



## Research report

## Consumer perception of the use of high-pressure processing and pulsed electric field technologies in food production

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## ABSTRACT

The success of new food processing technologies is highly dependent on consumers' acceptance. The purpose of this paper is to study consumers' perceptions of two new processing technologies and food products produced by means of these novel technologies. To accomplish this, a qualitative study on consumer attitudes towards high-pressure processing (HPP) and pulsed electric field (PEF) processing of food was carried out. In all 97 adults between 20 and 71 years of age participated in 12 focus groups conducted in Slovenia, Hungary, Serbia, Slovakia, Norway and Denmark using a common guideline. Participants were introduced to the HPP and PEF technologies and then to the effect of the two new technologies on two specific product categories: juice and baby food. The transcribed data was content analysed and the coded data was transformed into diagrams using UCINET 5 and NETDRAW. The results show that consumers perceived the main advantages of HPP and PEF products to be the products' naturalness, improved taste and their high nutritional value, whereas the main disadvantage was the lack of information about the PEF and HPP products. The results of the participants' evaluation of the PEF and HPP processes showed that environmental friendliness and the more natural products were seen as the main advantages, while they were concerned about body and health, the higher price of the products, the lack of information about the technologies and a general scepticism. The study also shows that North European participants were a bit more sceptical towards PEF and HPP products than the East European participants.

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### Introduction

New food processing technologies are developed on a continuous basis. While food scientists may applaud the progress of science, consumers have been known to take a more conservative approach and do not always readily see the benefit of new processing methods. Often consumers' product choices are influenced not only by attributes of the product itself, but also by production characteristics, including factors like origin, animal welfare, and production technology. Many consumers have developed preferences for particular production methods, like organic food production, and dislike of others, like the use of genetic modification (Bredahl, 2001; Frewer, Howard, & Shepherd, 1995; Grunert, Bredahl, & Scholderer, 2003). This occurs in spite of

the fact that production technologies are highly technical issues, and the average consumer probably only has a vague idea about what these technologies imply, let alone their effect on food products manufactured by means of these technologies.

This paper examines consumers' attitude formation towards two new food-processing technologies, high-pressure processing and pulsed electric field processing, and towards products manufactured by means of these technologies.<sup>1</sup> A better understanding of how consumers form attitudes towards these novel technologies and towards products produced by means of them is relevant to both marketers and R&D scientists. As learned from earlier examples (such as GMO and irradiation), the advantages that a new processing technology has to offer do not necessarily guarantee the success of a product in the market place. If consumers do not perceive the benefits of a new technology as

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<sup>1</sup> For a short description of the two technologies see Appendix A.

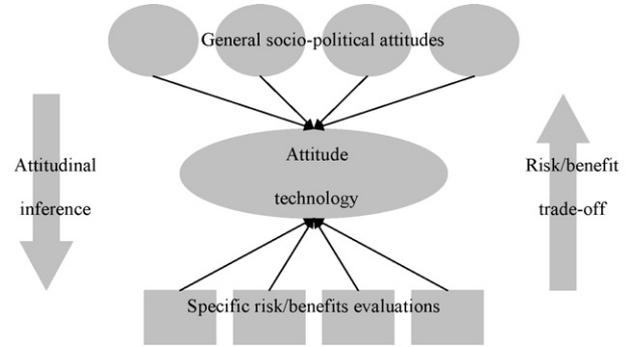
relevant, its application is threatened. For example, studies of consumer attitudes towards GMO have found that consumer acceptance depends on whether consumers perceive specific benefits associated with the product (Frewer, Howards, & Shepherd, 1996; Frewer, Howard, Hedderley, & Shepherd, 1997). Hence, a benefit that is perceived only to be in the interest of the manufacturer is not sufficient. From a managerial point of view, it is therefore important to understand how attitudes towards new processing technologies are formed, and to understand if marketers can influence this attitude formation through providing consumers with information about the technology.

The research presented in this paper is part of an EU project called Novel Q (2006–2011) whose main objective is to develop eco-friendly, novel processing technologies for improved quality (fresh-like character, extended shelf-life) food. For further information please see [www.novelq.org](http://www.novelq.org).

**Theoretical background**

The study draws on attitude formation theory from social psychology. There are two major classes of theories on attitude formation, which we can describe as bottom-up and top-down approaches (Scholderer & Frewer, 2003). The two approaches to attitude formation are not contradictory; if anything, they represent two basic mechanisms in how consumers form attitudes, both of which may be present to different degrees in any specific case.

Bottom-up formation of attitudes implies that the attitude towards, e.g. a product, is formed based on the knowledge about the product. Consumers form beliefs about characteristics of the product, and some of these characteristics they like, whereas others they do not like. The resulting attitude towards a product is a weighted average of the evaluation of its perceived risks and benefits (examples of this approach are the Fishbein attitude theory (1963) and the McGuire attitude change model (1969)). In the case of the high-pressure processing (HPP) or pulsed electric field (PEF) processing technologies, consumers may form an attitude by learning about certain process characteristics – how the technologies differ from conventional production methods, and about the fact that they result in food products with improved taste and texture, etc. Some of these features may be perceived as



Source: Søndergaard, Grunert & Scholderer (2005) and Scholderer, Bredahl & Frewer (2000).

**Fig. 1.** Attitude formation based on the top-down and bottom-up approach. Source: Søndergaard et al. (2005) and Scholderer et al. (2000).

good, others as inferior. As a consequence the overall attitude will be a result of a trade-off between the perceived benefits and risks of the technology or the product produced by means of the technology.

The top-down formation of attitudes regards an attitude as embedded into a system of general attitudes and values. These general attitudes guide the inference of attitudes towards more specific products or technologies in a way which preserves the evaluative tendency of the higher-order attitudes (e.g. Katz, 1960; Rokeach, 1968). Hence, attitudes toward a technology or product are inferred from general socio-political attitudes. When the attitude object is HPP or PEF, more abstract and general attitudes may include concern for the environment, attitude towards new technology in general or a general scepticism towards extensive processing. Previous studies on consumer attitude formation with regard to food processing technologies (focusing mainly on GMO) have found that general socio-political attitudes, such as attitude towards nature and the environment, and attitude towards new technology in general, play an important role in influencing consumers' attitudes towards new food processing technologies (Scholderer, 2005; Scholderer, Bredahl, & Frewer, 2000; Søndergaard, Grunert, & Scholderer, 2005). In Fig. 1, a visualization of

**Table 1**  
Facts about the 12 focus groups.

Country	City	When	Product	Number of participants	Gender	Age range	Mean age	Educational background
Denmark	Aarhus	12.06.06	Juice	7	4 men and 3 women	21–52 years	31.7 years	Mixed educational background - 4 students
	Randers	07.09.06	Baby food	5	5 women (all with young children)	23–28 years	26.4 years	Mixed educational backgrounds
Norway	Aas	07.03.07	Juice	8	5 men 3 women	23–50 years	42.2 years	All highly educated - 1 student
	Aas	07.03.07	Baby food	7	7 women (all with young children)	28–40 years	35.1 years	Mixed educational backgrounds - 1 student
Slovenia	Ljubljana	12.01.07	Juice	11	8 women 3 men	30–60 years	46 years	Mixed educational backgrounds
	Ljubljana	10.01.07	Baby food	4	4 women (all with young children)	30–39 years	33 years	Mixed educational backgrounds
Hungary	Szeged	23.11.06	Juice	9	6 women and 3 men	20–23 years	20.9 years	University students (no connection to food science)
	Szeged	23.11.06	Juice	10	6 women and 4 men	23–41 years	31.5 years	Mixed educational backgrounds
	Tapolca	09.12.06	Juice	9	7 women and 2 men	33–71 years	52.1 years	Mixed educational backgrounds, 2 retired citizens
Serbia	Subotica	04.05.06	Juice	12	6 women and 6 men	20–39 years	27.8 years	Mixed educational backgrounds
Slovakia	Bratislava	21.05.06	Juice	6	4 women and 2 men	26–56 years	42.3 years	Mixed educational backgrounds
Czech Republic	Brno	09.05.06	Juice	9	4 women and 5 men	26–50 years	36.4 years	Mixed educational backgrounds

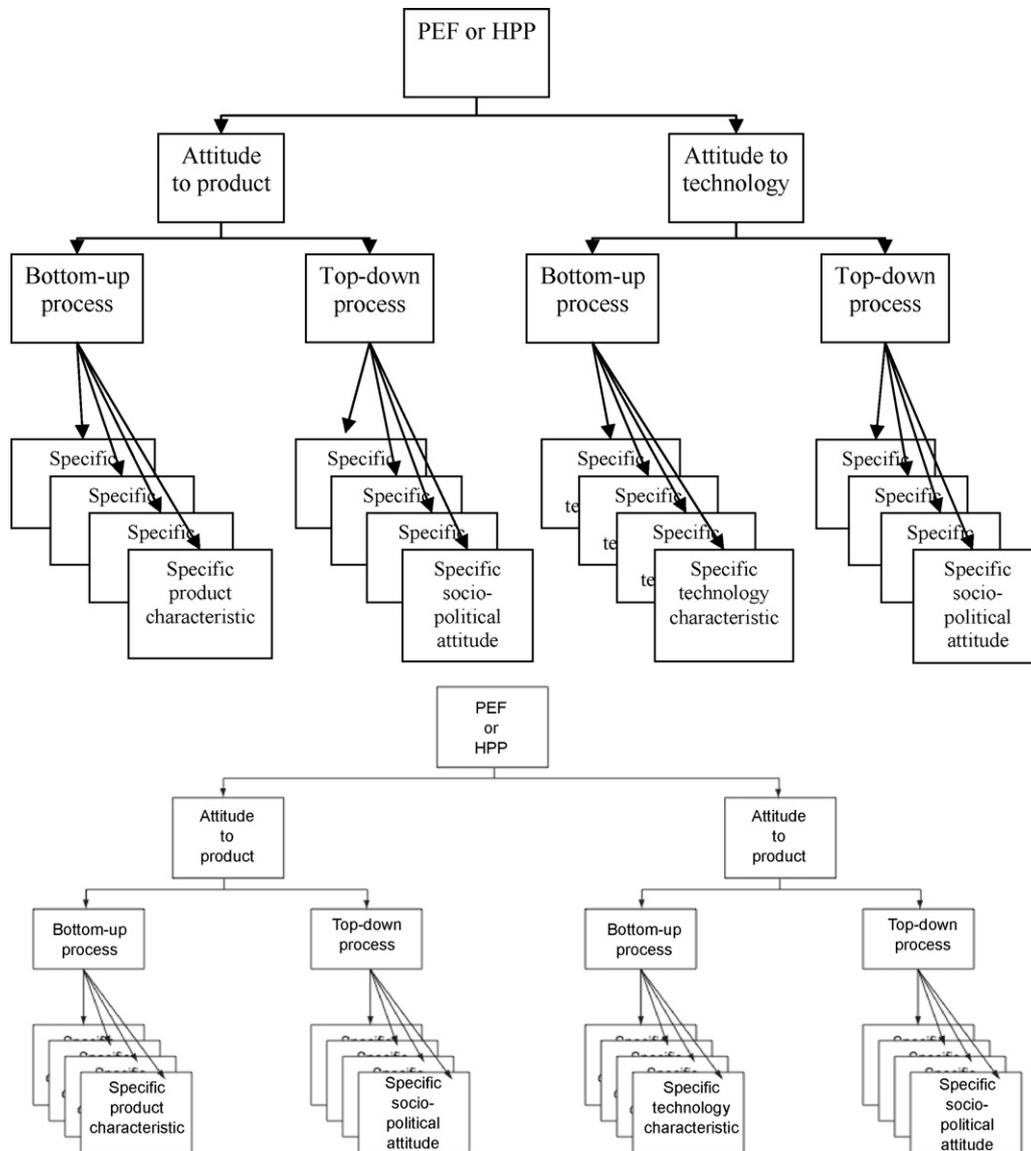


Fig. 2. Hierarchical structure of the four levels of coding.

attitude formation based on the bottom-up and top-down approaches can be seen.

### Design and method

Attitude formation is a cognitive process that can be verbalized (Ericsson & Simon, 1980). Attitude formation is therefore ideally studied in a setting where respondents are prompted to form new attitudes because of external stimulation with new information on attitude objects, and where they find it natural to verbalize their cognitive responses to this new information. A focus group provides the right setting for this, since participants will be stimulated both by information provided by the researchers' and by other participants' comments and they will be naturally prompted to verbalize their thought processes while reacting to the new information. Therefore, in order to study consumers' attitudes to PEF and HPP processing methods, a focus group study was set up in six European countries.

Since the attitudes formed during the focus group will be new and still weak, one might ask whether they will have any relevance for future behaviour. Attitude research indicates that while strong

attitudes will usually be behaviourally relevant, weak attitudes will be relevant only when primed in the behavioural situation (Fazio, 1986). Moreover, weak attitudes based on information may be superseded by own experience (Fazio & Zanna, 1978). Previous research on consumer acceptance of novel technologies in food processing (Grunert et al., 2003) has shown that weak attitudes based on information, when primed for example by media articles or advertising, may have a major impact on choice behaviour when own previous experience is non-existent, i.e. when a product is new on the market. This leads us to conclude that the attitude formation process as studied by a focus group method will be relevant for predicting future behaviour.

Focus groups were conducted in both Eastern and Northern Europe. This choice was motivated by the assumption that consumer attitude formation in Eastern and Northern Europe might differ, making it interesting to compare these areas. Until recently consumers in Eastern Europe used to live in a market environment characterized by limited product variety and limited use of advanced processing technologies compared to Northern Europe. On the other hand, consumers in Eastern Europe are more used to fresh food markets, and may be more used to the fresh taste

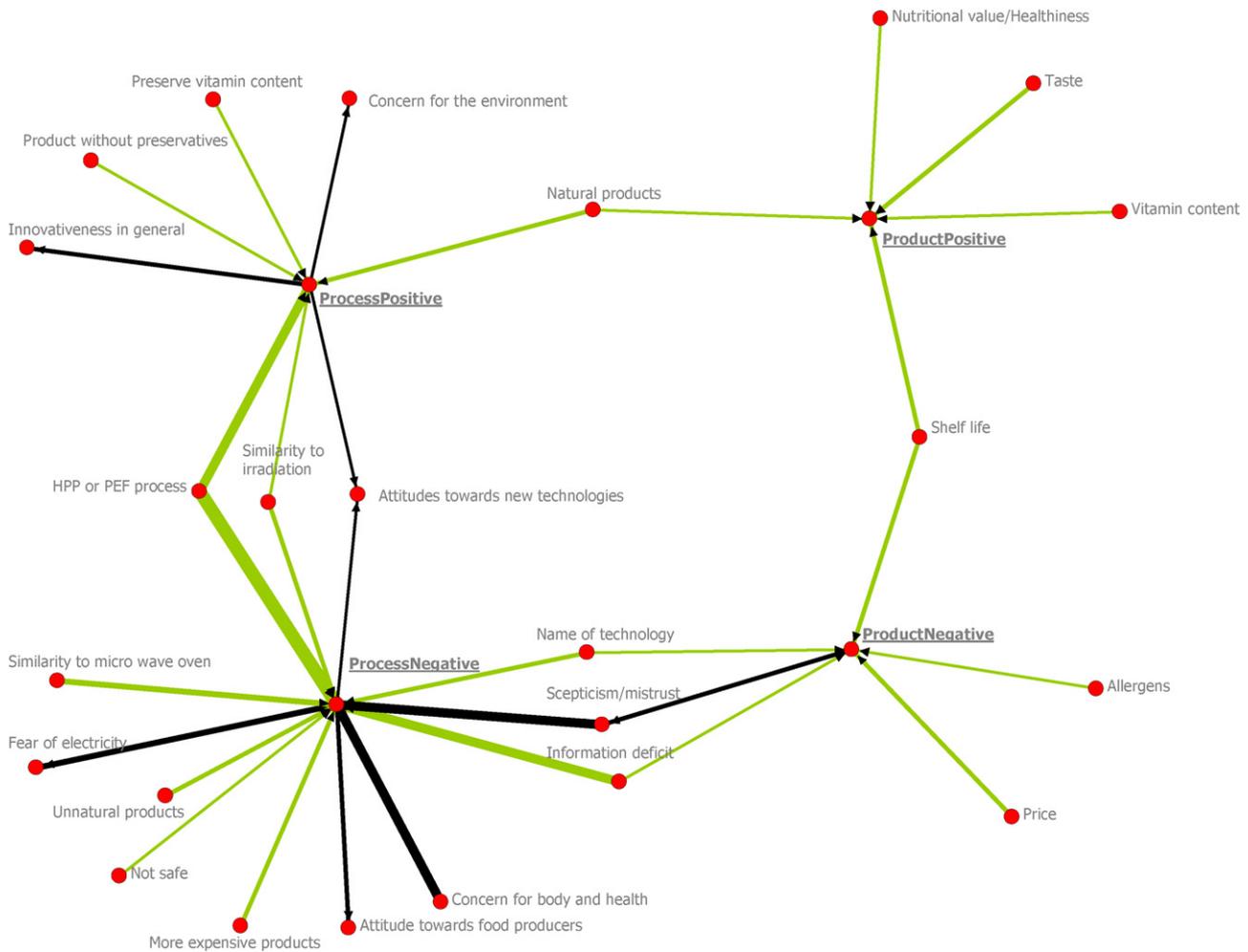


Fig. 3. Consumer attitude formation model for PEF, all countries and both products (Cut off-level = 2).

of food. These factors result in differences in knowledge on the basis of which consumers can form attitudes to new technologies, and in different baselines as regards expected shelf life and expected sensory properties of various food products. Altogether 12 focus groups were conducted. In Norway, Denmark and Slovenia two focus groups were conducted in each country, three focus groups were conducted in Hungary, and in Serbia, Slovakia, and the Czech Republic one focus group was conducted in each country.

Focus groups are a qualitative research method where results cannot be judged by the criterion of statistical representativeness. The results of any focus group are constrained by the composition of that particular focus group. This goes, of course, also for the present study. When focus groups are used in cross-national studies, cross-national differences cannot be reported in terms of proportions and statistically significant differences. What we can do is report differences in the patterns of responses of the various focus groups conducted, and interpret these in the light of the different composition of the focus groups, geographical and otherwise. Use of focus groups in cross-cultural research is widespread in many scientific disciplines (e.g. Hunter, 2001; Lazear, Pires, Isaacs, Chaulk, & Huang, 2008; Quine, 1999; Vrasti & Trotter, 1998).

A common focus group guideline was developed and followed in all countries to allow comparison of results across countries. The focus groups were structured along the following lines (see

Appendix B for more details): the moderator set out by introducing first HPP and then PEF, explaining the features of the new processing technologies. The order in which the technologies were introduced was varied across the focus groups to balance out any bias that might be caused by the sequence of presentation. The participants were then asked to voice their attitude towards the technologies. Later in the focus group, the participants were introduced to the effect that the two new food-processing methods would have on a specific product. The specific products selected for the focus group discussions were juice and baby food. Hence, in nine focus groups the product category discussed was juice, and in three it was baby food. This choice is justified mainly by the fact that the food products chosen had to be familiar to consumers in all the countries participating in the study. Furthermore juice was chosen because HPP and PEF treated juice already is accessible, and has been shown to have superior quality compared to thermally processed juice in terms of a more natural taste, texture, colour and vitamin content (Chern, Kaneko, & Tarakcioglu, 2003; Polydera, Stoforos, & Taoukis, 2005). Baby food was believed to be an interesting study objective since earlier studies have indicated that families with children may form stronger attitudes towards new technologies than families without children (Frenzen et al., 2001; Fox, 2002). Like juice, HPP and PEF treated baby food is expected to result in products with a more natural taste, texture, colour and vitamin content. Since the baby food that is on the market today is treated in a

**Table 2**  
Frequency of concepts.

	HPP		PEF		Total
	Positive	Negative	Positive	Negative	
<b>Bottom-up attitude formation</b>					
Allergens		2		3	5
Effectiveness of the process	1	2	1		4
Environment friendly	4		2		8
HPP or PEF process	32	3	15	26	76
Information deficit	2	16	1	23	42
Less waste due to use of technologies	5		2		7
Many benefits	15	1	2		18
Mineral content	1				1
Mistrust of high level of processing		3		1	4
More expensive products		18	1	7	26
Name of technology	2	1	2	10	15
Natural products	12		11	1	24
Not safe		7		3	10
Nutritional value/Healthiness	7		3	1	11
Preserve vitamin content	5		4	1	10
Price	4	13	2	6	25
Product without preservatives	5		5		10
Shelf life	2	5	6	9	22
Similarity to irradiation	2		5	7	14
Similarity to microwave oven			2	10	12
Similarity to GMO	1				1
Taste	16	1	7		24
Texture	3				3
Unnatural products		2		6	8
Vitamin content	13		3		16
<b>Top-down attitude formation</b>					
Attitude towards food producers	4	3		8	15
Attitudes towards additives	2	1	1	1	5
Attitudes towards new technologies	3	1	5	5	14
Concern for body and health	2	5		17	24
Concern for the environment	4	2	4	1	11
Family values	1		1		2
Fear of electricity			1	10	11
Food neophobia		1			1
Home made	1	2		1	4
Innovativeness in general	6		6		12
Perceived personal knowledge		4		2	6
Scepticism/mistrust		18	2	22	42
Total	155	111	94	183	543

relatively long heat sterilisation process the benefits derived from HPP and PEF are even more salient.

The focus group participants were recruited partly by means of notes posted in supermarkets, schools and daycare centres, partly by contacting members of consumer/member panels and partly by making use of the snowball method where one person was recruited and asked to recruit two additional persons not knowing each other to join the interview. Only persons drinking juice/buying baby food at least twice a month were recruited. Table 1 provides an overview of where and when the 12 focus groups were conducted and with whom.

In all countries except the Czech Republic a researcher with good knowledge of HPP and PEF moderated the focus groups. In the Czech Republic an expert in conducting focus groups was contracted to do the moderating. This person was given a thorough introduction to the two technologies. The average length of the focus group interviews was 1 h and 23 min.

The results were subjected to a content analysis procedure, which included six steps. In the first step, the focus group discussions were transcribed. In the second step, a researcher from each country went through the transcripts of the focus

group interviews identifying major concepts and assigning codes. Identification of concepts and coding was guided by the hierarchical structure shown in Fig. 2. Levels 1–3 were derived from our theoretical approach. Codes for level four were developed inductively from the transcripts. The coders had to ask themselves four questions when assigning codes at the fourth level: Is this attitude mentioned in relation to HPP or PEF? Is this attitude negative or positive and is it mentioned when talking about a specific product or about the technology in general? Is this attitude generated by a bottom-up or a top-down process? And finally, what kind of specific product or technology characteristic (in the case of bottom-up process) or specific socio-political attitude (in the case of top-down process) are we dealing with?

In step three, all codes from all the countries were compared and key codes for comparative analysis were developed. In step four, researchers in all the countries went through the key codes and checked for application to their own data, which resulted in a few modifications. Table 2 shows the final key concepts found for the fourth level of coding. In step five, each country went through the transcripts again and recoded them according to the new coding scheme. In step six, the codings from the new coding scheme were aggregated and transformed into diagrams using UCINET 5 (Borgatti, Everett, & Freeman, 2002) and NETDRAW (Borgatti, 2002).

The NETDRAW diagrams are based on the frequency table of the aggregated codings. The categories found in the content analysis are represented as nodes and the width of the arrows is proportional to the association frequency. In this analysis an arrow that points away from a central node in the diagram represents a top-down attitude and an arrow pointing towards a central node in the diagram represents a bottom-up attitude. For improved visualization the bottom-up arrows are green and the top-down arrows are black. The diagrams from this analysis are interpreted as models of consumers' attitude formation process. The models are presented and discussed in the next session.

In the analysis of the 12 focus groups, 37 different concepts were identified.<sup>2</sup> These concepts and the frequency of each concept are shown in Table 2.

The upper part of Table 2 includes concepts mentioned in a bottom-up context, while the lower part of the table shows concepts mentioned in a top-down context.

In the following, major patterns in the answers will be shown. First, consumers' attitude formation models for PEF and HPP are compared. Second, the attitude formation models of North and East European consumers are compared with regard to the formation of attitudes to the two technologies. Third, the attitude formation models for juice versus baby food produced by means of PEF and HPP are compared.

## Results

The following diagrams are to be read as follows. Each diagram consists of four central nodes: ProductPositive, ProductNegative, ProcessPositive and ProcessNegative. These four nodes represent level 2 in the coding: *Is this attitude negative or positive and is it mentioned when talking about the specific product or the specific technology?* The specific concepts mentioned in the focus group in relation to each of these four central nodes are connected to that node in the diagram.

<sup>2</sup> To simplify the figures, various cut-off levels have been chosen. This means that not all 37 concepts are shown in the figures.

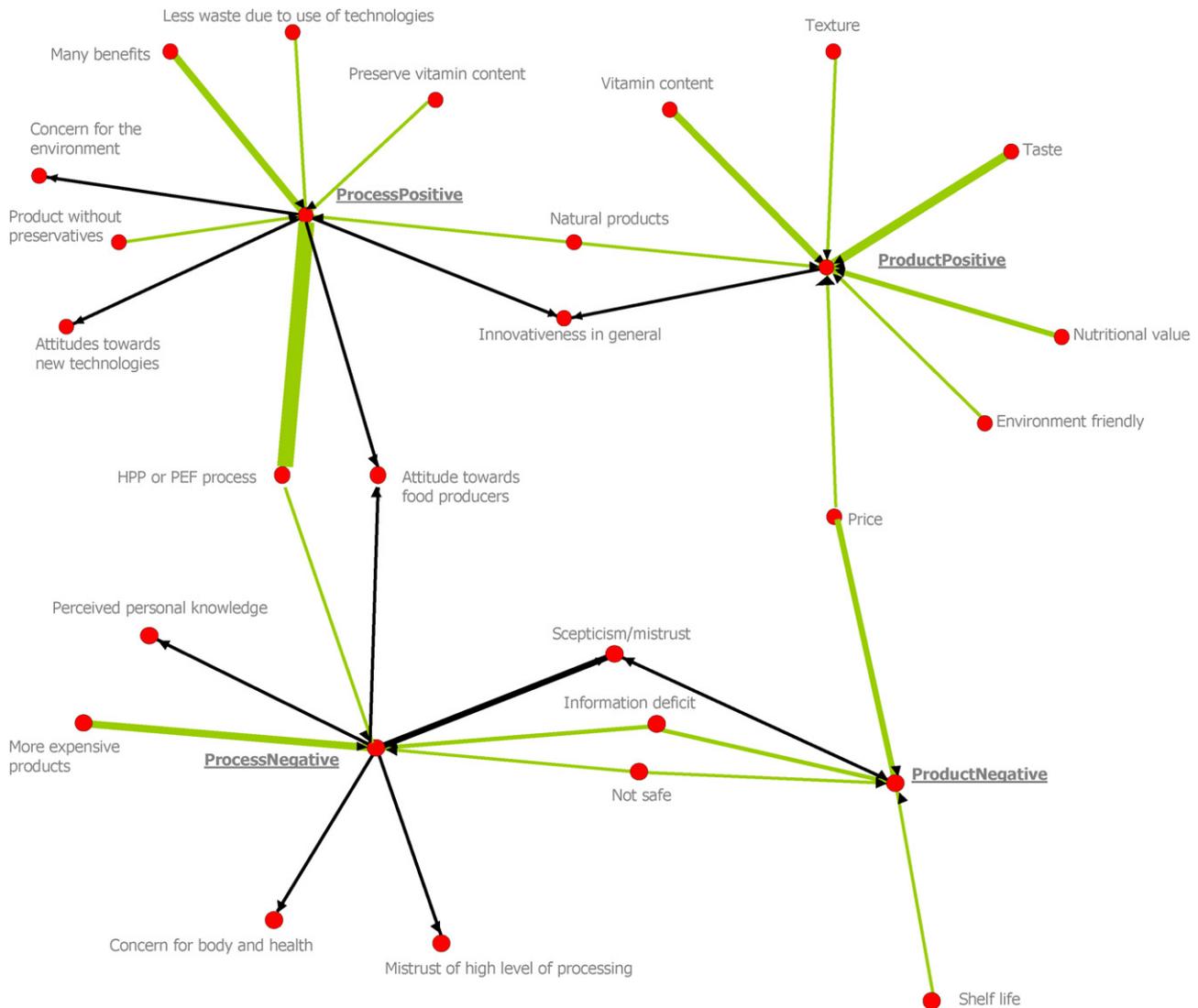


Fig. 4. Consumer mental model for HPP, all countries and both products (Cut off-level = 2).

#### Pulsed electric field versus high pressure processing

By looking at Figs. 3 and 4, it becomes clear that the participants were particularly positive towards the PEF and HPP products' (ProductPositive) naturalness, improved taste and their high nutritional value. In relation to the high nutritional value especially the high vitamin content was valued. Some of the reasons for the participants' negative attitudes towards PEF and HPP products (ProductNegative) were the higher price, the longer shelf life compared to freshly squeezed products, the lack of information about PEF and HPP products and a general scepticism towards the technologies. The participants were generally positive towards the PEF and HPP processes (ProcessPositive) as the processes are seen to be environmentally friendly and result in natural products with a high vitamin content. Furthermore there was a positive attitude towards the PEF and HPP processes as no food preservatives are used in the production. Some of the participants were also positive towards these new technologies because they generally have a positive attitude towards innovation. Some of the reasons why the participants were negative towards the PEF and HPP processes (ProcessNegative) was that they were sceptical in general, they were worried about their body and health, that the processes result in more expensive products, the lack of information about the

technologies and also because of a scepticism towards the food producers. Some people do not trust food producers, which a participant formulated in the following way: "Novel technologies have been elaborated only to produce more and more profit for producers. They have not been elaborated to comply with consumer demands or to produce healthier food products" (Male, 48 years old, juice, Hungary).

Figs. 3 and 4 also show that attitudes towards the PEF and HPP processes were formed based on the participants' general socio-political attitudes as well as on a risk/benefit trade-off of the product attributes, whereas attitudes towards the PEF and HPP products were formed mainly based on a risk/benefit trade-off of the product attributes.

A comparison of Figs. 3 and 4 reveal a number of differences. First of all, there are more negative attitudes and less positive attitudes towards the PEF process and the PEF products compared to the HPP process and the HPP products. The participants were sceptical towards PEF because of its name, which is not the case with HPP. This scepticism is partly due to the fact that the name generates a fear of electricity. This fear is highlighted in the following statement: "I just cannot imagine this high voltage. I'm afraid of it. It sounds bad. Electricity is not for me" (Female, 29 years old, juice, Hungary). In addition, PEF products were seen as

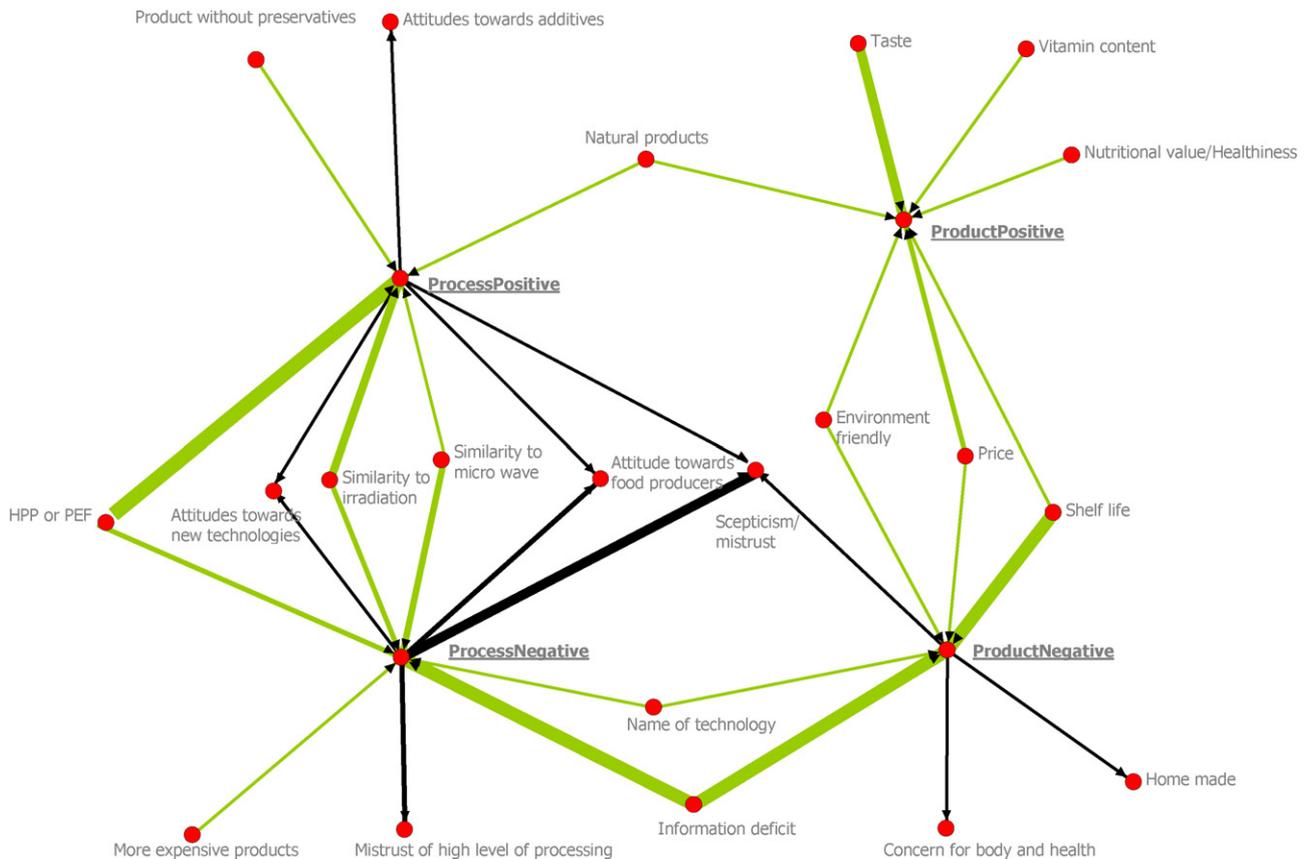


Fig. 5. Consumer attitude formation model for North European consumers, both products and both technologies (cut off-level = 1).

negative as they are believed to trigger allergic reactions: “I can’t help thinking about what else is in the product. More and more people are suffering from allergy these days. I don’t know if that is a problem with this technology but I can’t help wondering” (Female, 28 years old, baby food, Denmark). The more positive attitudes to HPP result from the participants’ preference for the HPP process compared to the PEF technology. This attitude was formulated by a participant in the following way: “My opinion is that this process (PEF) is not natural at all. That’s why I don’t like it at all compared to the other one (HPP), which seems to be more natural.” (Female, 37 years old, juice, Serbia). Furthermore, HPP products were seen as positive because the natural texture is retained better, and because of the environmental friendliness. Another difference between Figs. 3 and 4 is that only PEF is linked to already known processing methods like microwave oven and irradiation.

#### North versus East European participants<sup>3</sup>

One of the aims of this study was to look at potential differences between the North and East European participants’ attitudes towards the two technologies. By comparing Figs. 5 and 6 it can be seen that in general the North European participants were a bit more sceptical towards PEF and HPP products than the East European participants. This was first of all due to the fact that many of the North European participants see

the longer shelf life compared to a freshly squeezed juice as a negative attribute, which a participant formulated in this way: “But you become a bit anxious when you see the sell-by date. What have they added to the juice?” (Male, 50 years old, juice, Norway). In this connection it is important to note that in Eastern Europe almost all juices are highly processed resulting in a 12-month shelf life, whereas some juices in the Northern Europe are freshly squeezed or minimally processed with a short shelf life of a couple of weeks. Both the North and the East European participants preferred products with a relatively short shelf life, but in the North where there are juices with a short shelf life, the shelf life of the HPP and PEF products was seen as a negative attribute, whereas in the East where juices have a long shelf life the shelf life HPP and PEF products was primarily seen as a positive attribute. Secondly, the North European participants were a bit more sceptical towards the environmental benefits of the products, and thirdly many of the North European consumers thought that there was a severe lack of information about products produced by means of PEF or HPP.

However, the North European participants were not the most sceptical towards the PEF and HPP products in all areas. The East European participants saw the higher price solely as negative, while some of the participants in the North European countries see the higher price as positive. An East European participant formulated her negative attitude towards the higher price in the following way: “It is very convincing, but I do not think people in Hungary could pay for these products. They must be very expensive.” (Female, 21 years old, juice, Hungary). A North European participant formulated her positive attitude in this way: “If I were to choose between different types of baby food, I would choose the

<sup>3</sup> Please note that the number of arrows across the figures cannot be compared, as there were only four focus groups in the Northern European countries and eight in the Eastern European countries. The difference in cut-off level is a way to level this, but the fact remains that the focus groups do not have the same number of participants.

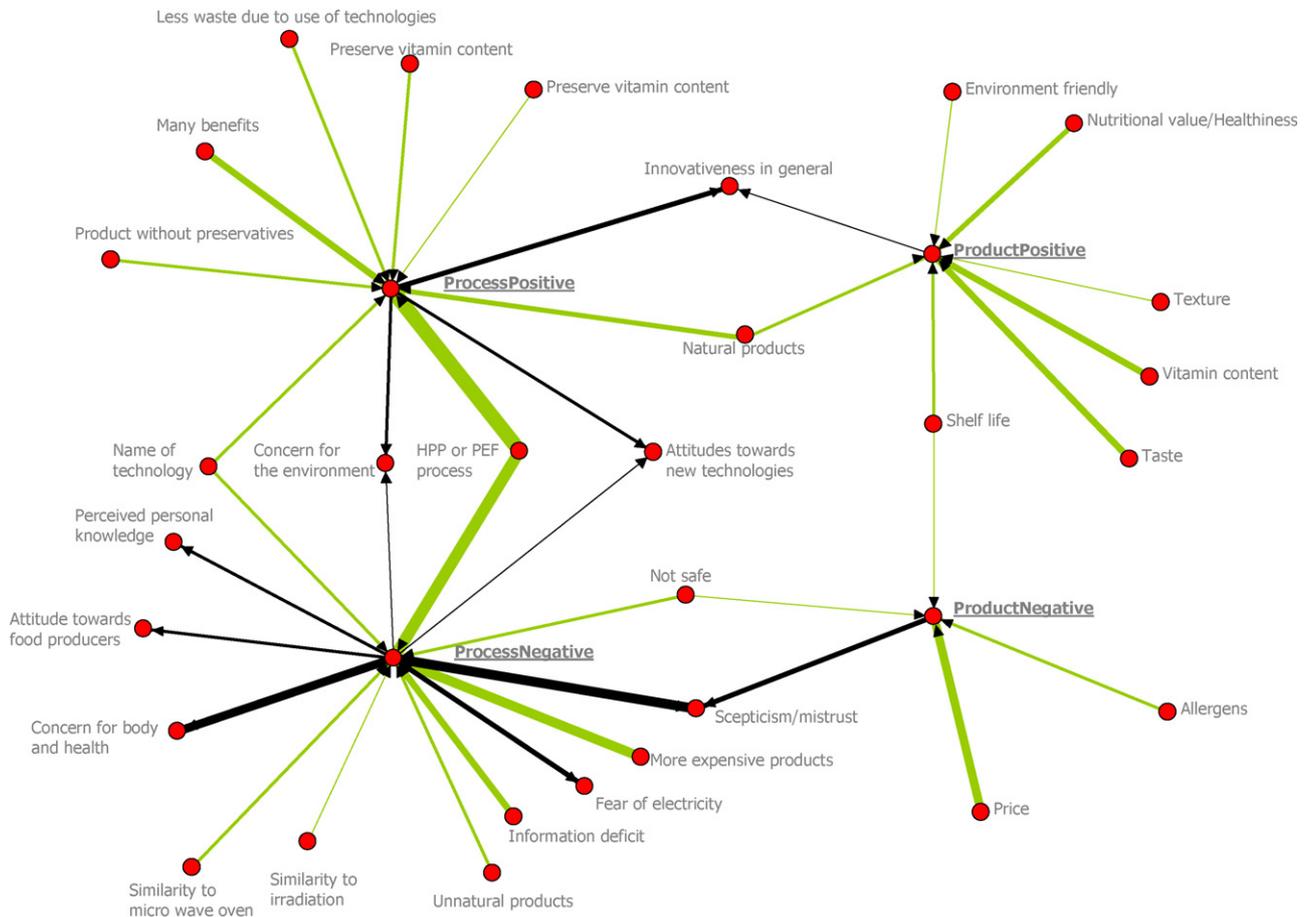


Fig. 6. Consumer attitude formation model for East European consumers, both products and both technologies (cut off-level = 2).

more expensive one because I hope it is of a better quality" (Female, 26 years old, baby food, Denmark). In addition to this, the East European participants were more worried about allergy caused by PEF and HPP products.

Another difference between East and Northern European consumers is that when comparing the PEF and HPP technologies with familiar technologies some Northern participants perceived them as positive and others as negative. In the East European countries this comparison was solely seen as something negative. One participant formulated this negative comparison like this: "It is like a microwave oven so I do not really like it. Using microwaves is fairly unhealthy" (Male, 33 years old, juice, Hungary). Another interesting result when comparing Figs. 5 and 6 was that the East European consumers were more positive towards the PEF and HPP products and processes because they had a positive attitude towards innovation in general. This positive attitude towards innovativeness was expressed by a participant in this quotation: "For sure, a new method is better than an old one. I would trust the new method more" (Female, 30 years old, baby food, Slovenia).

#### Baby food versus juice<sup>4</sup>

To detect whether there is any difference in the participants' attitude formation across product types, the consumers' attitude

formation towards two different products produced with PEF and HPP will be compared below. Fig. 7 gives insight into the consumer attitude formation for baby food, and Fig. 8 for juice. The main difference between the two figures is that the higher price of baby food was seen as a positive attribute of the product. This was expressed in the following quotation: "I would take it as a sign of a high quality product if the price was high, and then the price does not matter and I think all new mothers feel the same way." (Female, 28 years old, baby food, Denmark). Conversely, the participants in the juice focus groups saw the potentially higher price of juice as a negative product attribute.

Fig. 7 shows that some participants were negative towards HPP and PEF baby food as this product is not home made. This attitude is highlighted in the following quotation: "Ideal food for small children has to be fresh, like the one I prepare myself" (Female, 39 years old, baby food, Slovenia). Whether the product is home made was not an issue regarding juice. This difference is due to the fact that many people are very concerned about what they feed their children, and parents want to know exactly how the food is produced: "One of my arguments for making the food myself is that then I know how it has been made. I have cooked it long enough and used fresh ingredients. I have control" (Female, 38 years old, baby food, Norway).

Another difference between the two groups is that some of the participants from the baby food focus groups saw the longer shelf life as a positive attribute, while several of the participants from the juice focus group saw it as a negative attribute.

<sup>4</sup> Please note that the number of arrows is not strictly comparable across the figures as there were only three focus groups about baby food and nine focus groups about juice. The difference in cut-off level is a way to try to level this, but the fact remains that the focus groups do not have the same number of participants.

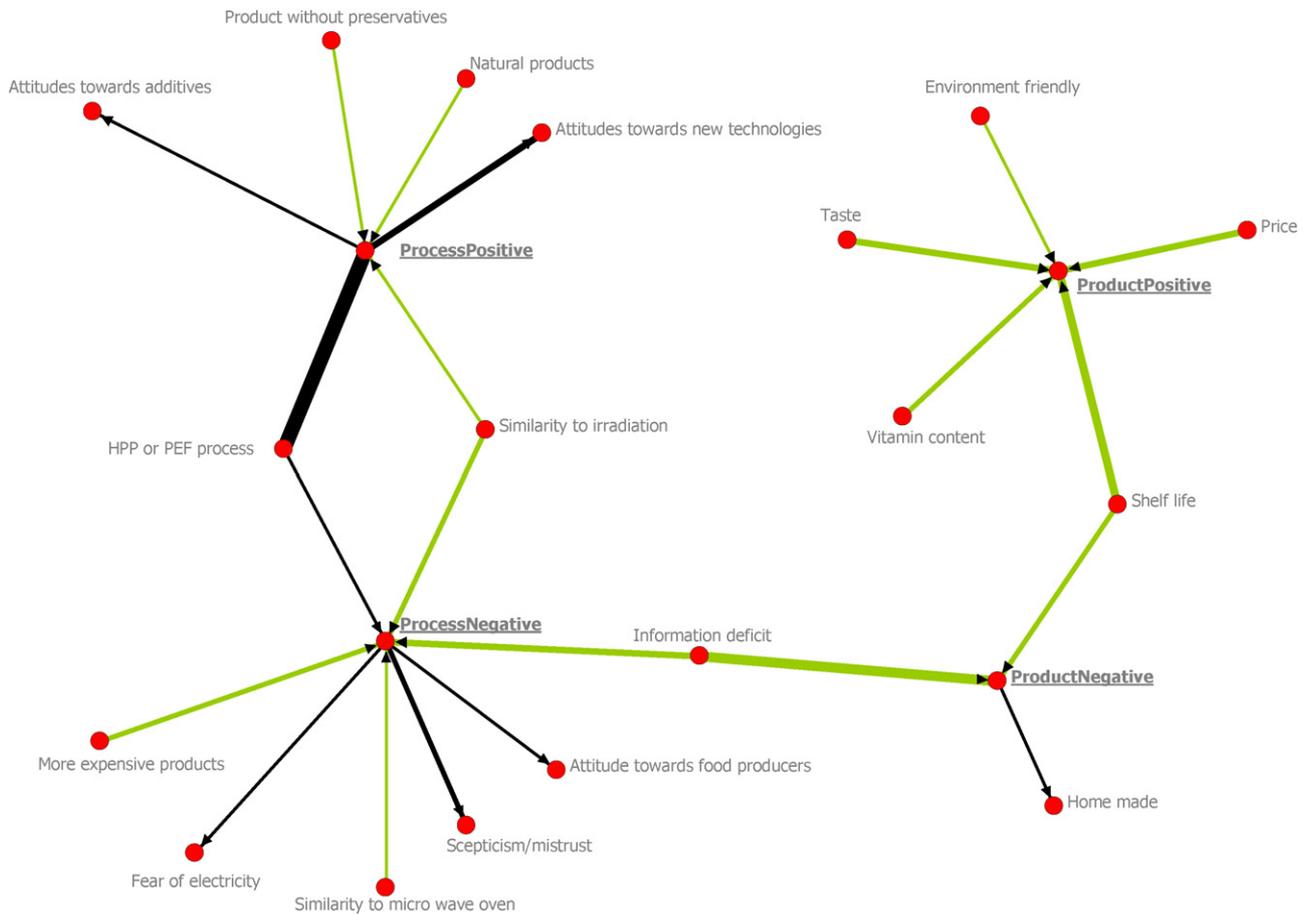


Fig. 7. Consumer attitude formation model for baby food, all countries (DK, N, SI) and both technologies (cut off-level = 1).

## Discussion and conclusions

It is important to point out that the attitude formation models are descriptions of consumers' perceptions of the two technologies and products derived from an aggregate analysis of the focus group transcripts, and not of individual participants. The six models are an attempt to characterize the differences in conceptualizations among different technologies, different types of food products and different countries as well as to summarize these to further our understanding of how consumers make sense of the world.

Another issue to keep in mind is that only one out of the 97 focus group participants had previous knowledge about the PEF and HPP technologies and how these technologies affect the product outcome. In cases like this, where there is no previous knowledge about the issue investigated, the way the attributes of technologies and products is presented impacts the result. Thus in this study, giving an objective description of the technologies and the way they affected the products was of the essence. Therefore, the information used for the study was sent to PEF and HPP experts for approval before carrying out the study, and both advantages and disadvantages were put forward to the participants.

The results of this study indicate that there are both top-down and bottom-up processes that affect consumers' attitudes towards the HPP and PEF technologies and the products manufactured by means of these. The attitudes towards the PEF and HPP processes are based both on general socio-political attitudes and on a risk/benefit trade-off of the product attributes, whereas the attitudes

towards the PEF and HPP products are mainly based on a risk/benefit trade-off of the product attributes.

When considering the HPP and PEF products, the main advantages perceived by the participants were the products' expected naturalness, improved taste and high nutritional value, whereas the main disadvantage were lack of information about the PEF and HPP processes, environmental friendliness and the more natural products were seen as the main advantages, while concern for body and health, the more expensive products, lack of information about the technologies and a general scepticism were seen as the main disadvantages. In a potential buying situation the participants said that quality and especially taste play a critical role in accepting and maintaining the commercial marketability of these novel products. One participant said: "I don't care too much about the method. I am interested in quality, i.e. smell and taste" (Female, 50 years old, juice, the Czech Republic). This result emphasizes the importance of making it easy for consumers to get product experience and consequently preference for the PEF- and HPP-treated products. This could be realized by means of introduction offers or letting consumers sample the products in shops or elsewhere. Also providing consumers with more information about the technologies seems to be a key to achieve consumer acceptance of products manufactured by means of these new technologies. This appears to be especially important in the case of introducing PEF products, since many consumers associated the name of the technology with electricity, and were sceptical about what the side effects of using electricity in food production might be. Hence, it is the responsibility of food

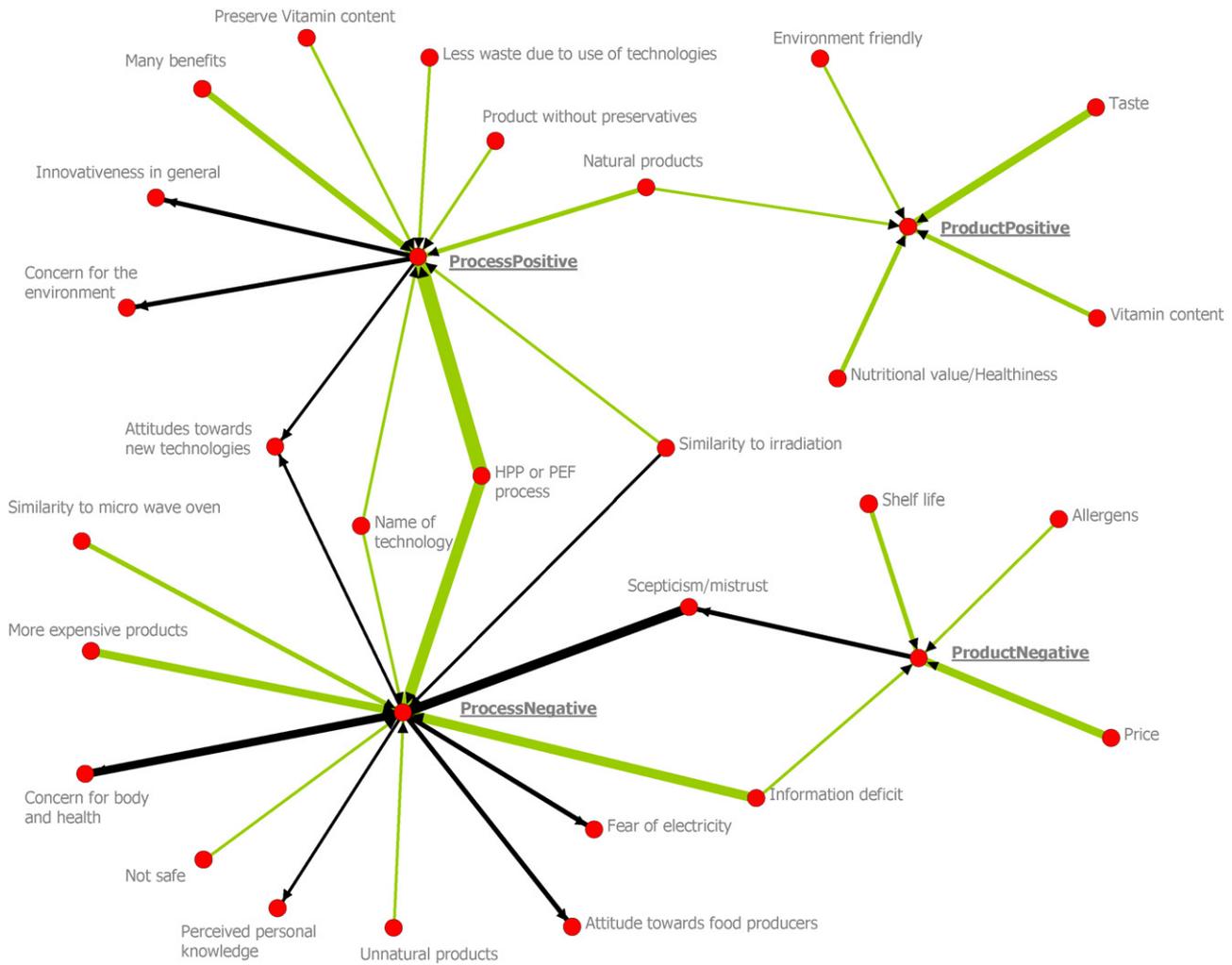


Fig. 8. Consumer attitude formation model for juice, all countries and both technologies (cut off-level = 3).

producers and food scientists to provide the evidence that will convince consumers that this technology is safe to use in connection with food processing. Such information provision should occur in the early phases of introduction of these new technologies, as research on GMO acceptance has shown that information may have the opposite of the intended effect once attitudes have become more stable (Scholderer & Frewer, 2003).

The longer shelf life of HPP and PEF products was perceived by some consumers as a positive attribute in the case of baby food and a negative attribute in the case of juice. The reason for this is most likely that juice is perceived to be a product where freshness – and thereby shorter shelf life – is associated with high quality. In the case of baby food the majority of products on the market are products in a can or jar (not chilled as in the case of many juices) so consumers are already accustomed to products with a long shelf life. As one of the goals of developing the PEF and HPP technologies is to extend shelf life, this is a very interesting result. It shows that what is in the interest of food producers and retailers is not always in the interest of consumers.

One of the puzzling findings was that East European consumers saw the comparison between PEF and HPP technologies and familiar technologies as something negative and at the same time they were more positive towards PEF and HPP products because they had a positive attitude towards innovation in general. We interpret this finding as indicating that some East European consumers were negative towards the PEF technology because

they compared it to familiar technologies that they had a negative attitude to, namely microwave ovens and irradiation. At the same time they did not have this negative association when presented with products manufactured with new processing technologies because generally they were positive towards innovative new products. This is probably also due to fact that attitudes towards PEF and HPP products were formed mostly on the basis of a bottom-up process where participants evaluated the characteristics of the products and their perceived benefits and risks. In this case it seems that the evaluated benefits of the products manufactured by means of the two novel processing technologies outweigh the perceived risk.

The finding, that several baby food buyers saw the higher price of the PEF and HPP products as positive while the juice consumers saw the higher price as negative, is, according to the participants themselves, due to the fact that parents want to feed their children high quality products. As high price indicates high quality, expensive baby food is sometimes preferred. This finding suggests that producers should concentrate on high value products when applying HPP and PEF.

In conclusion, there seems to be good reason for doing further work on the development of PEF and HPP, as consumers see potential in these products. What is still missing in research on PEF and HPP technologies is to examine consumers' trade-off between various product attributes, e.g. price, taste, shelf life and nutritional value. When actual PEF and HPP products will become available in

Europe it will also be interesting to examine consumer attitudes and behaviour towards PEF and HPP products in real-life situations and also to do sensory evaluations.

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## Appendix A

High Pressure Processing is a method for processing food products without using heat. The product is subjected to pressure that inactivates most micro-organism, by damaging cell components such as cell membranes. Pulsed Electric Fields is a food processing method that, like HPP, works without the use of heat. Electric impulses are sent through the object damaging cell components and deactivating/inactivating most of the micro-organisms.

Both HPP and PEF retain food quality and natural freshness, they produce nutritious and safe-to-eat foods and extend microbiological shelf life without using chemical additives. Products produced with HPP or PEF are expected to result in products that are 10–20% more expensive than the products that are on the market today.

## Appendix B

### B.1. Juice focus group discussion guidelines

#### B.1.1. Introduction

Participants are welcomed and told that the purpose of the focus group is to analyse how they as consumers form attitudes towards new technologies and a product produced by means of these.

Step 1: Participants are asked about their consumption and opinion of juice or baby food.

Questions concerned issues such as:

- frequency and situation of consumption;
- expectation to the product;
- preferred type of product (e.g. for juice NFC versus from concentrate);
- opinion of selection of products in retail stores within the category;

- opinion of the retail price of products in the category;
- opinion of the general quality of products in the store within the category;
- opinion of the shelf life of the products.

Step 2: Participants were asked to put down on a piece of paper, the criteria which are important to them when they buy juice or baby food.

Step 3: The discussion so far was summarized and participants were asked what in their opinion makes a juice excellent.

Step 4: Participants were introduced to High Pressure Processing. They were told that it is a new production method which manufacturers can use in the processing of juice or baby food. First they were told how the technology works and its advantages and second an explanation of how it influences the products produced by means of the method was given. They were also told that today HPP is used in the production of jam, dressing, yoghurt, milk, juice, guacamole, ham and various types of fish products. They were also informed that although there are already products on the market produced by means of HPP the products are mainly sold in Japan and the United States where they were introduced in the 1990s.

Regarding the advantages of the method it was explained that it reduces

- The waste of refrigerated products in the retail trade due to an extended shelf life of the products. Compared to pasteurization the method reduces
- The use of energy during production due to low-temperature and low-energy processing.
- The use of water and chemicals during production.

Participants were then asked to state their opinion about the HPP method. Here, the focus group moderator would try to uncover why the participants thought about

juice or baby food treated with HPP as they did – what they based their attitudes on.

The information participants were given regarding the effect of HPP on a product produced by means of this method included information on shelf life, colour, smell and taste, and nutritional content. The example below is the description of a juice produced by HPP:

- *Shelf life.* The shelf life is extended by inactivating micro-organisms compared to a freshly squeezed juice or a juice which has been exposed to a mild form of pasteurization.
- *Colour.* The colour is a bit different compared to freshly squeezed juice, but not as much as juice which has been pasteurized.
- *Smell and taste.* Smell and taste change a little compared to freshly squeezed juice, but not as much as juice which has been pasteurized.
- *Nutritional content.* The nutritional content is a bit lower compared to freshly squeezed juice, but not as much as juice which has been pasteurized.

After this introduction to the technology, participants were asked what they thought of juice or baby food which had been treated with HPP. Again, the focus group moderator would try to uncover why the participants thought about juice or baby food treated with HPP as they did – what they based their attitudes on.

Participants were then introduced to the second technology PEF (Pulsed Electric Field). They were told that it is a new production method which juice manufacturers can use in the processing of juice or baby food. PEF is especially useful for liquid foods such as: fruit juice, eggs and milk. First they were told how the technology works and its advantages, and second an explanation of how it influences the products produced by means of the method was given.

Regarding the advantages of the method it was explained that the method reduces:

- The waste of refrigerated products in the retail trade due to an extended shelf life of the products.
- Compared to pasteurization the method reduces:
- The use of energy during production due to low-temperature and low-energy processing.
  - The use of water and chemicals during production.

Subsequently the participants were asked what they thought about the PEF method? During the discussion the moderator would try to uncover why the participants think about PEF as they do – what they base their attitudes on.

The information participants were given regarding the effect of PEF on a product produced by means of this method included information on shelf life, colour, smell

and taste, and nutritional content. The example below is the description of a juice produced by PEF:

- *Shelf life.* As mentioned earlier, PEF inactivates micro-organisms thereby extending the shelf life compared to freshly squeezed juice or juice which has been exposed to a mild form of pasteurization. For example, PEF treatment can preserve the fresh taste of apple juice for a month at a temperature of 4 °C.
- *Colour.* PEF hardly affects the colour of the juice thus the colour of PEF juice will be very close to freshly squeezed juice. Compared to pasteurization the effect is very small.
- *Smell and taste.* Despite the extended shelf lift the smell and taste of the juice are hardly affected. Compared to conventionally heated juice the PEF-treated juice tastes better.
- *Nutritional content.* PEF does not affect the nutritional content in a negative way. (Some investigations even show that PEF can have a positive influence on the nutritional content due to the fact that the cell membranes are penetrated, thereby improving the availability of intracellular compounds. By sending electrical impulses through the product its cell membranes are penetrated more easily the result being that the product nutrients will stand out more.)

Subsequently participants were asked to state their opinions about juice or baby food which had been treated with PEF. During the discussion the moderator would try to uncover why the participants thought about juice treated with PEF as they did – what they based their attitudes on.

Step 5: In the last part of the focus group session, participants were introduced to two real products. In the focus group on juice participants were faced with one product where the label said it had been pasteurized and another where the label said it had been treated with PEF. In the baby food focus group the first product was described as having been pasteurized and the second as being treated with HPP. Participants were then asked to look at these products, compare them and elaborate on the following issues.

- What differences did they see concerning the two products?
- In what ways are these differences important?
- Which of the two products were they most likely to buy? And why?
- What would it take for them to choose a juice/baby food which has been treated with PEF/HPP? (This question was only addressed if the participants were most likely to buy the conventional product.)

Step 6: At the end of the focus group participants were asked to fill out a self-administered questionnaire containing questions on demographic data as well as user status on juice or baby food.