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Collation of Scientific Evidence on Consumer Acceptance of New Food Technologies:

Three roads to consumer choice

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Abstract

The current report investigates consumer acceptance of new food technologies by reviewing the scientific literature.

The review is organised along three routes to consumer acceptance of new technologies: *The consumer benefit road*: the central road of technology features influencing experienced product attributes; *the technology apprehension road*: a socio-political road where unfamiliarity and dread may lead to negative technology attitudes, which may create categorical rejection of any product created with that technology; and *the retail/caterer service road*: where novel technologies does not directly influence perceived product characteristics, but results in novel retail and caterer business models, product placement and customer relation services.

The available literature on 4 types of novel food technologies *Mild processing technologies*; *Electromagnetic methods*; *Texturizing technologies*; and *Novel packaging and storage technologies* is reviewed along these roads. The results show that research remains fragmented in approach and usually adopts the point of view of a single road to consumer acceptance of a novel technology. Nevertheless by combining the available evidence recommendation can be made how the different roads contribute to consumer acceptance or rejection of a novel food technology dependent on technology characteristics.

A checklist for the introduction of novel food technologies taking account of all the roads and the technology is presented at the end of this report.

Introduction

Innovative food technologies are continuously being developed. The success or failure of these innovations depends, to a large extent, on end-user uptake of the technologies, as evidenced through consumer use of products created with those technologies. Although the importance of consumer uptake of products incorporating innovative technologies products has long been acknowledged, the success rate of innovations in food remains low (e.g. Van Kleef, Van Trijp, & Luning, 2005). This implies that apparently, and in spite of major research efforts on technology acceptance, there is insufficient understanding how technology embedded in products influences end-user purchase decisions.

When considering consumer purchase decisions of products created with novel technologies, three issues stand out as important paths through which technology attributes can influence end-user choice (figure 1).

- 1) Tangible product attributes modified by a technology. Often, the purpose of new food technologies is to improve a particular product attribute (e.g. tenderising techniques improve texture) without altering other attributes (e.g. taste and safety). Such changes in product quality support the end-user in selecting the preferred product. Understanding consumer perceptions of product quality has been the subject of marketing and sensory research (see e.g. Andersen, 1994; Grunert, Hartvig Larsen, Madsen, & Baadsgaard, 1996; Poulsen, Juhl, Kristensen, Bech, & Engelund, 1996; Steenkamp & Van Trijp, 1996).
- 2) Specific attributes of a technology can create resistance against, or support for, the technology as a whole. These socio-political technology attitudes can influence the desirability of a product developed with those technologies. This approach has received considerable attention in risk psychology (following Slovic, 1987) and related applied research across several food technologies (Fife-Schaw & Rowe, 2000; Frewer et al., 2011).
- 3) Technologies can influence the way in which retail and catering offer products to the consumer. While the importance of product placement in the environment is considered basic knowledge (e.g. Kotler, 1991), the realisation that, and the idea of how, food technologies can contribute to a different presentation of product to the end-users leading to specific retail and service attributes, and as such contribute to success or failure of innovations, is relatively under-researched (Sorescu, Frambach, Singh, Rangaswamy, & Bridges, 2011).

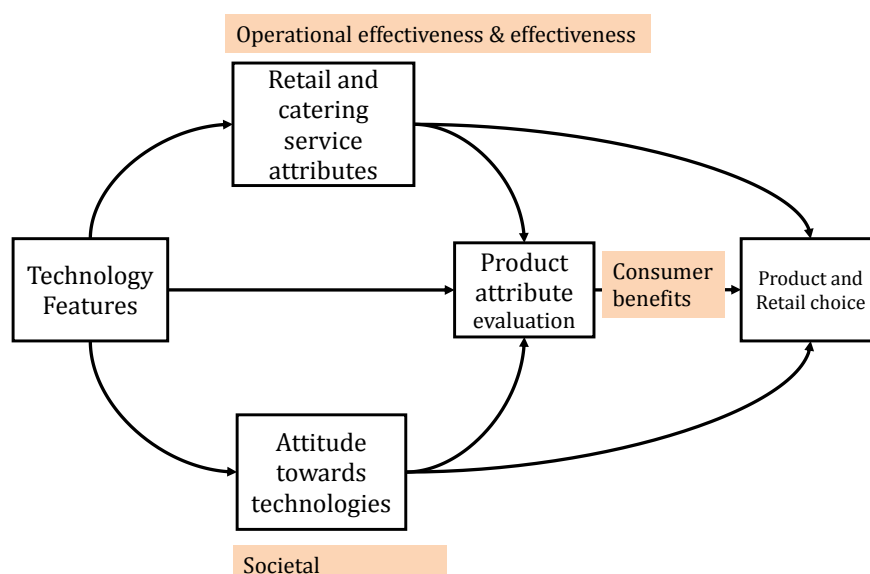


Figure 1: Three roads to product and outlet choice.

The three roads by which technology can reach and influence the end-user are recognisable in the consumer behaviour literature. Still, these roads are discussed in isolation and there is no systematic analysis of how technology attributes may influence end-user choice through a combination of these roads. The effects may interact at the product evaluation stage, or at the final choice moment. Knowledge of the effect of technology attributes through each route to final consumer choice allows the identification of a checklist of crucial technology attributes that may hinder or support consumer acceptance and choice for a product created with the new technology.

To this aim, the current report reviews the current view on the effects of product quality attributes, technology attitudes and retail service attributes on consumer uptake of innovative technology. Subsequently, and related to the existing and emerging consumer needs identified in D2.1, we review a range of promising technologies in order to identify specific attributes of these technologies that relate to consumer needs and thus trigger their support or rejection, on each of the lines: product quality, technology attitude and retail service quality).

Three roads to consumer acceptance of food products embodying new technologies

Product attribute evaluation

Existing attitude decisions models (e.g. those models underlying the theory of planned behaviour Ajzen, 1991; Fishbein & Ajzen, 1975) consider attitudes as a weighed sum of consumer-relevant product attribute evaluations. Consumers base their choice for food products and services, at least partially, on the specific attributes of the product. Product features that can be immediately verified by consumers at the time of purchase or consumption, are called *experience attributes* (e.g. Steenkamp, 1990). Important experience attributes in the context of food include convenience, and sensory features such as appearance, taste, smell, and texture. A product's price, be it expressed in currency or value for money, is another experience attribute that should be taken into account

If the experience attributes were the only factors influencing consumer evaluation of new products, substantial equivalence to existing products would be a sufficient argument to take away potential concerns consumers may have about new products. Similarly, improvements to experience attributes would automatically lead to positive new product evaluations. In reality intangible, more abstract product properties are also important for consumer choice. Such *credence attributes* cannot be verified by the consumer at purchase or consumption (Darby & Karni, 1973). Instead, consumers need to rely on information on the product. Examples include a product's health and environmental effects or supply chain relations behind the product, but also processing technology, such as genetic modification and irradiation, which may influence product perceptions. In food marketing, the importance of credence attributes next to experience attributes has become an integral part of food quality models since the mid-1990s (Andersen, 1994; Grunert, et al., 1996; Poulsen, et al., 1996; Steenkamp & Van Trijp, 1996). Besides experienced product attributes, credence attributes relating to health, authenticity, sustainability also play an important role in the food product choice nowadays.

The inclusion of credence attributes in food attitudes makes it reasonable to assume that credence about the acceptability or even desirability of a technology may influence the overall product quality assessment. This inference has indeed been found in different sensory studies (Porretta & Poli, 1997), where some consumers were informed a product was created by use of genetic modification, while others were not given this information. The mere knowledge of the processing technology resulted in different valuation of the product. This interaction between tangible product properties and evaluation of abstract credence attributes on product choice has been investigated in as a combination of deductive (or top-down) models of product evaluation based on the overall technology attitudes and inductive (or bottom up) models of product evaluation (based on more concrete product properties) (Brunsø, Scholderer, & Grunert, 2004; Søndergaard, Grunert, & Scholderer, 2005).

Societal attitudes towards technologies

Societal attitudes to technologies have been frequently studied in the context of risk perception (Ronteltap, Fischer, & Tobi, 2011). Early studies on risk perception on a range of technologies have shown that technologies that could lead to long term, major, fatal or catastrophic effects are dreaded more than would be predicted by a

technical risk assessment; and that technologies with little familiarity, that are perceived as more technological than natural, and many uncertainties also increase perceptions of risk (Fischhoff, Slovic, & Lichtenstein, 1978; Slovic, 1987, 1992).

From the mid-1990s onwards, a considerable amount of work has been dedicated to risk perceptions related to food (Frewer, Bergmann, et al., 2011). In agreement with the earlier work on general risk perception, dread and familiarity dimensions were shown to influence risk perceptions of foods similar to other technologies (Fife-Schaw & Rowe, 1996, 2000). In this tradition, a wide range of studies on consumer acceptance of novel technology in relation to risk perceptions has been conducted. These studies refer for example to the acceptance of irradiation (Bruhn, 1995; Marcotte & Kunstadt, 1993), high pressure processing (Sorenson & Henchion, 2011) (Sorenson & Henchion, 2011), nanotechnology in food (Frewer, Kampers, Fischer, & Norde, 2011; Siegrist, Cousin, Kastenholz, & Wiek, 2007; Siegrist, Stampfli, Kastenholz, & Keller, 2008), but foremost genetic modification (For a meta-analysis see: Frewer et al., in press).

Typical for these studies is their focus on the technology as a whole. Attitudes towards technology as a whole are measured both by surveying attitudes towards the abstract technology in isolation (e.g. Bredahl, 2001), or by inferring technology attitudes from response on products embodying these technologies (e.g. Siegrist, 2000). Once the attitude towards a technology is known, it can then be interpreted as a product attribute that contributes to overall evaluation of products created with the technology (for a meta-analysis see: Lusk, Jamal, Kurlander, Roucan, & Taulman, 2005). The outcomes of this line of research can be used to identify when a technology leads to categorical rejection of products created with the technology (Bonny, 2003), or at least a negative inclination that affects product choice beyond product evaluation.

Consumer researchers increasingly realised that people do not choose products based on abstract properties, but based on concrete benefits of products they consider to choose. Technologies without a relevant consumer benefit are unlikely to have a positive impact on consumer choice. Understanding the extent to which technologies can create concrete consumer benefits implies realising that relevant benefits exist in the context of goal achievement; that is, what is beneficial for some individuals, may not be so for others, or in a particular situation. Attitudes outside the frame of behavioural goals are therefore imperfect predictors of behaviour. Studying attitudes as product evaluations is relevant only if we accept that “thinking is for doing” (Fiske, 1992; paraphrased after James, 1890/1950). However, the behavioural goals are person and situation-dependent, and not necessarily stable over time (needs change with welfare level cf. Maslow, 1943). Hence, in practice, a technology may create a negative image for a product compared to an identical alternative created without the technology, but may still be acceptable if the negative image is offset by tangible personally relevant benefits resulting from that same technology (e.g. Schenk et al., 2008; Schenk et al., 2011). Thus, top-down inferences of the technology may influence product evaluation (Grunert, 2002), but this process requires integration with the evaluation of other product attributes (bottom-up approach) to arrive at a definitive judgement of the product.

Retail and caterer service attributes

Products reach the consumers through the retail channel. Retailers can, through their activities and infrastructure, influence how consumers perceive and value the products they offer for sale. Choosing specific product mixes (e.g. Conant, Smart, & Solanomez, 1993), pricing strategies to promote consumer switching behaviour (e.g. Kocas & Bohlmann), placing products at specific locations in specific ways in the shops (van Herpen, van Nierop, & Sloot, 2012), or in catering outlets (van Kleef, Otten, & van Trijp, 2012) are among the actions retailers and caterers can take to influence consumer decisions. In addition, the outlet atmosphere and image can be influenced by retailers and caterers.

While these classical marketing approaches are of high importance to introducing new technologies in food retail and catering, new technologies may allow further advances in the retail business strategies used (Sorescu, et al., 2011). New technologies may affect the retailers', or caterers' success in appropriating part of the market. New technologies may increase operational efficiency, for example by reducing wastage following longer shelf lives of products, or dynamic pricing of products approaching their sell-by-date. Technologies may allow retailers increase their effectiveness by offering bundled products based on consumer demand of similar products in similar situations, or may create customer lock-in by the retailer being the exclusive seller of a product, or by

continuously adjusting assortments and offers to specific consumers. New technologies may allow retail to create more value to the consumer, and thus increase profit margin, by increasing efficiency for the consumer for example by creating automated payment using RFID tags reducing waiting time before cashiers desks (Sorescu, et al., 2011). In addition, customer ordered products can be created, increasing the chance of consumers achieving their shopping goals, i.e. making shopping more effective as well as providing in depth background information on products, for example using smartphone applications to create consumer engagement with products (Sorescu, et al., 2011).

The applications of novel technologies that influence retail and caterer decisions and actions can influence consumer choice by affecting the choice of products and outlet directly, or by influencing consumers' inferences of product quality indirectly. The first type of effect relates to the outlet and brand image, resulting in the consumer repeatedly choosing the outlet or brand without further consideration of specific product attributes. The second effect refers to the situation where retailer or caterer actions result in product perceptions, for example, where placing dairy with extended shelf-life in uncooled shelf space, may reduce the perception of freshness, while bundling specific products, for example wine with olives and bread may create Mediterranean associations spreading to all products in the combined display.

In summary, based on the existing literature we propose a model for consumer uptake of new products and service in food that follows three roads to choice.

- (1) *The consumer benefit road*: this is the central road of technology features influencing experienced product attributes, leading to inductive inferences (bottom up) of quality and choice.
- (2) *A technology apprehension road*: a socio-political road where unfamiliarity and dread may lead to negative technology attitudes, which may create categorical rejection; or where naturalness may lead to positive attitudes limiting the choice set to the category of products produced with that technology. Besides limiting the choice of products, socio-political attitudes may also provide top-down, deductive inferences (top down) towards the product evaluation.
- (3) *A retail/caterer service road*: a service attribute road, where technology attributes may allow novel retail and caterer business models, product placement and customer relation services. Such business models may result in inductive inferences (bottom up) about product attributes and thus the product as a whole, or may result in changes in store image affecting choice directly (figure 2).

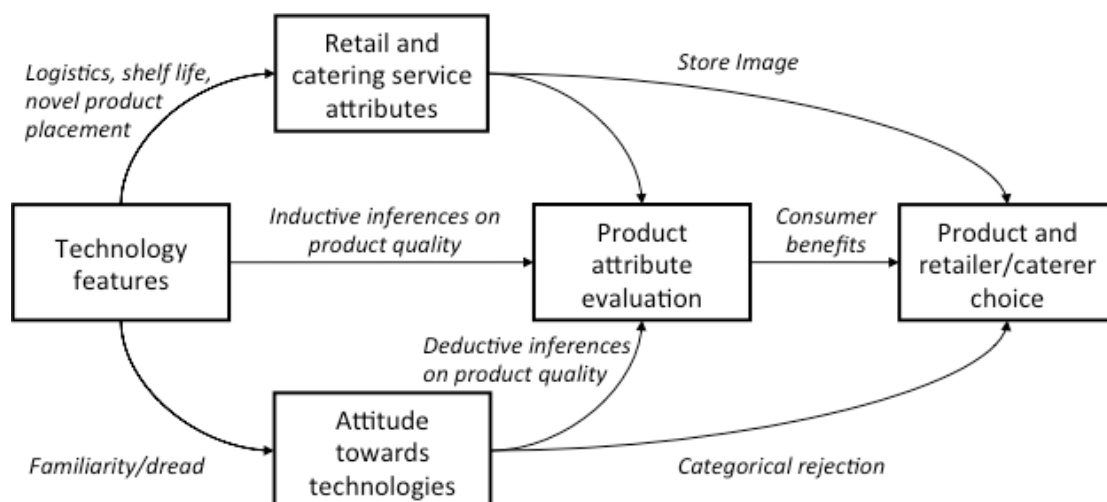


Figure 2: Theoretical basis for three roads to consumer acceptance.

Review of literature on selected technologies

To investigate the potential of the proposed framework, a selection of current technologies used in food production is reviewed. The selection consists of the novel technologies identified as important innovations in food identified by work package 3 of RECAPT (RECAPT WP3, 2012).

Technology attributes

In work package 3 of RECAPT, 15 promising novel technologies were selected for use within the project. Irradiation technology will, at this stage, be excluded from the current review, as this technology has by now a history of over 50 years of development, with several major controversies in the past (Spiller, 2004). Consequently, there is a high likelihood of categorical consumer rejection of this technology, and this aspect has resulted in regulatory limitations of its application, putting it outside the normal playing field of food production and sales (cf. Rothschild, 1999; Van Trijp & Fischer, 2011). Similarly, genetic modification is not considered relevant to the current review.

The current review aims to analyse existing scientific literature on how the selected technologies reach the consumers through the three identified roads. Following work package 3, these technologies were classified into four broad categories:

Table 1: Technologies studied within Recapt (based on: RECAPT WP3, 2012 pp. 8-17)

Technology	Description	Currently sold
<i>I Mild processing technologies.</i>		
1. High Pressure technology	Applying extremely high pressure (up to 6,000 Bar) to products in order to inactivate bacteria.	Beverages, some cured products
2. Pulsed Electric field technology	Sending a brief, strong electric field pulse through a product, destroying microbes.	Beverages, some special applications
3. Cold plasma	Pulsed radio frequency discharges in an electrically charged gas create a plasma on sterilising the treated surface.	Sterilized bottles
<i>II Electromagnetic methods</i>		
4. Ohmic heating	Electricity is passed through the food ensuring rapid and uniform heat treatment throughout the product.	None
5. Infrared heating	Use of infrared light to heat the (outside) of a product, without the need for contact with heat source, or heated environment	None
6. Electron irradiation (excluded)		
<i>III Texturizing technologies</i>		
7. High pressure homogenization	Fluids are pressed through small nozzles creating very homogenous emulsions down to Nano-scale	None
8. Shockwave technology	Ultrasound high-energy shockwaves used to tenderise meat	None
9. Super critical fluid extraction (SCFX)	A fluid is made supercritical and used to extract soluble materials from agricultural products (e.g. sugar beet processing)	Cacao butter, Decaffeinated coffee, cholesterol removal in fats
10. Ultrasonic cutting	Ultrasonic sounds are used to cut soft foods, reducing mechanical stress, pressure and contamination, without introducing problems associated with water jet (wetness), and laser cutting (burns)	Cheeses, ice-cream, baked products
<i>IV Novel packaging and storage technologies</i>		
11. Edible coatings	Transparent layer applied to the food to prevent oxidising and drying out of products	Meat, ready meals, fruit and vegetable
12. Active packaging	Materials actively applying gases and other substances within the atmosphere of the product	Meats, ready to eat meals, cheeses, fruits and vegetables
13. Intelligent packaging	Packaging that can identify and report product quality within the package to the processor, retailer or end-user	Time temperature indications
14. Biodegradable packaging film	Packaging materials that will biodegrade in a natural environment	None
15. RFID	Radio frequency identification to allow tracking and tracing of products through the production chain	Mainly in livestock, not in retail

Methods

Starting from these technologies, for each line of research (socio-political attitudes, product attributes, retail) a search term consisting of a string of keywords was developed. The search term consisted of a reference to the person involved (e.g. consumer or customer), the effect studied (e.g. attitude) and the technology being considered (the full search terms are reported in Appendix I). The search terms were entered into Scopus a

database holding scientific publications in a broad range of domain (www.scopus.com). This resulted in a number of papers that were screened on relevance based on abstracts and titles (Table 2). The content of these papers was coded in the context of each of the three roads to consumer acceptance of technology. Papers appearing in multiple search terms were, if relevant, coded within each research stream. Main conclusions of the papers were reported for across the three roads to consumer uptake of products per technology category.

Results

A first observation is that not all technologies have been studied to the same extent, with structuring technologies resulting in no papers on consumer acceptance. This isolated focus on a limited set of specific technologies may be due to the fact that technologies have not received the same societal attention, either because they are too novel, or because their application is too far removed from end-user views to be considered a relevant topic for research, or because they are deemed uncontroversial by all involved stakeholders (NGO's included) to raise acceptability concern.

Table 2: Overview of identified papers per road to product acceptance, and technology. Coded papers (papers found in initial search). Note that papers may occur in multiple cells.

		Product attributes	Socio-political attitudes	Retail / Caterer Value
<i>I. Mild processing technologies</i>	High Pressure technology	14 (102)	8 (30)	2 (41)
	Pulsed Electric field technology	5 (17)	3 (11)	1 (7)
	Cold plasma	1 (1)	0	0
<i>II. Electromagnetic methods¹</i>	Ohmic heating	1 (1)	0 (3)	0 (1)
	Infrared heating	0	0	0
	Electron irradiation	1 (1)	0 (1)	0
<i>III. Texturizing technologies</i>	High pressure homogenization	0 (2)	0	0
	Shockwave technology	0	0	0
	Super critical fluid extraction	0	0	0
	Ultrasound cutting	0	0	0
<i>IV. Novel packaging and storage technologies</i>	Edible coatings	3 (11)	0 (11)	0 (7)
	Active packaging	2 (14)	0 (6)	0 (5)
	Biodegradable packaging	1 (5)	1 (6)	0 (3)
	RFID	1 (50)	3 (34)	6 (39)

¹ NB Pulsed electric field can be classified as both a mild processing and an electromagnetic method. To avoid redundancies, it is only listed as mild processing in the current review.

I: Mild processing technologies

Product attributes

There is a considerable body of literature on the effectiveness of non-thermal processing technologies. High pressure technology (HPP) is suitable for preventing product spoilage by microbes, for example *Listeria* in ham (Hereu, Bover-Cid, Garriga, & Aymerich, 2012), or microbe spores in milk (Gao, Qiu, Wu, & Fu, 2011). HPP is effective in enhancing microbial product safety, particularly in combination with other treatments such as low temperature (Fernández et al., 2007), high temperature (Lori, Buckow, Knorr, Heinz, & Lehmacher, 2007), addition of naturally occurring substances (Hereu, et al., 2012), or Pulsed Electric Fields, addition of naturally occurring substances (Hereu, et al., 2012), or PEF (Sanchez-Moreno, De Ancos, Plaza, Elez-Martinez, & Cano, 2009).

One of the alleged benefits of HPP is that pressure-treated foods have sensory properties similar to fresh products (Deliza, Rosenthal, Abadio, Silva, & Castillo, 2005), thus satisfying the consumer demand for healthy, minimally processed foods. Indeed, sensory features of dairy products treated with HPP were found to be similar to those of natural products, which is a positive effect according to consumers (da Cruz et al., 2010). In the

context of fruit juice, consumer acceptability is reportedly maintained after applying HPP (Baxter, Easton, Schneebeli, & Whitfield, 2005)., HPP applied to beef actually helps to enhance sensory quality by preventing discoloration and water loss (Fernández, et al., 2007), and tenderness, juiciness, and flavour (Abadio Finco, Deliza, Rosenthal, & Silva, 2010; Ade-Omowaye, Angersbach, Taiwo, & Knorr, 2001; Deliza, et al., 2005; Gao, et al., 2011; Hicks et al., 2009). Other studies explicitly report other consumer considerations such as perceptions of risk and benefit (Bruhn, 2007), intention to buy (Deliza, et al., 2005), or naturalness perceptions (Evans & Cox, 2006). Cardello, Schutz and Leshner (2007) conclude that consumer perceived risk is the most important determinant in deciding whether consumer accept application of HPP (among other technologies). Australian consumers had a positive perception of HPP in comparison with other technologies, as they associated HPP less with “interference with the nature” compared to other technologies (Mireaux, Cox, Cotton, & Evans, 2007). In Finland, maintaining the same price as the conventional product, and offering environmental benefits were the two most important factors for stimulating consumer acceptance of HPP (Lampila & Lähteenmäki, 2007). A multinational study on fruit juice and baby food treated with HPP found that consumers perceived benefits are: naturalness, better taste, and more nutritional value (Nielsen et al., 2009). Nordic consumers recognized the benefits of HPP in terms of nutritional value, taste, and more environmental benefits compared to pasteurization (Sonne et al., 2012). The importance of processing method for acceptance of HPP vegetables was minor compared to price and environmental benefits (Urrutia et al., 2007).

Very similar results were found for the non-thermal processing technology Pulsed Electric Fields (PEF). Another non-thermal technology is cold plasma. There is one study claiming that cold plasma is effective in deactivating Salmonella and E. Coli in apples (Niemira & Sites, 2008); however, no report was found regarding consumer awareness and acceptability of products based on this technology (cold plasma).

The increase in consumer demand for superior food products in general, and healthy and minimally processed foods in particular, as the reason for the technology development in the first place (Abadio Finco, et al., 2010; Ade-Omowaye, et al., 2001; Deliza, et al., 2005; Gao, et al., 2011; Hicks, et al., 2009), is often presented as a persuasive argument towards consumer acceptance of novel technologies that bring clear end-user benefits.

Overall, according to the literature, HPP and PEF seem to be two effective methods for enhancing food safety. Positive effects on sensory features of treated food products have been reported in the literature. More importantly, consumers report a positive attitude towards HPP as it is seen as less intrusive compared to existing technologies, which makes this technology unique and promising.

Technology attitudes

For the acceptance of novel technologies such as HPP, consumer understanding of the mechanism that underlies the new technology and the process itself can be beneficial for consumer acceptance, as shown in focus groups and an experimental study (Deliza, et al., 2005; Deliza, Rosenthal, & Silva, 2003). It should, however, be noted, that HPP is a relatively easy technology to explain, and its application is not very controversial. This makes generalizability of these findings to other technologies not straightforward.

The addition of information on how the technology worked and what are its benefits improved the perception of pasteurisation (Abadio Finco, et al., 2010; Deliza, et al., 2005; Deliza, et al., 2003; Urrutia, et al., 2007). There are however some caveats to these findings. First of all, consumer knowledge and awareness of this technology is scarce (Hicks, et al., 2009), and different consumer segments in the population use different information sources to get that information (Hicks, et al., 2009). Thus, with regard to the products produced with new technologies, more research is needed to identify specific consumer segments that are interested or reluctant to adopt products embodying these technologies.

It is also noticed that a consumer's life stage determines which attributes (that can be influenced by a technology) are more important. For consumers with a (dependant) family, health is much more important, while hedonistic motivations of enjoying natural and fresh products are more important for consumers without family obligations (Sorenson & Henschion, 2011; Sorenson et al., 2011); in addition, the influence of advertising and whether the shopping for food in itself is a hedonic experience or a utilitarian exercise counts in the acceptance of high pressure pasteurisation of food (Sorenson, et al., 2011). For similar novel technologies, such as the

development of biodegradable packaging, it was shown that different consumer segments have different packaging preferences (Hall et al., 2012). Other research also shows that HPP is considered a fairly natural, and hence a positive way of food preservation (Nielsen, et al., 2009) although the studies show that participants distinguish between arguments related to the technology in itself and arguments about desired product properties, and that there are only few connections between these argumentation structures (Nielsen, et al., 2009). These findings reveal that, at least for high pressure pasteurisation, consumers can form an opinion about the technology in isolation, but that may not necessarily influence their opinion about the products made with that technology.

Although in general the mild processing technologies are relatively accepted, there are differences between specific technologies within this class. While high pressure pasteurisation was linked to natural and healthy associations (because of its gentle processing and lack of additives to the product), pulsed electric field preservation of foods, has led to a more sceptical response from consumers (Sonne, et al., 2012). High pressure freezing was hardly known by the public and was considered slightly negative compared to other freezing technologies (Lampila & Lähteenmäki, 2007) although Lampila and Lähteenmäki showed that the attitude towards the technology only slightly influenced the actual choice, implying that, at least in some cases, the influence of processing technology on choice is not an essential predictor for choice for these technologies. As highlighted before, the specific properties of a technology and the way it can be communicated and interpreted as a natural process may determine the consumer perception of the technology, but may not necessarily influence the perception of the products at the point of purchase/consumption.

Retail and service attributes

Most studies on non-thermal processing technologies focus on the effects of these technologies on product attributes. Two laddering studies identified consequences relevant to retailing (Sonne, et al., 2012) and compared consumer attitudes towards apple juice produced by high-pressure processing (HPP), pulsed electric field processing (PEF), and traditional pasteurization. Consumers attributed “long shelf life” and “well-known product” to pasteurized juice, which was associated with positive consequences such as “saves time in shopping” and “save money” (less waste). (Sorenson & Henchion, 2011) found that consumers attributed an extended shelf life to HPP chilled ready meals which was associated with “shop less frequently”, which in turn was associated with saving time and convenience. Extended shelf-life was also associated with less waste from spoilage and consequently less waste was associated with saving money.

II: Electromagnetic and texturizing technologies

Product attributes

Safety enhancing technologies and structuring technologies have hardly been studied in terms of their effects on product characteristics. In fact, only two papers were found with regard to this aspect. Ohmic heating was found to be effective in reducing cooking time for meat emulsions with only a small effect on sensory features. No account was taken of consumer acceptance of products based on this technology (Shirsat, Brunton, Lyng, McKenna, & Scannell, 2004). High pressure homogenisation was effective in enhancing the safety of apple juice, but no study was identified regarding consumer evaluation and acceptance (Kumar et al., 2009).

Technology attitudes

These actual application of these technologies is often in the future. The hypothetical nature of the future products, may mitigate any socio-political issues at this moment in time. In the current review, we found no papers discussing these technologies and consumer attitudes.

Retail and service attributes

These technologies are often still too much positioned in the future to impact retail or service in a way that can be studied at this stage. In the current review no papers on these technologies based on their impact on retail and service were identified.

III: Novel Packaging and Storage technologies: RFID tracing

Product attributes

RFID is a novel technology of which the possibilities of applications are widely studied. Of the issues relevant for consumer issues surrounding RFID, no papers were found that studied consumer perception of changed product attributes as a consequence of RFID or other tracing technology.

Technology attitudes

Consumers and chain actors recognise RFID technology as a relevant technology to establish chain control, and to allow for customer convenience. The actual RFID technology does not raise major issues in relation to product safety in any of the reviewed paper.

The acceptance of RFID does not lie with the physical technology itself, but with the responsible application and consumer protection against privacy violations. There is some variation in the level of protection required, college students seemed to be relatively positive about RFID loyalty programmes as these initiatives fit the modern culture and bring convenience to the end users (Hossain & Prybutok, 2008). Data security however raised concerns even in this population. Creating technological data management systems aimed at data protection did little to mitigate these concerns, and lead to consumers voicing to have little trust in such technological systems built by RFID users themselves. In such situations, consumers indicated that RFID trackers would better be permanently disabled when leaving the shop, even if this would eliminate the chance of convenient customer loyalty offers (Pramatari & Theotokis, 2009).

When less emphasis was placed on technological security, participants seemed less triggered about safety. Externally regulated and enforced control on the use of privacy sensitive information collected in association with RFID technology is considered to be a prerequisite for its acceptance, as less strict protection is considered insufficiently forthcoming in relation to levels of consumer trust at the moment (H. S. Lee & O'Mahony, 2007). (H. S. Lee & O'Mahony, 2007). Scenarios on customer loyalty programmes based on RFID chip-cards were generally appreciated, although transferring personal data to unknown cashiers, to allow for a personal greeting was felt as somewhat intrusive, the public remained largely indifferent to the use of RFID technology (Boeck, Roy, Durif, & Grégoire, 2011). A particular category of food products for which the application of RFID can be useful, is halal foods. For Muslims, the trustworthiness of a halal logo is essential. A Malaysian study on this topic revealed, that consumers were positive on using RFID for this purpose in terms of usability, efficiency, affordability, security, and profitability (Boeck, et al., 2011; Nasir, Norman, Fauzi, & Azmi, 2011).

Retail and service attributes

Three themes appear in studies on consumer acceptance of RFID in retail contexts: usefulness and ease of use, attitudes toward technology, and privacy. Three papers studied the acceptance of RFID applications in retailing by means of extended technology acceptance models (TAM Davis, 1989). Kowatsch and Maass (2010) studied the intention to use in-store, mobile recommendation agents (MRA) that provided product information and found that this intention was positively influenced by the perceived usefulness of the MRA. Perceived usefulness also had positive effects on intention to prefer a MRA-enabled retail store, and intention to purchase after using the MRA. Perceived ease of use had a positive effect on perceived usefulness. Müller-Seitz, Dautzenberg, Creusen, and Stromereder (2009) found that the acceptance of RFID checkouts, intelligent rack systems, and customer complaint handling was positively affected by the perceived usefulness of the technology, the general attitude toward data security, the general attitude toward new technologies, and the perceived ease of use. Security concerns had a negative effect. Finally, Pramataris and Theotokis (2009) conclude that the attitude toward dynamic pricing of perishable products is determined by the more general attitude toward an IT-based service, which in turn is influenced by the even more general attitude toward the service concept, as well as performance expectancy (i.e., perceived usefulness) and effort expectancy (i.e., ease of use).

Privacy seems to be an important issue related to RFID. Especially the question what to do with RFID tags when they leave the store (after sales) is subject for debate. Rothensee and Spiekermann (2008) show that privacy awareness is negatively correlated with the intention to use RFID information services. About 17% of the sample was labeled as “extreme rejecters”: consumers that were very negative about RFID information services. Privacy

awareness moderated the relationship between RFID information services and retailer reputation: for less privacy aware participants retailer reputation increased after seeing a film about RFID information services at the retailer, whereas the more privacy aware participants became more critical in their evaluation of the retailer. Interestingly, different privacy protection measures did not affect the acceptance of RFID information services. This finding is in line with Spiekermann (2009) who concluded that participants prefer to kill RFID at store exits rather than adopting any of two privacy enhancing technology (PET) solutions. The acceptance of such PET solutions is determined by peer opinion, usefulness of RFID, information about the privacy enhancing technology, and problems in maintaining privacy despite the application of some kind of privacy enhancing technology. In general, participants felt neutral to positive about RFID after-sales services.

Bardaki, Kourouthanassis, and Pramataris (2010) provided descriptive statistics on the acceptance of personalized selection of alternative promotion gifts through an interactive touch-screen in a supermarket. The majority of shoppers was satisfied with and approved the new service, was willing to continue using the service, and found interaction with the service through the touch screen easy and flexible to use. An experiment showed that shoppers were more attracted to use the interactive, touch-screen-based way of promotion compared to the contemporary way of selecting alternative coupons (a stand with printed coupons). However, the new service was not perceived as having more value than the contemporary service.

IV: Edible coatings, Active packaging, Biodegradable packaging

Product attributes

Edible coatings and active or intelligent packaging have received most research attention in the domain of novel technologies for packaging and storage. Product quality is the product characteristic mostly affected by this category of novel technologies, mostly by increasing shelf life and freshness. A relevant product category is therefore freshly cut fruits and vegetables. Active packaging can imply the controlled release of active compounds from the package (Almenar, Catala, Hernandez-Muñoz, & Gavara, 2009), or controlled atmosphere modification (Mohan, Ravishankar, Srinivasa Gopal, Lalitha, & Asok Kumar, 2010; Oms-Oliu, Hertog, Soliva-Fortuny, Martín-Belloso, & Nicolai, 2009). Generally, shelf life and or food safety are reported to be enhanced by these technologies. The conclusions on the use of biodegradable packages are mixed: (Del Nobile et al., 2009; Marcos, Aymerich, Monfort, & Garriga, 2007) report the effective use of biodegradable packages for shelf life, sensory features, and safety. There are also studies that report several limitations in the effective use of biodegradable films (Lucera, Costa, Mastromatteo, Conte, & Del Nobile, 2010).

Not surprisingly given the affected product feature (product quality), due account is taken of consumer acceptance of treated products by means of sensory evaluation tests. Active packaging of strawberries was concluded to be effective in increasing shelf life without modifying the taste (Almenar, et al., 2009). Treating freshly cut mango with an edible coating and citric acid dipping was effective in preventing texture and colour changes, and thus sensory acceptance was increased (Chiumarelli, Pereira, Ferrari, Sarantópoulos, & Hubinger, 2010). Freshly cut artichokes with an edible coating had a better appearance, less weight loss, better pH, and less microbe growth (Del Nobile, et al., 2009). For asparagus, none of the tested coatings worked perfect for optimal fresh weight, texture, sensory attributes, and tip-rot disorder (Fuchs, Mattinson, & Fellman, 2008). Modified atmosphere packaging was found to be detrimental for the firmness of carrots (Lafortune, Caillet, & Lacroix, 2005). (Almenar, et al., 2009; Chiumarelli, et al., 2010; Del Nobile, et al., 2009; Fuchs, et al., 2008; Mohan, et al., 2010). None of the studies, except those on RFID, include explicit consumer *attitude* measures in their studies. Some authors (Kumar, et al., 2009; Lafortune, et al., 2005; Lucera, et al., 2010) mention the increase in consumer demand for minimally processed foods as the reason for studying the technology. One of the papers (Kerry, O'Grady, & Hogan, 2006) refers to a study by Lähteenmäki & Arvola (2003), that argues that consumer attitudes towards active packaging concepts are positive. Some papers (Kerry, et al., 2006; Pérez-Gago, González-Aguilar, & Olivas, 2010; Rojas-Graü, Soliva-Fortuny, & Martín-Belloso, 2010) make the statement that more acceptability studies are necessary with regard to both sensory acceptance and benefit perception.

Technology attitudes

Packaging innovations may raise both positive and negative socio-political attitudes. In particular, if these packages involve nanotechnologies or other high-tech applications, certain concerns may appear. So far there is no clear evidence however on the consumer socio-political attitudes towards these technologies.

Retail and service attributes

Packaging innovations are promising as they may significantly and positively influence retail and service attributes. In particular, these packages may involve visible ‘time-temperature’ indicators indicating product freshness by indicating time on shelf in combination to exposure to higher temperatures, or other applications that change in-store presentation of products to consumers. However, the literature is scarce regarding the effects of these technologies in the retail environment.

Conclusions

The current report outlines three roads to consumer uptake of products created with new technologies. Based on the reviewed literature, approaching consumer acceptance of new technology-based products involves a broad range of factors. Literature supports that product attribute evaluations, general socio-political technology attitudes, and consumer response on changes in retail and service as a consequence of new technologies all matter. This statement is based on different cross-sectional and experimental studies which mainly consider these factors in isolation and take general contexts. Nevertheless, for a more detailed account of “when” each of the roads is most prevalent, it is worthwhile to extend the substantiation with more cases.

Approaching consumer uptake of new technologies along these three roads provides an overview across the different relevant ways in which new technologies reach consumers. However, literature on these topics remains fragmented, as in many cases it investigates one of the roads, without considering the interaction between them. In some cases interfaces between socio-political and product attribute-based evaluation have been explored (in particular for HPP), in other cases the relation between store optimisation and socio-political attitudes (in the case of RFID). No cases where all three effects were combined were found. In addition, the three roads have received unequal amount of attention in the literature, with especially the retail impact receiving little attention.

This fragmented approach to evaluating new products, technologies and their introduction to the public may help to explain the limited success in developing and marketing innovative food products. Based on these results, it is recommended to explore all three roads to consumer uptake, and make sure the developed technology does achieve added value to the consumer in at least one road, and does not encounter negative response in any of the other roads. To facilitate the evaluation of a product before market entry, a checklist is provided on the next pages.

Checklist

When developing a novel product or technology, all three roads to uptake should be checked for potential consumer benefits, or blocking negativities. Importantly, since consumers tend to be conservative in their food behaviour, a product without negative attitudes, but lacking extra-benefits is unlikely to replace an existing product doing comparably well.

Five stage checklist for determining novel technologies in food products ¹	Example	Consumer trends	Effect on product introduction ²
ROAD 1 – Product attributes			
1 <i>Does the technology change (experience or credence) product attributes</i>			
<u>Yes:</u> Conduct sensory tests to make sure product perception is as good or better than alternative	Edible coatings on vegetable	Quality, taste	
<i>Is the sensory quality better than the alternative</i>			
<u>Yes:</u>	Potential for added consumer value, potential for price premium		+
<u>Indifferent:</u>	No added consumer value, end-user discount probably needed		0
<u>Lower:</u>	Substantial end-user discount needed		-
Conduct marketing research to determine acceptability of the product as a whole (including price effects)			
<i>Is the overall acceptability higher than the alternative</i>			
<u>Yes:</u>	Potential for added consumer value, price premium		+
<u>Indifferent:</u>	No added consumer value, end-user discount probably needed		0
<u>Lower:</u>	Substantial end-user discount needed		-
<u>No:</u> No consumer drive to adopt the new product at added value is present	HPP processed pineapple juice		0

ROAD 2 – Socio-political attitudes

2	<i>Has the technology perceived dread elements? (e.g. many affected people, chance of mortality, long term effects)</i>	Health and perceived risks
<u>Yes:</u>	Negative socio-political attitudes are likely.	
	<i>Is the negative attitude very strong?</i>	
<u>Yes:</u>	Products/technologies may be categorically rejected, resulting in legislation blocking innovation. At best end-user discount needed.	Irradiation --
<u>No:</u>	Overall evaluation of product will be negatively influenced Clear end-user benefits, or considerable discount need to be provided with the product to offset negative attitudes	Genetic modification -
<u>No:</u>	Negative socio-political attitudes not likely, but no consumer drive to pay price premium is present	HPP 0
3	<i>Is the technology perceived more technological than natural</i>	Naturalness
<u>Yes:</u>	Negative socio-political attitudes are likely.	
	<i>Is the negative attitude very strong?</i>	
<u>Yes:</u>	Product lines may be categorically rejected by society / legislation. At best end-user discount needed.	Irradiation --
<u>No:</u>	Overall evaluation of product will be negatively influenced Clear end-user benefits or considerable discount need to be provided with the product to offset negative attitudes	PEF -
<u>No:</u>	Negative socio-political attitudes not likely	
	<i>Is the technology perceived more natural than technological</i>	
<u>Yes:</u>	Product lines may be perceived as positive, some price premium may be acceptable	Bio-degradable packaging +
<u>No:</u>	No outspoken socio-political attitudes expected, no added value to consumer.	0
4	<i>Is the technology otherwise socially or politically sensitive</i>	Ethics/ Sustainability

Yes: Negative socio-political attitudes are likely.

Is the negative attitude very strong?

Yes: Product lines may be categorically rejected by society / legislation. --

No: Overall evaluation of product may be negatively influenced -

Clear end-user or societal benefits need to be presented in the product to offset negative attitudes

No: Negative socio-political attitudes not likely

Is the technology perceived as ethically or morally positive

Yes: Product lines may be perceived as positive, some price premium may be acceptable Local production, Fair trade +

No: No outspoken socio-political attitudes expected, no added value to consumer. -

ROAD 3 – Effect through retail/caterer business models

5 *Does the technology change the way products are presented/delivered to the consumer in retail or catering* Convenience

Yes: *Does the product presentation create new product categorisation*

Yes: Inferences on product quality are likely.

Are associations toward product quality towards exclusivity, freshness and other desirable attributes?

Yes: Higher quality inferences will be made. Price premium maybe possible. Cooled fruit juices +

No: Low quality inferences are likely. These need to be compensated by discount. Non cooled HPP dairy -

No: No immediate product influence is expected

Does the product change the shopping experience

<u>Yes:</u>	Store image is likely to change	
	<i>Does the new shopping experience involve sensitive issues, like data protection?</i>	
<u>Yes:</u>	Negative socio-political attitudes are likely to harm store image. Additional customer benefits need to be added (e.g. discount)	RFID tracking -
<u>No:</u>	No effects expected	0
	<i>Does the new shopping experience involve increased customer efficiency (fast check out) or effectiveness (larger available assortment)</i>	
<u>Yes:</u>	Positive effects on store image expected, some price premium maybe possible	+
<u>No:</u>	No effects expected	0
<u>No:</u>	<i>Is the new technology considered fair to all involved chain actors and end-users</i>	
<u>Yes:</u>	No impact on store image expected	0
<u>No:</u>	Negative socio-political attitudes are likely to affect store image. Additional customer benefits need to be added (e.g. discount)	-

NOTES:

¹ Check the applied technology and track the scores (--, -, 0, +).

If any double minus (--) are scored: seriously consider that you might run into protest and/or legal limits.

Several plusses (+) and not a single minus (-): technology will likely provide desirable end user benefits; which may warrant somewhat higher prices compared to conventional alternative.

Only neutrals (0): no added value to consumers, but protest not very likely. No indication higher price than alternative will be accepted. Mainly (or only) minuses (-): consumer adoption is unlikely unless additional benefits are added to the product, possibly by offering product at seriously reduced price compared to conventional alternatives.

Mix of plusses and minuses: consider that negative image may dominate the discourse, while positive attributes may in part determine sales. Consumer response and behaviour likely unpredictable and changeable.

²-- = very negative expected response, may be critical; - = negative expected response; 0 = neutral response, neither negative response, nor positive (added value) expected; + = positive response expected.

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Appendices

I: Search terms

Search was conducted in Scopus

Product evaluation

TITLE-ABS-KEY((consumer* OR customer*) AND (attitude* OR acceptance* OR response* OR reject* OR intention* OR "willingness to pay" OR "willingness to accept" OR wtp OR wta) AND ("High Pressure" OR hpp OR "Pulsed Electric field" OR pef OR "Cold plasma") AND product*)

TITLE-ABS-KEY((consumer* OR customer*) AND (attitude* OR acceptance* OR response* OR reject* OR intention* OR "willingness to pay" OR "willingness to accept" OR wtp OR wta) AND ("Ohmic heating" OR "electrical resistance heating" OR "Infrared heating" OR "Electron irradiation") AND product*)

TITLE-ABS-KEY((consumer* OR customer*) AND (attitude* OR acceptance* OR response* OR reject* OR intention* OR "willingness to pay" OR "willingness to accept" OR wtp OR wta) AND ("High pressure homogeni*ation" OR "Shockwave technology" OR "hydrodynamic pressure" OR HDP OR "Super critical fluid extraction" OR SCFX OR "Ultrasound cutting") AND product*)

TITLE-ABS-KEY((consumer* OR customer*) AND (attitude* OR acceptance* OR response* OR reject* OR intention* OR "willingness to pay" OR "willingness to accept" OR wtp OR wta) AND ("Edible coatings" OR "Active packaging" OR "Biodegradable packaging" OR rfid) AND product*)

Technology attitudes

TITLE-ABS-KEY(consumer AND (attitude OR acceptance OR "willingness to pay" OR "willingness to accept" OR wtp OR wta) AND ("High Pressure" OR hpp OR "Pulsed Electric field" OR pef OR "Cold plasma"))

TITLE-ABS-KEY(consumer AND (attitude OR acceptance OR "willingness to pay" OR "willingness to accept" OR wtp OR wta) AND ("Ohmic heating" OR "Infrared heating" OR "Electron irradiation"))

TITLE-ABS-KEY(consumer AND (attitude OR acceptance OR "willingness to pay" OR "willingness to accept" OR wtp OR wta) AND ("High pressure homogenization" OR "Shockwave technology" OR "Super critical fluid extraction" OR SCFX OR "Ultrasound cutting"))

TITLE-ABS-KEY(consumer AND (attitude OR acceptance OR "willingness to pay" OR "willingness to accept" OR wtp OR wta) AND ("Edible coatings" OR "Active packaging" OR "Biodegradable packaging" OR rfid))

Retail

TITLE-ABS-KEY((consumer OR customer OR retail) AND (attitude OR acceptance OR "willingness to pay" OR "willingness to accept" OR wtp OR wta) AND ("High Pressure" OR hpp OR "Pulsed Electric field" OR pef OR "Cold plasma"))

TITLE-ABS-KEY((consumer OR customer OR retail) AND (attitude OR acceptance OR "willingness to pay" OR "willingness to accept" OR wtp OR wta) AND ("Ohmic heating" OR "Infrared heating" OR "Electron irradiation"))

TITLE-ABS-KEY((consumer OR customer OR retail) AND (attitude OR acceptance OR "willingness to pay" OR "willingness to accept" OR wtp OR wta) AND ("High pressure homogenization" OR "Shockwave technology" OR "Super critical fluid extraction" OR SCFX OR "Ultrasound cutting"))

TITLE-ABS-KEY((consumer OR customer OR retail) AND (attitude OR acceptance OR "willingness to pay" OR "willingness to accept" OR wtp OR wta) AND ("Edible coatings" OR "Active packaging" OR "Biodegradable packaging" OR rfid))

II: Summary of reviewed papers

Source	Technology	Road to acceptance	Summary
(Almenar, et al., 2009)	Active packaging	product attributes	Release of Nano none from active package to increase shelf life. Effective to prolong strawberry shelf life without modifying the taste, according to sensory test
(Angeles, 2007)	RFID	product attributes	RFID and privacy, utility, fairness shows consumers are positive under protective law in Canada Not food explicitly, but retail in general
(Bardaki, et al., 2010)	RFID	Retail catering; product attributes	Personalized selection of alternative promotion gifts through interactive touch-screen in supermarket The majority of shoppers: were satisfied with and approved the new service; were willing to continue using the service; found interaction with the service through touch screen easy and flexible to use; were more attracted to use the interactive, touch-screen based way of promotion compared to contemporary way of selecting alternative coupons (stand with printed coupons); did not perceive the new service as having more value than the contemporary service. RFID results in some problems with readability and health concerns
(Bertolini, Ferretti, Montanari, Rizzi, & Vignali, 2012)	RFID	product attributes	RFID for out of stock management is economically sustainable for retail and manufacture, especially for fresh foods. Impact on the food attributes is not focus
(Boeck, et al., 2011)	RIFD	Socio political attitude	Compares 5 different customer loyalty programmes, using either a scanning-card or increasingly personalised tracking in a retail outlet based on RFID technology. Although the most personal tracking system where the individual customer is recognised by the system/staff in the shop creates the feeling of intrusion, the increase of less personal RFID systems create hardly any increase in perceived intrusion (not significant). The authors conclude that consumers are largely indifferent towards the use of RFID systems.
(Bruhn, 2007)	New technologies in general	Socio political attitude	Argues in a conceptual paper that the focus on consumer acceptance of new technologies has created an atmosphere where risk has become decisive, since no consumers ask for new technologies, but consumers may desire products with properties created with the new technology. Thus benefits should be leading. Communication can also help acceptance of new technologies, especially if endorsement by relevant opinion leaders can be realised. Benefits are essential both in fulfilling consumer demand and in mitigating risk perception, and that repeated factual information can create sufficient experience and knowledge to increase acceptance of new technologies.
(Chiumarelli, et al., 2010)	Edible coating and citric acid dipping	product attributes	Sensory features, health value (β -carotene), safety (microbial growth) of freshly cut mango investigated. Treatments are effective to prevent texture and colour changes (thus enhances sensory acceptance) but not weight loss and microbes.
(Del Nobile, et al., 2009)	Edible coating, citric acid/calcium chlorine dipping, different packaging films	product attributes	Fresh cut artichoke hearts to improve shelf life, sensory features, and safety. Coating improves shelf life, and is acceptable in sensory tests. Biodegradable film is the best package for appearance, weight loss, pH, and prevention of microbe growth.
(Deliza, et al., 2003)	HPP	Socio political attitude	Indicates using focus groups that being open about a new technology (in the case of HPP) and how HPP contributes to improved product characteristics make the technology more acceptable.
(Deliza, et al., 2005)	HPP	Socio political attitude	Confirms that adding explanation what HPP is and how it positively affects product quality on the label does increase consumer acceptance and willingness to pay for the product.
(Evans & Cox, 2006)	HPP	Socio political attitude	Shows that it is important to consider a food technology in its context in a full product, and in competition with other products. In the case of HPP consumers equate the technology with pasteurisation (convenient) but less natural and fresh.
(Fuchs, et al., 2008)	Edible coatings.	product attributes	Coating of asparagus to improve sensory features and safety. None of the coatings worked perfectly for optimal fresh weight, texture, sensory attributes (using sensory test), tip-rot disorder.
(Hall et al., 2010)	Biodegradable packages	Socio political attitude	Studies biodegradable packages. They find differences between consumers segments in preference for rice hulk, straw based packages based on household composition, age, income, and education level. They conclude that technology acceptance may differ between consumer segments.
(Hicks, et al., 2009)	HPP	Socio political attitude	Show that knowledge about HPP application is fairly rare amongst consumers. They show a shift from use of "in shop", printed media and TV and radio (classical media) towards internet based information sources with decreasing age (cohort). Influence of information from family and friends is highest among the younger and older population groups. Lowly educated participants are most influenced by TV/radio and printed media. 40% of all participants indicate they would be willing to pay more for additional food safety by use of HPP, with another 45% being unsure, but actual commitment to an amount is not very specific. It seems that a (absolute) higher WTP for a more expensive product is acceptable.
(Hossain &	RFID	Socio political	Show that (among college students) the application of RFID technology is more

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Prybutok, 2008)		attitude	dependent on convenience, culture and security of personal data, rather than privacy per se. In other words, if the use and control of privacy sensitive data is well secured, participants see little problems with the technology.
(Kerry, et al., 2006)	Active and intelligent packaging	product attributes	Active packaging to improve quality and shelf life/safety of meat, Recognition of the benefits of these packaging technologies by industry, economically viable packaging systems and consumer acceptance are necessary for the commercial realisation. No empirical consumer research but concludes that “the ultimate incentive for use of any new technology is cost. Cost effectiveness depends on perceived benefits (profit for producers, satisfaction/utility for consumers).”
(Kowatsch & Maass, 2010)	RFID	Retail catering	In-store, mobile recommendation agents (MRA) that provide product information Lab experiment among 47 Swiss bachelor students who had to buy a mobile navigation unit and accessory Perceived ease of use of the MRA has a positive effect on perceived usefulness of the MRA. Perceived usefulness of the MRA has positive effects on intention to use the MRA, intention to prefer a MRA-enabled retail store, and intention to purchase after using the MRA.
(Kumar, et al., 2009)	High pressure homogenisation and chitosan treatment	product attributes	Reason of HPP is an increase in consumer demand for minimally processed foods. Food safety can be improved but no original consumer data in the paper.
(Lafortune, et al., 2005)	Coatings, combined with modified atmosphere packaging and gamma irradiation.	product attributes	Reason of technology development is an increase in consumer demand for minimally processed foods. Sensory features (firmness, discoloration, whiteness), safety (microbiological stability) of carrots studied. Irradiation in combination with coatings does not affect quality, but reduces microbes. Modified atmosphere packaging is detrimental for firmness.
(Lampila & Lähteenmäki, 2007)	HPP	Socio political attitude	Show that High pressure freezing is not well known by consumers compared to other techniques for food preservation. This resulted in neutral attitudes, so apparently the term does not create feeling of major unease. The use of the technology was considered less favourable compared to the alternatives, and the importance of the use of this technology ranked lowest among four determinants for acceptance (use of technology, price, environment, and sensory).
(Lucera, et al., 2010)	packaging systems	product attributes	Reason of technology development is an increase in consumer demand for minimally processed foods, in this case zucchini. Studied in sensory effect on prolonged shelf life. Biodegradable film is not effective in this case based on, sensory testing.
(Marcos, et al., 2007)	biodegradable packaging	product attributes	Country authors: Spain Product group: ham Affected product feature: safety Conclusion: zein (specific type of package) is effective to reduce microbe activity. Account of consumer response: no
(Mohan, et al., 2010)	modified atmosphere packaging and sodium acetate treatment	product attributes	Prolonged shelf life of fish steaks for safety (microbial quality), sensory features (appearance, colour, odour, flavour, firmness, taste). The combination of packaging and treatment effective for safety. No clear conclusions on sensory features.
(Müller-Seitz, et al., 2009)	RFID	Retail catering	RFID checkouts, intelligent rack systems, and customer complaint handling Survey among 206 customers of a German electronics retail chain Acceptance of RFID technology is affected by: the perceived usefulness of the technology (+); the general attitude toward data security (+); the general attitude toward new technologies (+); security concerns (-); the perceived ease of use (+); political attitude are important element for acceptance.
(Nasir, et al., 2011)	RFID	product attributes	Credibility halal credence attribute supported by RFID. Good evaluation of consumers (on usability, efficiency, affordability, security, profitability).
(Nielsen, et al., 2009)	HPP, PEF	Socio political attitude	Show, using focus groups, that HPP and PEF conservation of drinks is considered a fairly natural way of preservation. The lack of information about the technology results however in a lot of associations around the technology, and several around the products, but few relations between the technology and product properties.
(Oms-Oliu, et al., 2009)	modified atmosphere packaging	product attributes	Fruits and vegetables packaged under modified atmosphere for sensory and nutritional quality (freshness). Flavour and nutritional quality remain serious challenges, and may be solved by combining modified atmosphere with edible coatings.
(Pérez-Gago, et al., 2010)	edible coatings	product attributes	Edible coating on fruits and vegetables to improve overall quality (freshness). Material selection is crucial and depends on the specific product. More sensory studies are necessary.
(Pramatari & Theotokis, 2009)	RFID	Retail catering	Dynamic pricing of perishable products Survey among 575 shoppers of a Greek and Irish supermarket Attitude toward RFID-enable service is determined by attitude toward IT-based service (+). Attitude toward IT-based service is determined by attitude toward service concept (+), performance expectancy (+), and effort expectancy (+)
(Rojas-Graü, et al., 2010)	edible coatings	product attributes	Edible coating applied to fresh and cut fruits and vegetables, to improve overall quality (freshness) Commercialisation and consumer acceptance remains hardly understood
(Rothensee & Spiekermann, 2008)	RFID	Retail catering	Information services (IS) Survey among 336 German consumers, experiment among 306 German consumers (scenario-based, participants were shown a film) Privacy awareness is negatively correlated with the intention to use RFID-IS. Emotional reaction when imagining to shop in a RFID supermarket is negatively correlated with privacy awareness. For less privacy aware participants retailer reputation increased after the film, whereas the more privacy aware participants became more critical in their evaluation of the retailer. Different privacy protection measures (privacy enhancing technology vs. information policy) did not affect RFID-IS acceptance. About 17% of the sample was ‘extreme rejecters’.
(S. M. Lee, Park,	RFID	Socio political	Study the application of RFID technology in developing ubiquitous commerce.

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Yoon, & Yeon, 2007)		attitude	Based on a theoretical model which includes repeated behaviour and storage and use of consumer data by the companies, the authors show in complex system simulations that the presence and strict enforcement of privacy protecting policies is an essential prerequisite for consumer acceptance. In other words, it is not so much the technology as the guarantees against abuse that are focus of debate.
(Shirsat, et al., 2004)	Ohmic heating	product attributes	Meat emulsions, treated by Ohmic heating. Springiness reduced and instrumental colour changes. Reduced cooking time with only subtle differences in colour. Effect on consumer acceptance deemed unlikely.
(Singh, 1991)	Food irradiation	product attributes	Higher dose rates from electron beams may reduce nutrient loss compared to gamma irradiation. Pork, potatoes, onions treated. Less thiamine loss in pork, less sprouting in potatoes/onions. No difference in other cases. Account of consumer response: no difference in consumer acceptance ratings.
(Sonne, et al., 2012)	HPP, PEF	Retail catering; Socio political attitude	In-depth laddering interviews with 120 consumers in Norway, Denmark, Hungary, and Slovakia. Juice preferences for 1. HPP, 2. PEF, 3. Pasteurized. Consumers recognize and appreciate benefits of HPP and PEF processed food when this information is provided on the product label. Consumers attributed long shelf life to pasteurized juice, which was associated with saving time in shopping and saves money (less waste). Healthiness caused by the gentleness of processing and lack of additives (and vitamins to fruit juice) was raised as most important reason to prefer HPP techniques. More natural taste was also considered of relevance, especially for hedonic reasons. PEF was evaluated rather similar to HPP, although participants were somewhat more sceptical about its benefits.
(Sorenson, et al., 2011)	HPP	Retail catering; Socio political attitude	Chilled ready meals. In-depth laddering interviews with 40 purchasers of chilled ready meals. Respondents were generally receptive towards trial purchasing HPP chilled ready meals. Benefits relate to the nutritional value and taste of the products. Consumers attributed a longer shelf life to HPP chilled ready meals, which was associated with positive consequences: shop less, (which saves time and is convenient), less waste (which saves money), and flexibility (choice). Psychological determinants of acceptance using PCA on the psychological data revealed for factors 1 "influence of advertising and information", 2 "cooking methods and responsibility", 3 "Shopping mode" and 4 "hedonistic properties". Based on cluster analysis, the method was more acceptable for convenience and uninvolved consumer groups.
(Sorenson & Henchion, 2011)	HPP	Socio political attitude	Analyses consumer cognitions towards high pressure processing using means end chains. He shows that important elements for adopting the technology are healthiness of ingredients and fresh taste leading to good life and pleasure mainly for those participants without family responsibility or alternatively naturalness (i.e. no additives) of the product leading to fulfilling the duty for the wellbeing and health of the family for participants with families. Thus the study shows that technology acceptance motivations may shift with life phase.
(Spiekermann, 2009)	RFID	Retail catering	After-sales services. Two experiments among 234 and 306 German consumers (scenario-based, participants were shown a film). Participants feel neutral to positive about RFID after-sales services. Participants prefer to kill RFID tags at store exits rather than adopting any of the two privacy enhancing technology (PET) solutions. PET acceptance is determined by peer opinion, usefulness of RFID, information through PET, and helplessness despite PET.
(Suppakul, Miltz, Sonneveld, & Bigger, 2003)	active packaging	product attributes	Fruits and vegetables protected with active packaging to increase safety (microbial activity) and nutritional quality. Although these packages may be effectively antimicrobial, effect on nutritional quality remains unknown.