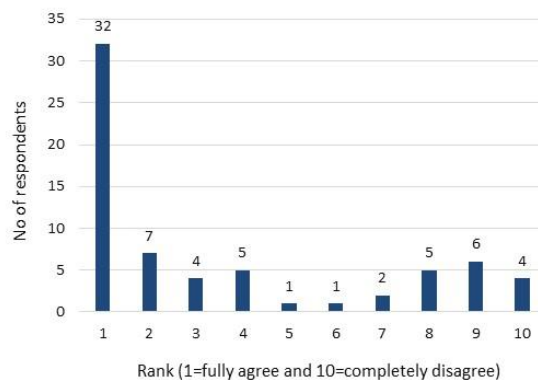


Question 3: I want to buy yoghurt with longer shelf life than my normal yoghurt, if I can help to reduce food waste



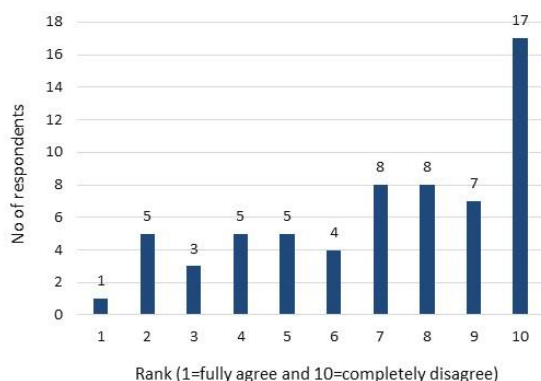
Source: Mini-consumer survey of consumers before shopping in four of the biggest Danish retail stores.

Question 4: It is important for me that my yoghurt is natural, and does not include artificial additives (E-numbers) to prolong its shelf life



Source: Mini-consumer survey of consumers before shopping in four of the biggest Danish retail stores.

Question 5: I would like to pay more for a yoghurt with longer shelf life if everything else is similar to my normal yoghurt



Source: Mini-consumer survey of consumers before shopping in four of the biggest Danish retail stores.

Finally, question 5 was whether consumers were willing to pay more for a yoghurt with longer shelf life if everything else is similar to their normal yoghurt (same taste, freshness, natural-ness). Only 19 respondents agreed to the statement, while 44 respondents disagreed.

A pattern seems to emerge with the respondent having a preference for yoghurt with the longest remaining shelf life when purchasing yoghurt, but otherwise split between being in agreement or disagreement on whether they would accept longer shelf life if it enabled them to save money and/or reduce food waste. Most respondent also have a clear preference for natural yoghurt and will not pay more for yoghurt with longer shelf life.

Summary of finding from mini-consumer survey

The results of the mini-survey were not clear-cut in terms of clearly indicating a consumer acceptance of reducing yoghurt waste with a longer shelf life. The respondents were evenly split when it comes to buying yoghurt with a longer shelf life if it enables them to reduce waste.

However, an even split was actually a bit surprising since the perception of many dairy manufacturers seem to be that no consumers will accept longer shelf life. It is also interesting that most respondent have a preference for the yoghurt with the longest remaining shelf life when they purchase yoghurt.

Finally, it is important to emphasise that freshness is not fixed. How freshness is defined and understood varies from country to country and so does the total available shelf life days. Considering the significant variation in available shelf life, consumers experience when buying yoghurt⁷⁴, extending shelf life with three days might not necessarily result in contractions in demand. But this requires further analysis of consumer preferences and behaviour to answer properly.

⁷⁴ In the UK average available life in the shops is 13.7 day, but the minimum days is zero and the maximum days is 27. Lee, P., Osborn, S., & Whitehead, P. (2015), p. 16.

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Appendix A: Expert review

Review by Tom Quested from WRAP

I have reviewed the white paper Reducing food waste and losses in the fresh dairy supply chain. The initial review was on a version of the paper dated 23rd September 2016, with a subsequent check of the version on the 30th September.

The paper contains an analysis of the potential impact of introducing a bio-protective culture to yoghurt, which increases the shelf life of the product. The resultant effect on waste levels within the following is assessed: dairy manufacturers, retailers, households. It examines the changes in waste levels and the associated economic impacts for each of these three groups to understand how incentives are distributed. Furthermore, it explores a number of 'levers' – different ways of distributing the extra shelf-life and savings – to find situations in which all the sectors studies have a positive outcome.

The authors have used existing information from a wide range of sources effectively. In addition, they have obtained new information where necessarily and feasible. The analysis conducted appears robust and the results of this analysis support the conclusions made. With studies of this type, assumptions have to be used. Those used in this study are reasonable and have been described in the report. Their implications on the results acknowledged.

The initial review of the paper highlighted a small number of areas for improvement, relating to details of the analysis and the presentation of the results. These suggestions were acted upon and were incorporated into the later version of the paper seen.

Currently studies examining the potential for and implications of food-waste reduction are limited – they do not cover the wide range of products and sectors that could potentially generate less food waste. Of the existing studies, there are very few examining yoghurt waste and none that I am aware of that take a whole chain approach (for any product). As such, this paper represents a positive contribution to the existing evidence base. Furthermore, by focusing on a practical question about incentives, it should help facilitate real change with a positive environmental and economic impact.

Tom Quested, WRAP

30th September 2016