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Revision 1

Information exchange between communicative packaging concepts and infrastructure in the distribution chain and at the customers'

A SustainPack Report

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Report 387

Colophon

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Summary

This report is a deliverable of Sub-project 6 ('Communicative packaging') of the European FP6 funded project SustainPack. This is the first deliverable of workpackage 6.3 ('Integration of communicative packaging in the supply chain'), one of the three workpackages of Sub-project 6.
This report consists of 3 major parts:

- an overview on the trends and market expectations;
- the definition of communicative packaging concepts for perishable products;
- the implementation of the first packaging concept in the form of a case study: the tomato production and distribution chain from Europe to the USA market.

The overview of trends and market expectations is carried out on different levels:

1) Inventory on actual trends in the food and packaging industry based on studies conducted by PIRA and A&F: From these studies, it is concluded that consumers seek safe products. This is reflected both in food safety issues, in anti-counterfeiting of brand products and tracking and tracing systems. Another important trend is the role of packaging as part of product marketing. The packaging contributes actively to sell the product. In addition, the consumer wants more and detailed product information to be available. Also, market globalisation is an important trend, resulting in complex logistics. Finally, counterfeiting is a huge business, which grows as the globalisation of the market also increases, costing brand owners large amounts of money. Therefore, companies are willing to invest in anti-counterfeiting technologies.

2) Market expectations identified by the industrial partners participating in the project;

3) Retailers survey: From this survey, it can be concluded that retailers are interested in communicative features on the packaging but they are currently not yet active in implementing these. An other important conclusion is that communicative features which give direct indication on the product quality should not be readable by consumers. Such quality indicators could be implemented for internal use.

4) Technology mapping study conducted by PIRA (activity of Sub-project 1). A broad range of communication related packaging features have been identified.

Based on these trends, 6 scenario's for communicative packaging concepts for perishable products have been defined:

- The reliable box;
- The smart box;
- The proud box;
- The special box;
- The handy box;
- The convenience box.

The scenario 'the reliable box' is chosen. In order to concretise this scenario, a detailed analysis of different product-market-combinations (PMC) is carried out. The PMC with highest score is: tomato production in Europe and distribution overseas. The scenario 'Reliable box' and this respective PMC form the first case study of SP6: *A communicative transport package for tomatoes produced in Europe and distributed overseas (USA). The sensor will register temperature and humidity*. This case study will lead to the first communicative packaging concept.

The case study begins with a chain inventory and definition of communication infrastructure covering the following aspects:

- Identification and definition of the different chain links and participants;
- Content of the information exchanged within the chain;
- Mapping of the actual communication infrastructure and flow.

This case study will be continued with the following major activities:

- Chain simulations;
- Development of a temperature/RH sensor;
- Application of the sustainability framework;
- Simulations tests under chain realistic conditions.

Content

1 Introduction on communicative packaging concepts

The main objective of a packaging is to protect its contents from the production site all the way through the distribution channel until the moment of use. However, increasingly important are the communicative aspects of the packaging. Sub-project 6 of SustainPack is dedicated to technology development and implementation of communicative packaging. Four aspects of communication can be distinguished as is outlined in Table 1: Identification, Appeal & information, Quality Indicators and Anti-counterfeiting.

Table 1 Type of information to be communicated by packaging of the product

Identification - Type of product - Origin of product - (Batch)number of product	**Appeal & information** - Catch the eye of potential buyer, marketing - Product information relevant for handling/buying the product
Quality Indication - Updated information about product quality - Based on treatment of product in distribution chain (shock, temperature, package integrity etc)	**Anti-counterfeiting** - Incorporation of new technology gives unique fingerprint - Distinguishes brand products from imitation products

1.1 Identification

Registration of type and origin of products at all points in the distribution channel is a precondition for tracking and tracing. Traceability of products has for years been a common practice in the pharmaceutical industry. Since January 2005, the General Food Law dictates that all players involved in food business operations must at least be able to identify the immediate supplier of a questionable product and the immediate subsequent recipient. Especially for fast moving consumer goods such as groceries, the introduction of new technology for fast, cheap and reliable registration of identification is a big topic.

1.2 Appeal & information

The packaging is an important part of the marketing of the product. To sell a product from the shelf in a shop, the package has to convey the message. This is even more the case if the packaging material, such as cardboard, is not transparent. The message goes far beyond telling what type of product the packaging contains. For food products, legislation requires all ingredients and their origins to be mentioned. A medicine package additionally contains a leaflet with more information and directions for use.
To attract the attention of potential buyers, a package has to communicate better than the neighbouring packages. In 70% of the cases, consumers decide what product to buy while in the shop.

1.3 Quality Indicator

The quality of perishable food and pharmaceutical products depends considerably on the temperature and sometimes relative humidity too at which the products are kept. Sensors monitoring these conditions can communicate values indicative for the product quality.

Quality can be communicated to customers to underline quality standards. Alternatively, quality can be communicated among chain partners to optimise distribution chains and prevent product loss. Resulting profits can be enormous. Even in a highly developed country such as The Netherlands, stock loss due to unacceptable quality is estimated to be 5-10% of turnover.

1.4 Anti-counterfeiting

Counterfeiting activities constitute a major problem for consumer goods producers around the globe. Figures from the EU show that customs seized almost 85 million counterfeited or pirated articles at the EU's external border in 2002 and 50 million in the first half of 2003. Anti-counterfeiting methods always need to be of cutting edge technology to stay ahead of the criminals.

Ultimately all types of packed products will benefit from communicative packaging. However, new technologies leading to communicative packaging will not be introduced in all market segments simultaneously. In Table 2, the current relevance of information content to be exchanged is indicated for each product category.

Table 2 Relevance of information content per product category, ranking from high to low

Pharmaceuticals	**Perishable food**	**Groceries**	**Non-food**
1. Anti-counterfeiting	1. Quality indicator	1. Identification	1. Anti-counterfeiting
2. Quality indicator	2. Product information	2. Product information	2. Appeal
3. Product information	3. Identification	3. Appeal	3. Identification

To transport products from the factory to the consumers', several types of packaging are used. Apart from some perishable food such as common fruits and vegetables, products are always packed in consumer packs. In the shop, small products are often presented in a display unit. For transport, most products are bundled in a transport box. Fruit and vegetables are usually presented in the transport box, though also for these products, there is a trend towards pre-packed consumer packs. Each package has a different communication task as is shown in Table 3.

Table 3 Communication tasks for each type of package

Transport unit	**Display unit**	**Consumer pack**
- Identification	- Identification	- Appeal
- Handling information	- Appeal	- Identification
- Quality indication		- Product information
		- Quality indication
		- Anti-counterfeiting

2 Trends and market expectations

2.1 Trends in communicative packaging

In sub-project 1 of SustainPack, a Situation Analysis and SWOT has been carried out for the fibre-based packaging value chain [PIRA, 2005]. In addition, a literature review on (perishable) food products has been performed [A&F, 2004]. This paragraph will outline how general trends affect developments in communicative packaging.

2.1.1 Safety above all

Consumers are concerned about food safety. This is even more true for the increasing elderly population who suffer more from decayed food products. Quality indicators warning consumers when the product is no longer safe for consumption will be applied much more to generate more confidence on food safety.
Insecurity also arises if products are suspected to be falsifications. Threats of (bio-) terror actions enlarge the feeling of insecurity. Apart from temper- proof packaging, anti-counterfeiting technology can assure consumers that the products really come from the brand owner whose name is printed on the label.
Many brand owners operate on a global market. If the word spreads that their products are unsafe, they could go out of business. Quick, dedicated recalls of unsafe items, preferably before they reach the shops, will keep the costs low and the damage small. The trend is therefore to install a fine-meshed tracking and tracing system with small lot sizes. This will activate the request for automatic readable item identification codes.

2.1.2 The package sells the product

There is a trend in increasing diversification of products. Markets polarise into premium and budget products. (Food) products from the region try to stand out as high quality specialities. Since the total consumption of food products in Europe is fairly stable, different types of food products are competitors in a fight for stomach share. Attracting the attention of potential customers is increasingly important and this will stimulate the introduction of innovative (printing) technology on packages.

2.1.3 Product information on a want-to-know basis

Transfer of information about the product accompanies purchase of a product. The oldest examples of information transfer are the instruction manuals of technical instruments and the instructions for use that come with medicines. Also, daily used products such as foods are provided with information on ingredients, nutritional value, origin and guidelines for preparation. But the amount of information is expanding rapidly with documentation on GMO-based ingredients, functional ingredients, possible allergic reactions and safety and environmental issues.

While the amount of information is increasing, the space to print the information decreases. Food products are packed in smaller portions mainly due to decreasing household size. Secondly, the multicultural society of today requires essential information to be printed in several languages.
Although customers highly appreciate the availability of information, all they also want is to just take a quick glance at the products on the shelf to find out which suit them best. It can be expected that innovative technology able to provide product information on a want-to-know basis will be commercialised in the future.

2.1.4 Distribution till the limit

Geographic shifts in manufacturing and global trading result in long transport channels of products. Advances in logistics such as chilled food storage and innovative packaging concepts allow transport of perishable (food) products across the world. The high quality of the products as demanded by the powerful retail sector has to be in balance with cost reduction efforts enforced by strong competition. A key parameter for successful distribution of perishable products is good quality control of the transport and storage conditions. Innovations in printable electronics can be applied to transport units of perishable products to enable cost-effective quality control at micro-level.

2.1.5 Global market for falsifications

Business consolidation and globalisation will result in world-wide exploration of brand names and product logo's. Once counterfeiters are able to copy the products as well as the printing of brand names and logo's, they too can operate on the world market. Since the potential market for counterfeit products is so big, counterfeiting is becoming more profitable every day. Thus, the application of anti-counterfeiting technology will be a requisite to complicate the production of falsifications.

2.2 Anticipation of the packaging industry

Apart from general trends and the opinions of brand owners, the cardboard industry is confronted daily with questions concerning and requests of communicative packaging. Their participation in the sub-project Communicative Packaging is a result of that. The priorities and expectations of Smurfit and Stora Enso are briefly described in this paragraph.
A clearly identified demand from the market is anti-counterfeiting functionality. This can be achieved by visual effects but also by specific components added to the fibres or prints. Alternatively, anti-counterfeiting functionality can be realised by applying innovative chip-less remote readable memory functions.
Specifically for consumer food packaging, quality indicators will give added value. Information about the quality can be obtained through chip-less remote readable sensors or colour changing inks.

For full-scale production of the newly developed communication technologies, the following boundary conditions have to be fulfilled:

- Product safety cannot be compromised. All chemicals utilised in the process (or in support processes) are BfR and FDA-approved and the guidelines of the new Superdirective are contained – food contact.
- The demonstrators are taint and odour neutral.
- The demonstrators are robust, i.e. they function in a consumer environment, e.g. in the chain of custody (production – packaging - logistics/ transport – wholesalers – retailers - consumers). This includes mechanical, chemical and thermal stability.
- Low cost is a primary issue; Added costs must be small or negligible compared to the cost of the packaging itself or to the added value created.
- Printing can cover the added intelligent functions or a coating that does not compromise the possibilities for adding printed communication or high quality prints for customer appeal.
- The demonstrators and all materials in these are repulpable and recyclable.

2.3 Retailers' attitude towards communicative packaging

2.3.1 Objective of retailer survey

Retail plays a crucial role in the marketing of many consumer products. Their attitude towards new products and product features determines to a large extend the shelf area available to promote these products. Yet, it is not often that retail itself participates in product and packaging development routes. Also their participation in the technology mapping sessions (see section 2.4) was limited. To overcome this blank spot in information, it was decided to make an inventory of retailers' attitude through a questionnaire.

The survey among European retailers has been carried out in the period from August to October 2004. The bottom line questions were:

a) do retailers want temperature or other sensors in consumer/transport packages?
b) if they do, what kind of sensors, which demands/requirements do they have?
c) would optical sensors, which can also be 'read' by the consumer, be acceptable?

The survey will focus on the **pro-active and passive communicative technologies**. The pro-active consists of technology capable of communication and information exchange within the different levels in the entire supply chain. Examples could be different chemicals or electric indicators and sensors built into the packaging.

The passive are technologies focussed on information exchange specifically towards end-users/consumers.

The complete report of this survey is included in appendix 1.

2.3.2 Set up

The retailer research was founded primary on a questionnaire. The questionnaire was divided in to two types of technologies:

- pro-active communicative technologies (different types of sensors and indicators)
- passive communicative technologies (different types of marketing/branding elements).

Further, the questionnaire had two types of questions:
- Questions which require a yes or no.
- Questions which require an assessment of the importance

To each technology, there were several statements, which should be evaluated as:
- Without any importance
- Little importance
- Important
- More important
- Very important

The following pro-active technologies were included in the survey:
- Time Temperature Indicators
- Leak Indicators
- Freshness Indicators
- Bio Sensors
- Light Indicators (barcodes, RFID)
- Logistics Indicators
- Relative Humidity Sensors
- RFID (more than logistics)
- Maturity Sensors

The following passive technologies were included in the survey:
- Optical (3D, Holography, interactive features…)
- Electronic (electronic codes, trade mark protections, counterfeiting…)

The questionnaire was sent to a large number of retailers. Prior to this, the contact person was contacted by telephone and brieved on the background of the survey to increase his/her motivation to return the questionnaire. The feedback rate was approximately 20%. Feedback came from 12 retail companies from Central Europe and Scandinavia.

Figure 1 presents an overview of the results, concerning the total assessment of the pro-active technology. Further results of the survey are presented in appendix 1.

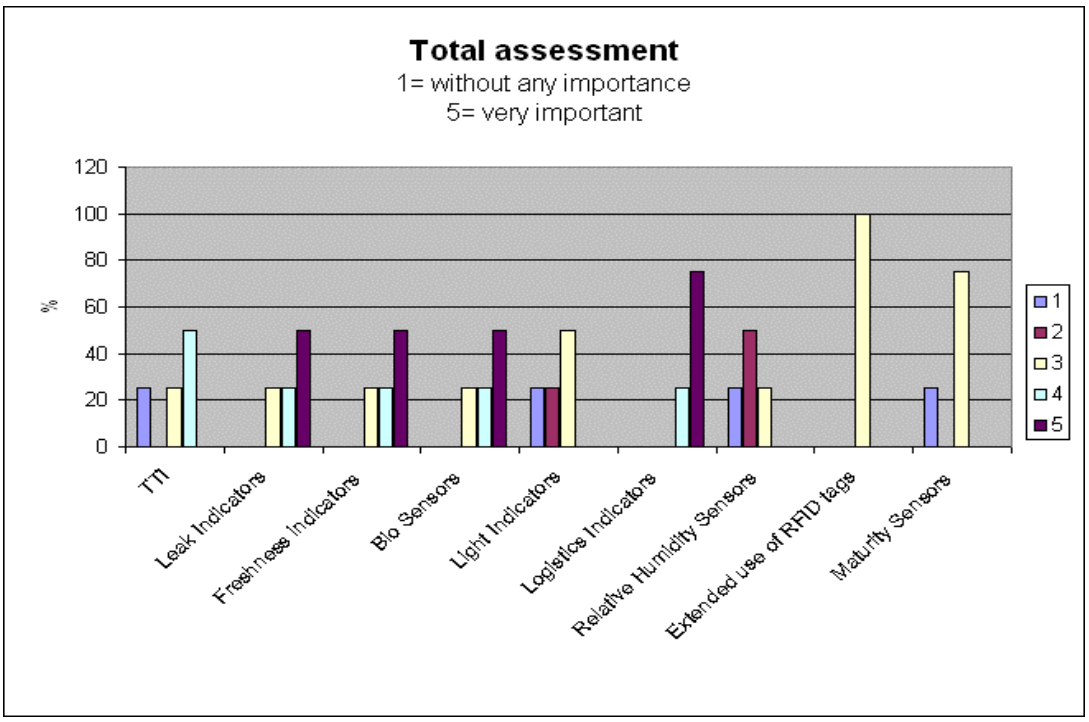

Figure 1 Total assessment of pro-active technologies included in the questionnaire.

2.3.3 Conclusions

In general, the retailers' attitude can be described as 'wait and see" towards communicative packaging or the 9 different sensor technologies as mentioned above. The retailers found it unacceptable that consumers could read the output from the sensors. On the other hand, it was important for the retailer that the consumer accepted the technology – a paradox. A reason for that could be that the retailer wants to use the technology as proof to the consumer that systems for quality control were internally in place.

This also could explain the high rating on the logistics and quality indicators, while indirect indicators such as maturity, light and RH had a low rating.

This conclusion is also confirmed by the statement that retailers only accept indicators on trade units.

The benefit for the retailer should be a possibility to optimise the supply chain by using communicative packaging from the supplier to the store, but not in the store.

Concerning Time Temperature Indicators, Leak, Bio and Logistics indicators (RFID), a majority of the retailers knew these technologies and had interest and plans to implement them. In contrast to this, a minority of the retailers knew about the Freshness, Light and Relative Humidity indicators and had no plans to implement these technologies.

2.4 Technology mapping study

As part of subproject 1, Pira has facilitated six mapping sessions which were attended by supply chain stakeholders. The workshops have focused on defining the trends and drivers, and defining the packaging features required in response to these. Extensive reporting and analysis on these findings will be carried out in subproject 1. At this stage, a summary of the packaging features specific to Communicative Packaging are presented here (Table 4).

Table 4 Communication related packaging features as identified in technology mapping workshops (more information in subproject 1).

General		
- Lightweight - Printed - Food contact friendly	- Cost effective - Non metallic - Linked to phone	- Inconspicuous - Wate management friendly - Reliable
Quality / consumer assurance	**Talking pack / other senses**	
- Changing use by date - Shelf life indicator - Light exposure - Bacterial growth - Distribution data - Physical damage alert - Gas composition – indicator and active adjustment - Preparation / defrosted indicator - Historical vs Real time	- Instore sales promotion - Provision of information instructions for use at home - Audible alert - Linked to consumer loyalty card - Content level indicator of ordering of new product - Plays jingle - Aroma release	
Artificial intelligence	**Moving graphics / visual interaction**	
- Store / shelf interaction - Safety mechanisms - Self heating and cooling - Controlled dispensing / opening - Provides a medical diary - Programmes appliances	- Moving brand logo - Image of product - Interactive entertainment - Product information	
Changeable information	**Tags**	
- Multi-language / multi-information (e.g. press flag) - Stored / remote information - Shelf life data (sell by date, price, promotions)	- Checkout-less retail - Inventory management - Supply chain tracking (track and trace) - Traceability	
Security	**Anti counterfeiting**	
- Activated / opened by biometric information - Anti-theft (from warehouse / retail situation) - Tamper evidence alert / alarm	- Coded pack (linked to mobile phone for opening)	

Following the six workshops on drivers and platforms, a technology mapping workshop was organised recently. This workshop concentrated on the technology requirements and R&D activities necessary to deliver these future packaging features. At first glance, the outcome of this workshop shows a good fit with the technology path chosen by the SustainPack consortium (see next paragraph). However the results need to be further analysed which will be done in subproject 1.

2.5 R&D activities in communicative packaging

It is clear from Table 4 that the packaging features for communication are many and of large diversity. They need to be prioritised and selections for technology developments have to be made. On the other hand, the SustainPack subproject 6 consortium has started a number of technical developments based on its own judgement and expertise. In Table 5, the technical developments are listed. For each subject, its connection with one or more of the trends and market expectations is indicated.
In general, the technologies chosen are well founded by the trends and technology mapping results.
The fit with the results of the retail survey is not obvious for all subjects. It is clear that anti-counterfeiting technology is not an issue for the range of products found in supermarkets. Retail persons do not rank the Humidity-Time-Integrator as important. The reason for that can be that the questionnaire was not limited to cardboard packaging. Many moisture sensitive food products are packed in plastic materials for which control of humidity is not so obvious. On the other hand, parties in the supply chain of perishable products, which are packed in open cardboard boxes, are very conscious of the effect of humidity on the quality of perishable products.

Table 5 Argumentation for current technology developments in subproject Communicative Packaging of SustainPack.

Technology Development	Type of communication	Trends	Retail study	Technology Mapping
Changeable text/images (proof of principle)	Appeal & Information Anti-counterfeiting	Package sells the product Product info want-to-know basis Safety above all / Falsifications	Important technology	Moving graphics/visual interaction Changing use-by-date Changeable information
2D barcode linked to phone (extension to invisible inks)	Information Anti-counterfeiting	Product info want-to-know basis Safety above all / Falsifications	Important technology	Interactive entertainment / talking pack Multi-language information Coded pack (anti-counterfeit)
Printable chipless RFID (feasibility study)	Identification (Link to) information Anti-counterfeiting	Distribution till the limit Product info want-to-know basis Safety above all / Falsifications	Very important to implement this technology	Tags Anti-theft Store-shelf interaction
Humidity-time-integrator (optical signal)	Quality Indication	Safety above all Distribution till the limit	40% knows this technology no plans for implementation	Changing use-by-date Tamper evidence
Relative humidity sensor (digital signal)	Quality Indication	Safety above all Distribution till the limit	80% has interest in this technology	Changing use-by-date Tamper evidence
Temperature sensor (digital signal)	Quality Indication	Safety above all Distribution till the limit	80% has interest in this technology	Changing use-by-date Preparation/defrosted indicator
Volatile indicator (optical signal)	Quality Indication	Safety above all Distribution till the limit	>60% has plans for implementation	Changing use-by-date Bacterial growth Tamper evidence
Digital clock (part of sensor)	See sensors	See sensors	See sensors	See sensors
Magnetic pigments (in paper/coating/printing)	Anti-counterfeiting	Safety above all / Falsifications	Not so important	Coded pack (anti-counterfeit) Tags / Anti-theft Store-shelf interaction

3 Scenarios leading to interesting packaging concepts

3.1 Scenarios

One of the objectives of this part of the SustainPack project is to facilitate the implementation process of communicative packaging in the chain of production, storage, distribution and use of packed products. New packaging concepts are more easily implemented if the benefits can be demonstrated. Activities are undertaken to answer two questions:

- How must the communicative technology perform to be applicable?
- What will be the Return on Investment (ROI) of the communicative technology?

This type of information is valuable if it can be concretised for specific, relevant packaging concepts. In this chapter, scenarios are formulated for a specific product group (perishables). For one scenario, a Product-Market Combination (PMC) is selected which will lead to a communicative packaging concept (see next chapter).
The main application of fibre-based packaging is in food. For transport packaging, this is over 40%; for consumer packaging, 55% of the corrugated board and cartons is used to package food [Euromonitor 2000]. Quality indicators, being an interesting and important part of communication technology, will have the most impact on perishable products. Therefore, scenarios in the application area of perishable produce (fruit and vegetables, fish and meat, flowers) will be chosen, first and foremost.

Three important aspects of packaging have been used to define scenario's representing 'real-life' packaging applications:

- Material (type of cardboard, package)
- Product to be packed (perishables such as fruit and vegetables, fish and meat, flowers)
- Communication features (quality indicator, identification and product information)

Based on the trends as presented in chapter 2, six scenarios for perishable products have been defined. A short description of each scenario is illustrated in the next table.

Table 6 Scenarios for packaging concepts for perishable products

Scenario 1. (Reliable box)	**Scenario 2. (Smart/proud box)**
Large quantities of perishable products (mainly fruit, vegetables and flowers) are transported overseas in disposable transport packages. - Cardboard transport package - Bulk products - Quality indicator and identification - Quality-based tracking and tracing - Distribution till the limit	For the out-of-home market (e.g. at the gas station), fresh fruit products are marketed as healthy snacks. - Cardboard display package - Ready-to-eat perishable products - Quality indicator and information - Health awareness - Safety above all - Package sells the product
Scenario 3. (Proud box)	**Scenario 4. (Special box)**
For bulk products (apples & pears), the transport	Specialities (e.g. off-season products) are sold in

box serves as display unit in the store. - Cardboard transport package - Display function at retail - Common ware - Appeal and information - Package sells the product	special consumer packages. - Cardboard consumer pack - Specialities fruit/vegetables/flowers - Quality indicator and information - Product information on a want-to-know basis
Scenario 5. (Handy box)	**Scenario 6. (Convenience box)**
For the out-of-home market (e.g. at the gas station), fresh fruit products are marketed as healthy snacks. - Cardboard consumer pack - Ready-to-eat perishable products - Quality indicator and identification - Health awareness - Safety above all - Distribution till the limit	Convenience products have a high added value and very limited shelf life. - Cardboard consumer pack - Convenience food products - Quality indicator and identification - Appeal and information - Quality-based tracking and tracing - Safety above all - The package sells the product - Product information on a want-to-know basis - Distribution till the limit

The first scenario will be further elaborated and concretised with a Product-Market Combination. This scenario is chosen because it represents a large volume of cardboard packaging. Also the benefits of communicative packaging are expected to be present when Quality-based tracking and tracing can be applied. The concept of Quality-based Tracking and Tracing (QTT) is explained in the next paragraph.
Future activities in this workpackage of SustainPack will be to identify more packaging concepts. These have to fit with the demonstrators developed in SP1 as well as with the possibilities generated by the communication features developed in this sub-project (WP 6.1 and 6.2).

3.2 Quality-based tracking and tracing (QTT)

A tracking & tracing system makes it possible for the partners in the chain to follow (track) produce and events throughout the chain and to trace the history. Supply chain partners can find out where the products are at a particular moment and where they have been in the chain. For this system, it is necessary to label the products with an identification code and register the identification as the products move through the chain.
QTT is actually the same as conventional T&T with the addition of an extra aspect: the product quality is measured (with a quality indicator) and also registered so that it is possible to follow the product quality throughout the chain (and of course also trace it back when necessary).
QTT makes communicative packaging useful because information on quality offers several benefits, including important economical benefits. Large amounts of money can be saved when product losses can be significantly decreased through its application.

To reduce product losses, it is essential to know the remaining shelf life of products while distributed through the chain, so there something can be done about it. Data from the quality indicator can be used to predict the remaining shelf life when the quality decay process of the perishable product is known.
Communicative packaging enable distribution of products according to a FEFO system (First Expired First Out) in contrary to the currently used FIFO-concept (First In First Out) which does not act upon remaining shelf life.
Other benefits of QTT are improved assurance of food safety and improved customer service through better matureness, colour and taste of food products.
All aspects of QTT are illustrated in an article by Scheer [Scheer, 2005].

4 Case study: tomato distribution

4.1 Product-market combination (PMC) selection for the scenario 'reliable box': Why Tomato distribution?

Specific PMC's will be used to define communicative packaging concepts. As described in the previous chapter, the 'reliable box' is the scenario which at the moment has been selected. This scenario will be concretised with a PMC and hence lead to a communicative packaging concept.
The selection of the PMC is done as follows:

1. a pre-selection in the field of interest, followed by
2. a more specific analysis based on criteria.

4.1.1 PMC pre-selection

The following background information (based on knowledge and experience of A&F in this area) has been used in the pre-selection of PMC's for communicative transport packages (reliable box) for perishables:

- Perishable products with different shelf-life: fruit & vegetables (medium/long shelf-life), meat & fish (short shelf-life), and cut-flowers (medium shelf-life).
- Export/import of fruit & vegetables (product volume): largest volume world-wide: banana and citrus. Bananas are not grown in Europe in large scale but are imported in large amounts. The growth of citrus is mainly in some countries in the south of Europe. Citrus are also imported to Europe. European largest export volumes are: tomato, bell pepper and apple.
- High added-value product (expensive products in the market): high value fruits grown outside Europe: (sub)tropical products such as mango and avocado; high value products grown in Europe: strawberries and other berries (higher value product make the use of a more expensive package system more probable since).
- cut-flowers combine a relatively high export volume with high added-value.
- meat & fish: food safety is an important issue for these kind of products (packaging can play a specific role in this issue). Next to it meat and fish products also have a relatively high added-value.

This leads to the following pre-selected PMC's:

1. banana distribution
2. citrus distribution
3. higher value (sub)tropical products distribution
4. tomato production in Europe and distribution overseas
5. bell pepper production and distribution in Europe
6. apple production and distribution in Europe
7. higher value non-(sub)tropical products (soft fruits) distribution
8. cut-flowers distribution
9. meat or fish distribution

4.1.2 Criteria

The criteria are essential requirements for a PMC to be a candidate for communicative packaging concepts. Whether, and under which conditions, implementation of communicative packaging for this PMC can actually be successful has to be analysed and is a main objective of this part of the report.
The criteria are divided in 4 different categories: cardboard, chain, consumer, and product and are defined as follows.

Cardboard

- Large volume: the extent to which the packaging for this type of product represents a large volume of cardboard use.
- Sustainability: the extent to which the image of sustainability of cardboard can be used to support the use of cardboard transport packages for this product.

Chain

- Possibility for system analysis: the extent to which it is possible to perform deeper system analysis with the gathered information.
- Competition position chain players: to what extent is the market of this product highly competitive, and can the different chain links (excluding the retailers) use communicative packaging to distinguish themselves from their competitors?
- Quality-based logistics decisions possible: to what extent is quality-based logistics possible in the chain (are there important decision moments in the supply chain where information on product quality can lead to different decisions on the product destination)?

Consumer

- Willingness to pay for quality: the extent to which consumers are willing to pay more for better quality of the product.

Product

- Losses due to quality deterioration: the extent to which quality-related losses are present in the distribution chain.
- Quality-temperature-related: the extent to which product quality is related to temperature (important and measurable parameter in the distribution chain)[Eskin, 1989; Paull, 1999].
- Quality-moisture-related: the extent to which product quality is related to moisture/relative humidity (important and measurable parameter in the distribution chain) [Eskin, 1989; Paull, 1999].
- A&F knowledge: the extent where A&F has knowledge on the product and experimental data is already available.
- Constant initial quality: the extent to which the initial quality of the product is constant/homogeneous.

The 4 categories and their respective criteria are weighed according to their importance to judge whether a certain PMC will be successful for the introduction of communicative packaging concepts. The weightage is done on a scale from 3 (most important) to 1 (not important). Next, a score has been given to quantify the importance of each criteria to each PMC (0= not relevant to 3= very important).

Table 7 Criteria application

The table shows the weightage and the score of each criterion for the pre-selected PMCs. The importance of each criterion within the PMC is judged as high (3), medium (2), low (1) or not relevant (0).

The criteria are essential requirements for a PMC to be a candidate for communicative packaging concepts. Successful implementation of a communicative packaging concept is expected to be most likely for the PMC with the highest score.

No	Category	Criteria	Weighing Category	Weighing Criterion	PMC								
					1 Banana	2 Citrus	3 sub-tropical products*	4 tomato	5 bell pepper	6 apple	7 non-(sub)tro-pical products*	8 cut-flowers	9 meat or fish
1	Cardboard	Large volume	*1*	*3*	3	2	1	2	1	2	0	2	0
2		Sustainability (competitive packaging; use of material type)	*1*	*1*	0	0	0	0	0	0	0	0	3
3	Chain	Quality-based logistics decisions possible	*3*	*3*	0	0	1	2	2	2	2	2	2
4		Possibility for system analysis	*3*	*1*	0	0	0	2	2	2	2	1	1
5		Competition position chain players (not retail)	*3*	*2*	2	0	1	2	2	2	1	3	3
6	Consumer	Willingness to pay for quality	*1*	*3*	1	1	3	2	1	2	3	3	2
7	Product	Losses due to quality	*2*	*3*	0	0	2	2	2	2	3	1	0
8		Quality-temperature-related	*2*	*2*	2	2	2	2	2	2	2	2	3
9		Quality-moisture-related	*2*	*2*	0	2	2	3	3	2	2	2	0
10		Food Safety	*2*	*2*	2	2	2	2	2	2	2	0	3
11		A&F knowledge	*2*	*1*	1	0	1	2	2	2	1	2	1
12		Constant initial quality	*2*	*1*	2	2	0	2	2	2	0	1	2
		Total			46	37	65	96	90	92	83	82	78

* products with high added value

The scores of each PMC are presented in Table 7.
The scenario 'Reliable Box' will be concretised with the following PMC (highest score):

A communicative transport package for tomatoes produced in Europe and distributed in overseas (USA). The sensor will register temperature and humidity.

It is important to realise that this PMC, though selected after thorough analysis, cannot by itself represent the complete scenario. Based on knowledge generated in the project, it might be necessary to choose a second or even a third PMC from this series.
The scenario 'Reliable box" and this respective PMC form the first case study of SP6 which will lead to a first communicative packaging concept. The case study is started with a chain inventory and definition of the communication infrastructure as described here below.

4.2 Chain inventory

4.2.1 The tomato market

Fresh tomatoes are one of the most important fresh vegetables in Europe, accounting for 10% of the total vegetables consumption in Europe (after potatoes which represent more than half of the total consumption) [CBI, 2003].
Tomatoes are by far the leading vegetable product group grown in the EU, which makes this product less interesting for exporters from developing countries. Hence, tomatoes and bell peppers are the leading European export products, together representing 40% of the total vegetables export (figure 2).

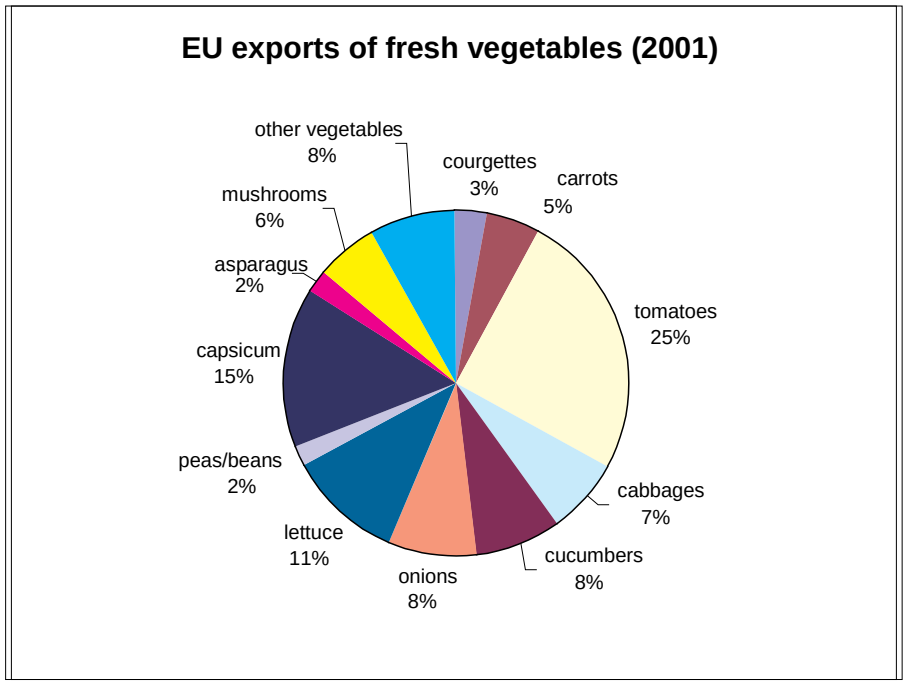

Figure 2 Export of fresh vegetables from the EU in 2001 [CBI, 2003].

The consumption of tomatoes is, just as other fresh vegetables and fruits, rather stable in the EU countries. However, the consumer demands a high quality product which also should be available the whole year, independent of the seasonal growth cycles. This results in a dynamic market where tomatoes are imported and exported both intra-Europe and extra-Europe.
Table 8 shows the large amount of transport operations within the whole of Europe; almost all countries both import and export tomatoes. Increasing internationalisation is also an important trend in the fruit and vegetable trade, contributing to a large import/export activity.

Table 7 Annual production, import and export of tomatoes in Europe and USA (2003) [PT, 2004].

Country	**Total production (million kg)**	**Import (1000 kg)**	**Export (1000 kg)**	**No 1 destination/ origin country**
The Netherlands	595	n.a.	541.329	Exp: Germany
Germany	45	732.615 *	n.a.	Imp:The Netherlands
France	618	425.158	128.000 (in 2002)	Imp: Marocco/Spain
Spain	n.a.	n.a.	1020.813 *	Exp: Germany
Belgium	210 (via auction)	n.a.	207.693 *	Exp: Germany
UK	102 (in 2002)	328.000	n.a.	Imp: Spain
Italy	n.a.	89.713	107.274 *	Exp: Germany
USA	1.481	939.000	142.000	Imp: Mexico

* = estimated value; Export value for 2003 was only available for the period January to September 2003. Therefore, the last quarter is estimated (based on a comparison between the periods Jan.-Sep. 2002 and the same period in 2003. It was assumed that the variations between 2002 and 2003 for the other 3 quarters was the same in the last quarter).
n.a. = not available

4.2.2 Description of the distribution chain

This case study deals with the production of vine tomatoes in The Netherlands and distribution in the USA market. In order to prove the usefulness of communicative packaging, it is necessary to identify and characterise the different steps in the chain (who are the partners, how is the product handled, how long is the product in transit, what are the ambient conditions, etc)
There is a strong tendency in the horticultural trade towards operating in ''straight lines', meaning concentrating the number of partners in the distribution and supply chain. This is certainly the case in the production and distribution chain of vine tomatoes from The Netherlands to the USA, specially when the transport is done with containers in boats. Vine tomatoes are perishable products and therefore their quality decays rapidly in time. Therefore, it is important to decrease the number of participants and assure that the product reaches the end-users as fast as possible.

Based on interviews with agro-distribution experts who know the production and distribution chain of tomatoes well, this chain is defined and characterised (see Table 9). Hereby, focus had been given to the transportation per boat as this form of transportation is more sustainable than by air.

Table 8 Summary of the production and description chain of vine tomatoes from The Netherlands to the USA.

	Duration (average)	**Temperature (average)**	**Relative Humidity (average)**
1. Grower	8 hours	18°C	75%
2. Transport to the harbour + Customs proceedings + Shipping	1 day	8°C	85%
3. Boat transport to New York	7 days	8°C	85%
4. Customs formalities + Transport to importer in USA	2 days	8°C	85%
5. DC in USA	1 day	8°C	85%
Transport to supermarket	Not relevant	8°C	85%
6. Supermarket (shelf live)	3 days	18°C	75%

1) In The Netherlands, vine tomatoes are grown in Greenhouses. The tomatoes harvest is done manually. It starts early in the morning, and is usually completed around midday. Tomatoes are packed in 5 kilo cardboard transport boxes, specifically designed for the transportation of tomatoes in containers. The tomatoes are placed directly in the transport boxes during plucking. The product is sorted out during plucking (too small, misshapen, unripe or mouldy tomatoes are immediately removed). The boxes are then stacked on pallets and the pallets are driven into the container.
Nowadays, the production capacity of growers is high enough to be able to fill up an entire container from one single or at most, 2 growers. In this way, a container is transported to the greenhouse and it is directly loaded with pallets. In case a second grower also supplies tomatoes to the container, the pallets from this grower are transported to the grower where the container is placed. This 'extra' step does not have impact on the product quality since usually the distance between the growers is short and therefore the transport duration is small.
The time span at the grower is in average 8 hours (at 18°C and 75% RH on average).

2) When the container is full, it is transported by truck to the harbour. In the harbour, the customs proceedings have to be followed. This means that the container must remain in the harbour for 24 hours for inspection. When all formalities are successfully accomplished, the container is shipped. The time span in the harbour is in average 1 day. During this period,

tomatoes are kept at 8°C because the containers used for this kind of transportation are self-refrigerating (8°C is the set point temperature).

3) The boat transport to the harbour of New York city in the USA takes approximately 7 days. During this period, the temperature in the container is set at 8°C just as in the previous step. The relative humidity is not controlled. Simulation tests carried out at A&F with fully loaded containers have shown that the average relative humidity in this containers during transport is 85%.

4) After arrival, the load is submitted to the legal customs formalities. These formalities include, among others, the phyto-sanitary controls which require that the freight should remain at the harbour for approximately 48 hours. When the legal procedure is finished, the container is transported with truck to the importer. At the importer, a rough quality evaluation of the product is done. This evaluation is based on a visual assessment of the product by a product examiner (this means that no quantitative analysis is done). The main objective of this evaluation is to pick out the rotten tomatoes. However based on this screening, a rough estimation is also done on the most appropriate final destination for the product. Usually, the supermarket is the final sale outlet. However, products of low quality will end in the street market.

5) Distribution Centre (DC) of the supermarket: The necessary number of pallets is transported from the importer to the DC of the supermarket (by truck). In the DC, order picking is done to supply the different supermarkets of the region. The supply chain is designed so that the time span of the tomato products at the DC is as short as possible. The average timespan at the DC is around 1 day. The temperature at the DC is controlled and is in average 8°C.

6) Supermarket display and consumer phase: From the DC, the tomato boxes/pallets are transported to the respective supermarkets. Once at the supermarket, the tomato boxes are placed on the shelf in the vegetables and fruit department. The objective of this supply chain is to achieve a remaining shelf live of 3 days in this last part of the chain (supermarket display). At the supermarket, the temperature is kept at 18°C. Within the consumer phase, i.e. after leaving the supermarket, there is no temperature or relative humidity control. Retailers are however keen on guaranteeing that the product also remains acceptable for some time in the consumer phase, despite the way the product is handled. From a commercial point of view, these kinds of aspects are important as they influence the image/concurrency position and hence the sales of retailers. It is therefore important to ensure maximum and enough quality at the end of the chain.

The values presented in Table 9 for time periods, temperature and relative humidity are average values. However in practice, there can be huge variations due to:
- season/weather;
- temperature and RH variations in time and position inside the container;

- unexpected delays, e.g. at customs;
- changes in the departure time of boats and length of boat transport (depends again on ao. weather conditions);
- unexpected failure of the climate control system;
- logistical choices such as FIFO (First In First Out) or FEFO (First Expired First Out);
- mistakes caused by the personnel, e.g. storing the pallets at the wrong place/temperature, leaving a pallet too long outside in the sun or in the rain, etc.

These variations in time, temperature and relative humidity have a strong impact on the product quality, especially at the end of the chain at the supermarket (shelf life) and the consumer. This is why it is important to a) monitor and communicate ambient conditions and b) generate information on product quality status in order to ensure maximal quality throughout the chain.

4.3 Communication Infrastructure

The objective of this part of the case study is to identify a) what kind of communication is exchanged between the different partners; b) how does communication take place and c) how is the information/communication flow in the chain.

4.3.1 Communication content

Different levels/kinds of communication content have been identified which can be exchanged among the participants in this chain. Some of these kinds of communication are intensively exchanged whereas others, such as ambient conditions during the whole chain and the product quality status throughout the chain, are not monitored nor communicated at the moment. It should be stressed that only external communication to the other links in the chain has been considered. Internal communication inside each chain participant has not been taken into account.

Commercial information: this comprises legal documents, buying/selling agreements, product orders, invoices and receipts of trades, market data, etc.

Product information and identification: according to the General Food Law, in force since January 2005, all products should be provided with an identification number so that they can be tracked and traced at every moment and location in the chain. The product identification is compulsory and must be communicated among partners. Other product information (e.g. tomato variety, batch number, growing conditions, time of harvest, grower identification, etc) is often associated to the identification number and hence can be passed on to the other links.

Logistical information: this kind of information covers a wide range of issues but the most important concerns the transport and storage of the product. This includes information on the

amounts to be transported, transport route, how transport will be done, who will be doing the transportation, expected arrival and departure dates-times, necessary floor area for storing, storing conditions, etc.

Ambient conditions during the whole chain: Perishable products such as tomatoes need to be transported and stored under specific ambient conditions. Temperature and relative humidity are the most important as these two factors have a great impact on product quality [Paull, 1999]. Information on temperature and relative humidity (RH) needs first to be measured and next communicated. There are several sensors already available to measure temperature and RH and different possibilities to communicate these results from the measuring unit to a reader and from the reader to the other chain participants. This kind of information is however not measured nor exchanged at the moment, at least not as a standard procedure.

Status of product quality: After harvesting, tomatoes start to decline in quality [Nyalala, 1998; Islam, 1996]. The most important quality parameters of tomatoes are:

- Green stem: the stem should look green and vital as this is an indication for the consumer that the tomatoes are fresh. Dried and yellow/bruin stems are not acceptable. The presence or absence of moulds on the stem is also important. The presence of moulds is not acceptable.
- Firmness: this parameter concerns the flesh firmness. Tomato flesh should not be too soft.
- Decay: presence or absence of moulds on the tomato flesh/surface. The presence of moulds is not acceptable.
- Drying out (weight loss): this parameter is not important for consumers but it has an important economical impact as trade between chain participants is based on weight. Since the water content of the air is lower than that of the tomatoes, this results in loss of moisture from the tomato and therefore weight loss.

Green stem and decay are measured visually. However optic techniques and computer image analysis can also be used. Product drying out can only be measured with a balance. Firmness can both be sensorially or instrumently measured [Auerswald, 1999]. At the moment, in practice, instrumental techniques are not yet used to assess the product quality.

Product quality decay depends on several aspects, of which the initial product quality, time, temperature and relative humidity are the most important. Quality decay models are mathematical descriptions of the relationship between these aspects (usually temperature and RH) and the product quality. Based on the temperature and/or RH history which the product has been submitted to throughout the chain, the product quality can be predicted at any moment by applying these quality decay models. In this case, the product quality is not actually measured but calculated based on the monitored ambient conditions, e.g. temperature and RH. The predicted product quality status can then easily be communicated to the other chain partners. These know the quality of the product they will receive and adjust their logistical decisions based on this information. This logistical principle is denominated Quality-Based Logistics (see also chapter 3).

4.3.2 Mapping communication infrastructure and flows in the chain

An overview on the applied communication technologies and infrastructure in the tomato production and distribution chain has been compiled. The results are summarised in Table 10.

Table 9 Overview of applied communication technology and respective infrastructure in the production and distribution chain of tomatoes at the moment.

Communication content	Communication technology	Necessary infrastructure
Commercial information	- Paper documents - Digital documents - e-mail	- Post - Fax - Scanners - Computers/Internet
Product identification and information	- Bar code - Paper/stickers - e-mail	- Bar code printers - Bar code scanners - Computers/Internet - Fax
Logistical information	- Paper documents - Digital documents - e-mail	- Post - Fax - Scanners - Computers/Internet
Ambient conditions throughout the chain	- Fixed temperature and RH sensors - Dataloggers (temperature and RH)#	Such information is currently not exchanged between chain participants.
Status of product quality	- Visual assessment of the general product quality	Such information is currently not standardly exchanged among chain participants.

Occasionally, dataloggers are sent to monitor temperature and RH during the transport in the boat. This happens seldom and the results are usually not communicated to the other chain participants. These data-loggers are usually read out via the RS232 port to a computer. However, there are also data-loggers which use infra-red technology in order to read out the dataloggers without removing them from the object (freight) to be monitored. In this case, the data is downloaded to a data-stick which is then read out in a computer.

This table summarises solely the communication technology and respective infrastructure which is applied at the moment in the production and distribution chain of tomatoes. Bar code technology is not always used for product identification. In some cases, boxes and/or pallets are only identified with a piece of paper or sticker with a description or identification number. The use of bar codes can both be applied on boxes or pallets. More advanced technology with Radio

Frequency tags is not yet used. The transport boxes are printed at their production site. The printed information on the box consists of:

- Product content (sometimes the tomato variety is also identified);
- Product category (class);
- Product origin and name of supplier;
- Weight;
- Temperature to be kept;
- Eventually a bar code.

A certain graphic presentation is also given in order to easily identify the content (drawing of tomatoes) and to make it more attractive (appeal is however a secondary aspect in this kind of package). Containers have an identification number placed on a signboard at the container.

Commercial and logistical information is usually not communicated through the transport packaging or pallet. This information should be available at the following chain participant before the product arrives.
Since communication concerning product quality and ambient conditions in the chain is not exchanged, the more advanced technology based on Radio Frequency for instance is not yet applied. In the following phases of this case, new technology and technology to be developed will be considered.

In figure 3, the tomato production and distribution chain is schematically presented. The arrows in this figure represent the different communication flow levels throughout the chain**.** The **blue arrows** show the product flow (boxes, pallets, containers of tomato). **Red arrows** show specifically how the product order communication is accomplished. The commercial information as described above however is exchanged among all chain participants. The **green arrows** show information exchange concerning logistical issues (content of the freight, departure and arrival date and time, departure and arrival point, etc.). Product identification is nowadays compulsory. Therefore, this level of information is exchanged among all chain participants. Product information (represented with **purple arrows**) is mainly communicated from the grower to the end chain participants. Part of the product information (at least the price and often the product origin) is also communicated to the consumers.

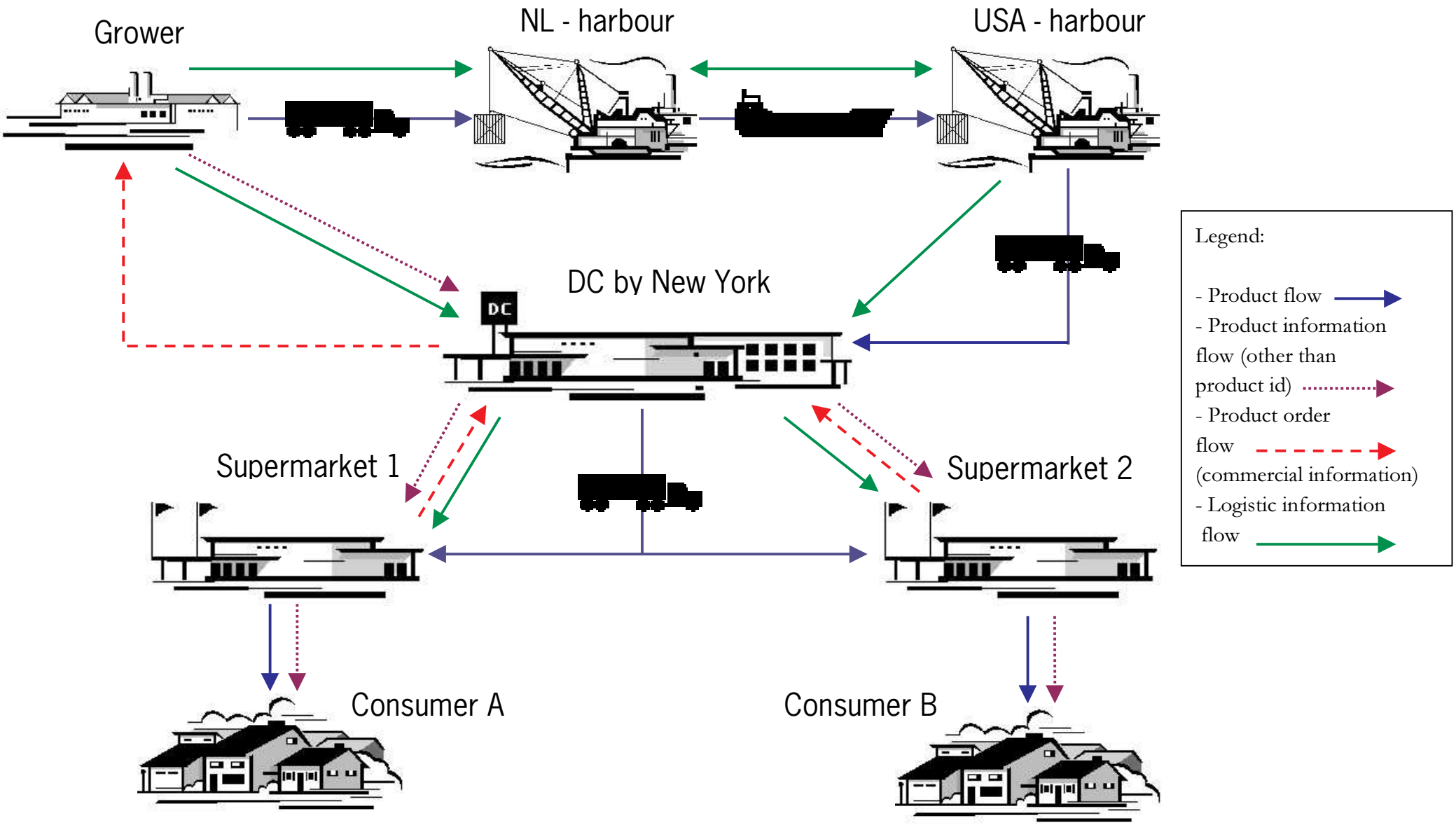

Figure 3 Scheme of the production and distribution chain of tomatoes and the communicationflow among the chain partner

4.4 Follow up

The development of a communicative packaging concept for this case study, the transport of vine tomatoes from Europe to the USA, should focus on quality. Tomatoes are perishable products and therefore their quality and hence economic value decrease quite fast. Therefore a packaging concept able to communicate the quality status of the product is useful because information on quality leads to several benefits, including important economical benefits. Large amounts of money can be saved when for instance product losses can be significantly decreased through the application of Quality Tracking & Tracing based on a communicative packaging (see chapter 3).

This case study will proceed with the following major activities:

- Chain simulations with the software tool Aladin: the objective of this activity is to quantify the costs and benefits of a communicative packaging focussed on quality applied in this production and distribution chain. These will be done with computer simulations, where different scenarios of this chain will be analysed and their impact on the costs/benefits will be calculated. The chain inventory which has been carried and described above will supply the necessary input to perform the simulations.
- Development of a temperature/RH sensor: this sensor forms the heart of the communicative feature of this packaging concept focussed on quality. These activities will be carried out within the other work packages of the project (WP 6.1 and WP6.2).
- Application of the Sustainability Framework: the objective of this activity is to analyse the sustainability of the selected sensor technology (e.g. material choice). The chain simulations referred to above will prove the economical feasibility of the concept and this activity will ensure the sustainability of the concept.
- Simulations under chain realistic conditions: the aim of this part of the case study is to test the developed communicative packaging concept under chain realistic conditions.

5 Conclusions

Trends and market developments have been identified through different approaches: literature studies, feed-back from the industry, retail survey and technology mapping (carried out by PIRA). An important conclusion is that similar trends and market expectations have been identified from these different approaches.

On the other hand, the SustainPack subproject 6 consortium has started a number of technical developments based on its own judgement and expertise. In particularly, the results of the technology mapping session show a solid link between the trends/market expectations and the chosen technology developments. This is an important conclusion since SustainPack is a market-driven project.

Based on the identified trends and market expectations, six scenarios have been defined. These scenarios will be concretised with a product-market combination (PMC), leading in this way to communicative packaging concepts. For the moment, the scenario reliable transport box was chosen because it represents a large volume of cardboard packaging. This scenario is concretised with the PMC 'tomato production in Europe and distribution overseas'.
The scenario 'Reliable box' and this respective PMC form the first case study of SP6 'A communicative transport package for tomatoes produced in Europe and distributed overseas (USA)' which will lead to the first communicative packaging concept. In the follow up of the project, other packaging concepts will be identified.

Within this case study a chain inventory is carried out. Next to this, the communication infrastructure in the chain is identified. The chain is well defined and kept as simple as possible, for instance in the number of partners. Because the distance and time length is long, it is important to keep the chain compact, especially since tomatoes are perishable products which lose quality and value rapidly.

The most important conclusion of this study is that the communication exchanged among partners is rather limited to commercial information, some logistical information and some form of product identification. Information on ambient conditions in the chain and on status of product quality is not exchanged. The communication infrastructure identified at the moment is relatively simple and makes use of basic technology as computer/e-mail, fax machines/paper, and in some cases bar codes. Because the most complex levels of information, such as ambient conditions and product quality are not exchanged, more advanced communication and sensor technology is not yet applied.

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Appendices Retail Survey

Sustain Pack

SP 6.3 Communicative packaging in the supply chain

Retail Survey (August – October 2004)

1. Background for the Survey

The purpose of this project supported by the EU Commission is to mobilise the European scientific expertise in the value chain to establish the European forest industry cluster as the dominant player in the packaging area within a decade.

The overall objective of the activities is to develop and implement a Sustainable Packaging Tool Platform based on renewable resources, giving innovative properties to packaging, thereby offering new value added packaging options for packaging users and for the consumers.

One subproject is to develop communicative packaging. This is a very critical area, wherefore it is important to investigate the positions and requirements in the retailer area **before** the decisions and developments of the communicative packaging technologies are taken.

The survey will focus on the **pro-active and passive communicative technologies**. The pro-active are wireless communication – and information technologies valid in the entire supply chain. Examples could be different chemicals or electric indicators and sensors build into the packaging.
The passive are technologies used for one or two way communication with packaging products and the consumer. Focus in the survey will be on electronic and optical functionalities.

2. Survey methods

A survey could have been conducted by following methods:

- personal interviews
- questionnaire
- combination interviews and questionnaire

Due to timing and resource optimisation in the project it was decided only to do a survey based on a questionnaire.

The retailer research was therefore founded primary on a questionnaire, which was divided in to two types of technologies:

- pro-active communicative technologies (different types of sensors and indicators)
- passive communicative technologies (different types of marketing/branding elements)

The questionnaire had two types of questions:

a. Questions, which require a yes or no.
b. Questions, which require an assessment of the importance

To each technology there were several statements, which should be evaluated as:

1. Without any importance
2. Little importance
3. Important
4. More important
5. Very important

Following pro-active technologies were included in the survey:

1. Time Temperature Indicators
2. Leak Indicators
3. Freshness Indicators
4. Bio Sensors
5. Light Indicators (barcodes, RFID)
6. Logistics Indicators
7. Relative Humidity Sensors
8. RFID (more than logistics)
9. Maturity Sensors

Following passive technologies were included in the survey:

1. Optical (3D, Holography, interactive features…)
2. Electronic (electronic codes, trade mark protections, counterfeiting…)

In figures 1 and 2 below can be seen examples of the two types of questions. In this case the questions are about Time Temperature Indicators (TTI).

	Yes	No
Does your company want sensors/ indicators on consumer packaging?		

Figure 1

Statements	**1**	**2**	**3**	**4**	**5**
Using TTI, should help you securing the product quality – freshness					
Using TTI , should help you securing product safety					
Consumer acceptance is a premise for acceptance of this technology (only if yes in 1.b)					
When using TTI this can conflict with the expiry date because TTI is a dynamic system and expiry date is a fixed date. TTI will then overrule the expiry date.					
Use TTI as sales parameter in the store – consumer preference.					
The consumer should be able to read the results of TTI					
The technology must have high reliability					
The technology must be easy to implement					
In general: to implement this technology is ?					

1 = without any importance 5 = very important

Figure 2

After the questionnaire was developed, it was mailed out to key retailers in Europe. The feed-back rate was approximately 20 %.

A complete list of retailers, which returned the forms, could be found in *attachment 1*.

2.1 Calculations

The calculations in the survey (results) were done after following principles:

In the general questions (type yes or no) concerning indicators each statement was evaluated.
If 8 of the replies were yes and 4 were no, it should be 66% yes and 33% no.

In the assessment questions each category was calculated based on how many replies rated 1, 2 and up to 5 in importance. In total 100% per category.

3. Results

In the following the results from the Survey should be found.

3.1 General knowledge and use

The first results were concerning general knowledge and use of sensors – figure 3. 50% of the retailers want sensors/ indicators on consumer package. 80% indicates that the consumer should not be able to read the results from the indicators and all indicates that the indicators should only be for retail use. More than 60% are willing to pay extra for indicators and all indicates that the technology should be sustainable.

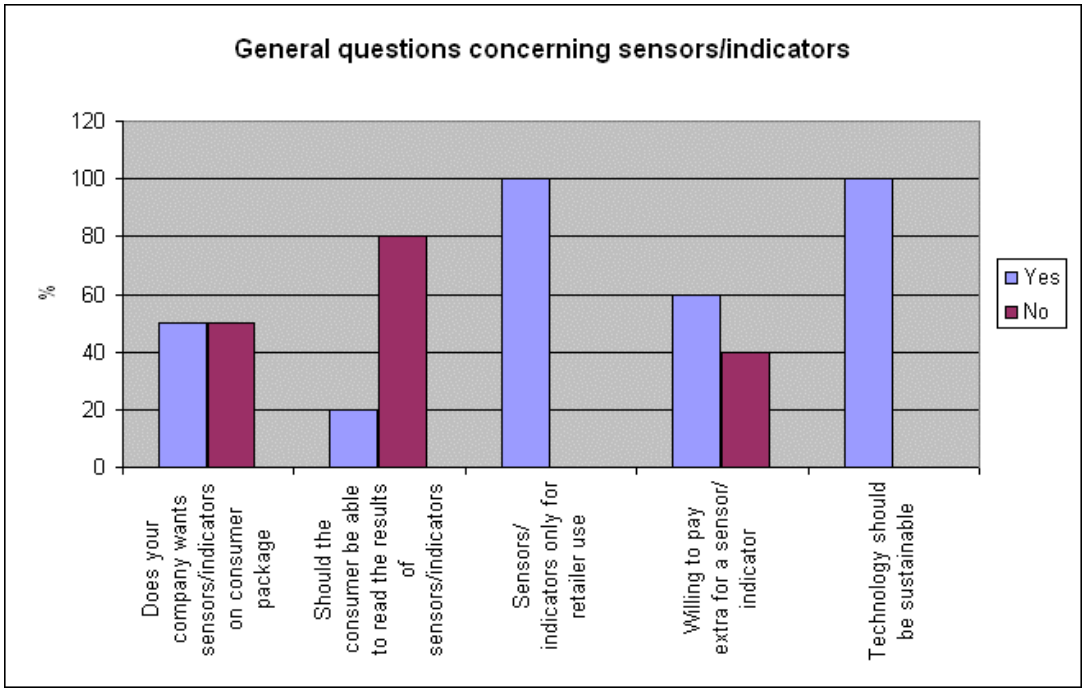

Figure 3

3.2 Time Temperature Indicators (TTI)

TTI measures and monitor, if the product has been kept within the required temperature in the entire cooling chain. The technology could be based on a colour change.

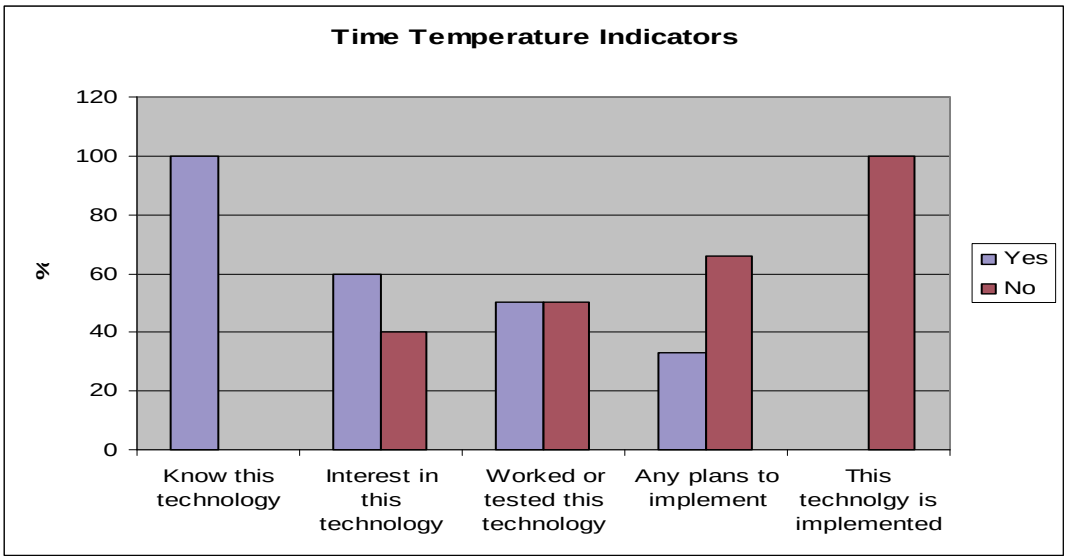

Figure 4

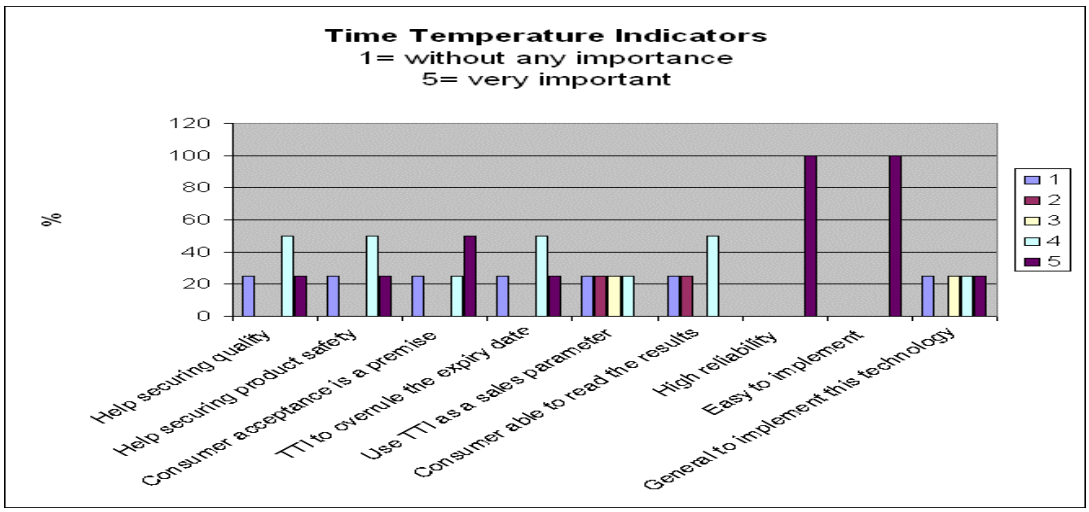

Figure 5

All retailers in the survey knew this technology and 50% had worked or tested the technology (figure 4).

The results (figure 5) concerning TTI were that quality and product safety were important as well as consumer acceptance, technology reliability and easy to implement.
Not important were the use of indicators as a sales parameter and that the consumer should be able to read the results.

3.3 Leak Indicators

A technology based on a chemical colour change, which indicates a leak – penetration of oxygen or CO_2.
The results concerning the Leak Indicators - figure 6 and figure 7, were very similar to the TTI findings.

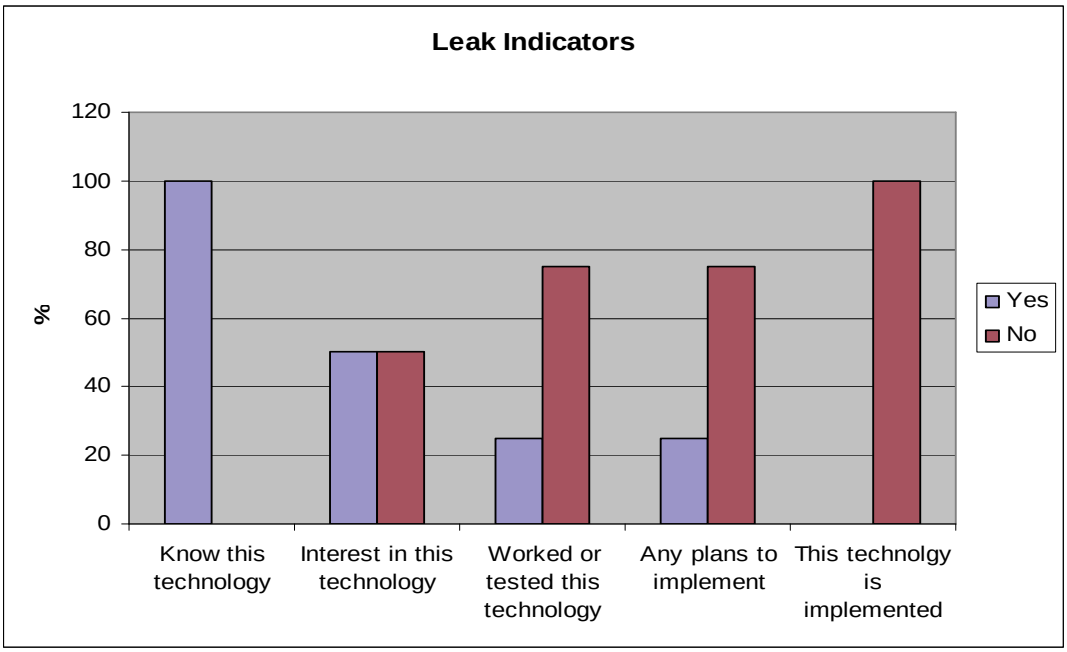

Figure 6

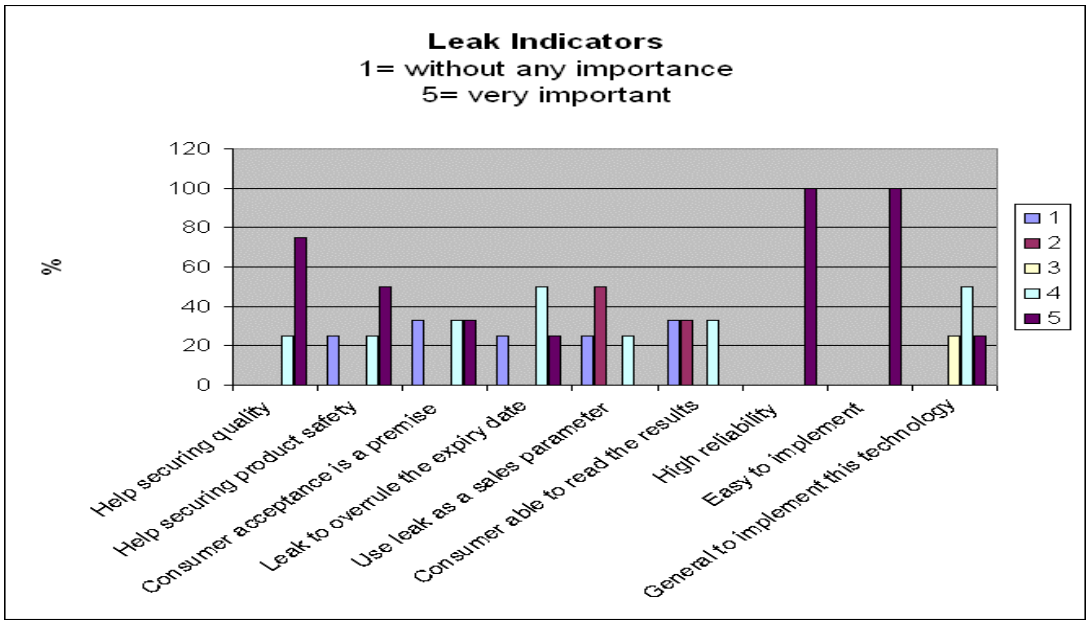

Figure 7

3.4 Freshness Indicators

A technology based on a chemical colour change, which indicates the freshness of the product – example is freshness of fish. The indicator detects decay of aromas. The results concerning the Freshness Indicators – figure 8 and figure 9, were very similar to the TTI.

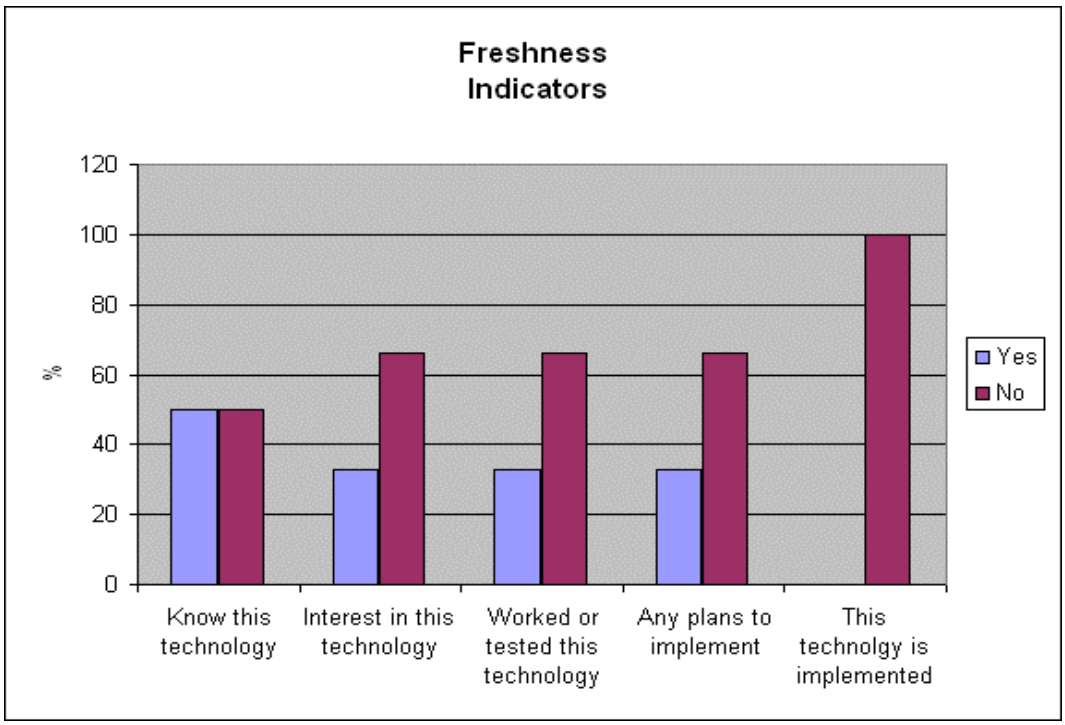

Figure 8

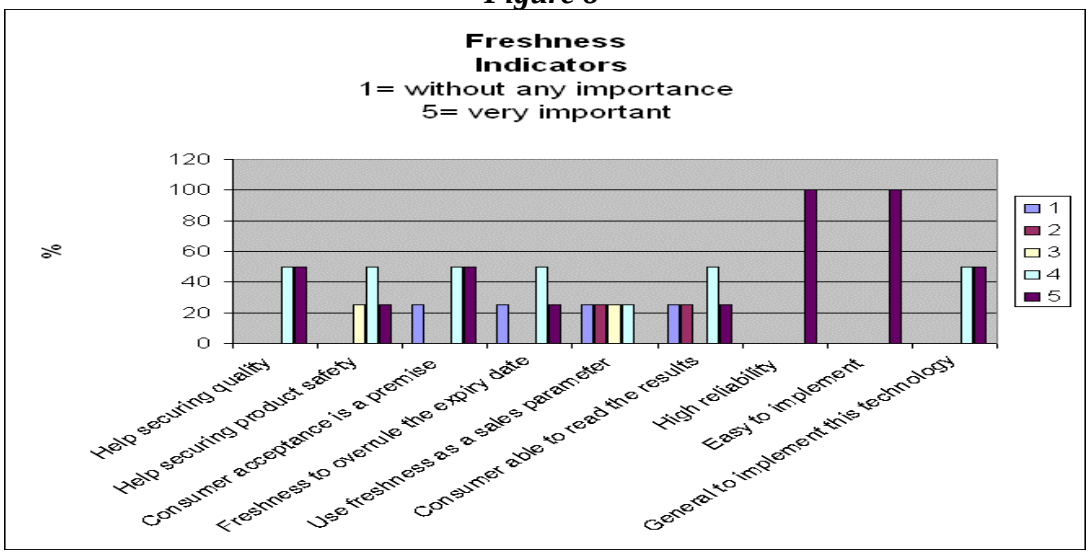

Figure 9

3.5 Bio Sensors

A technology, which can detect bacterium by colour change – an example is salmonella. The technology is specific for each bacterium.
The results from Bio sensors were that few retailers had worked with this technology compared to the technologies just mentioned – figure 10.
The rating of the importance was similar to the previous findings – figure 11.

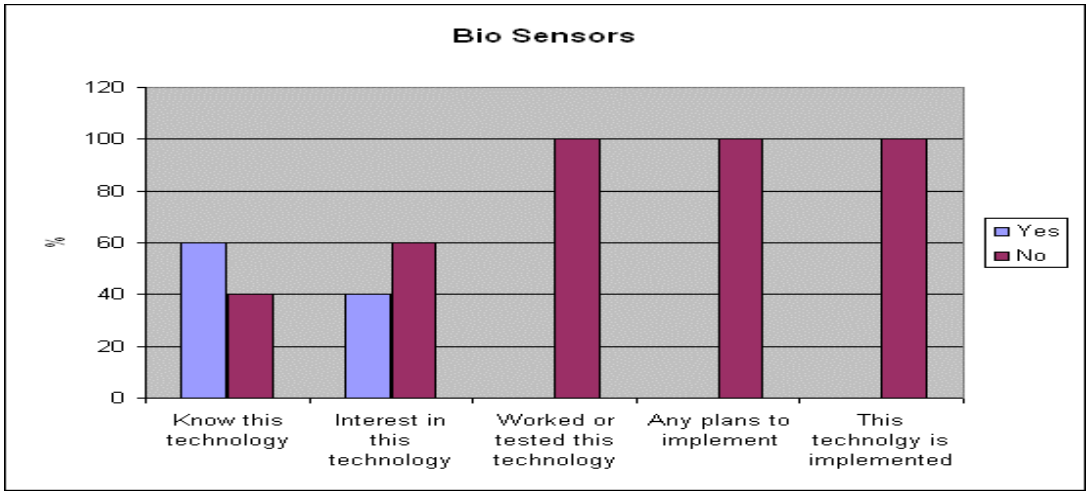

Figure 10

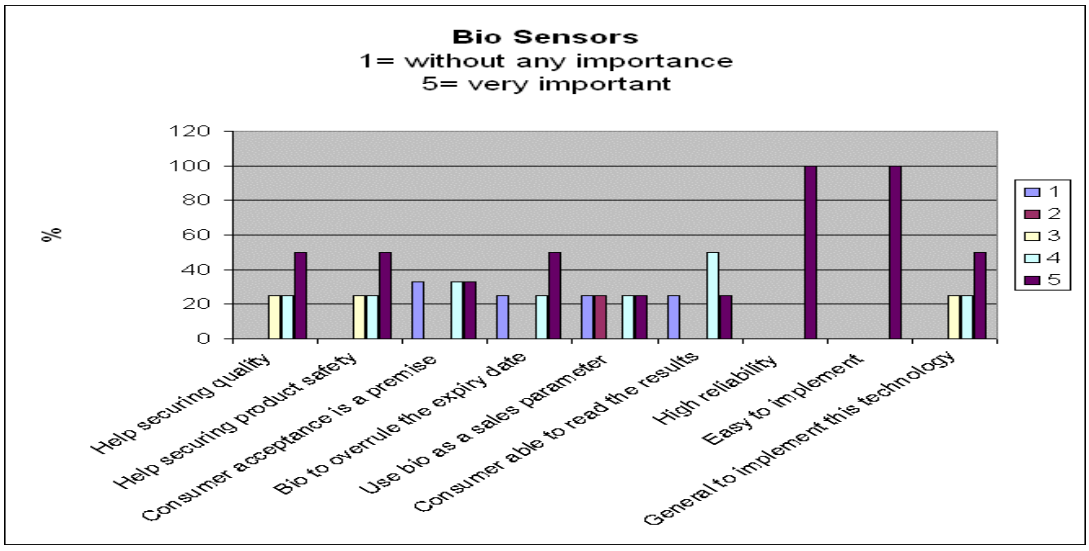

Figure 11

3.6 Light Indicators

This technology can be used to detect, if a product has received too much light and resulting in decline of taste. Examples are wine and beer.
Only 20 % of the retailers knew light indicators and none had worked or tested this technology – figure 12.
The quality, reliability and easy to implement were still important here as well as the consumer acceptance was not important figure 13.

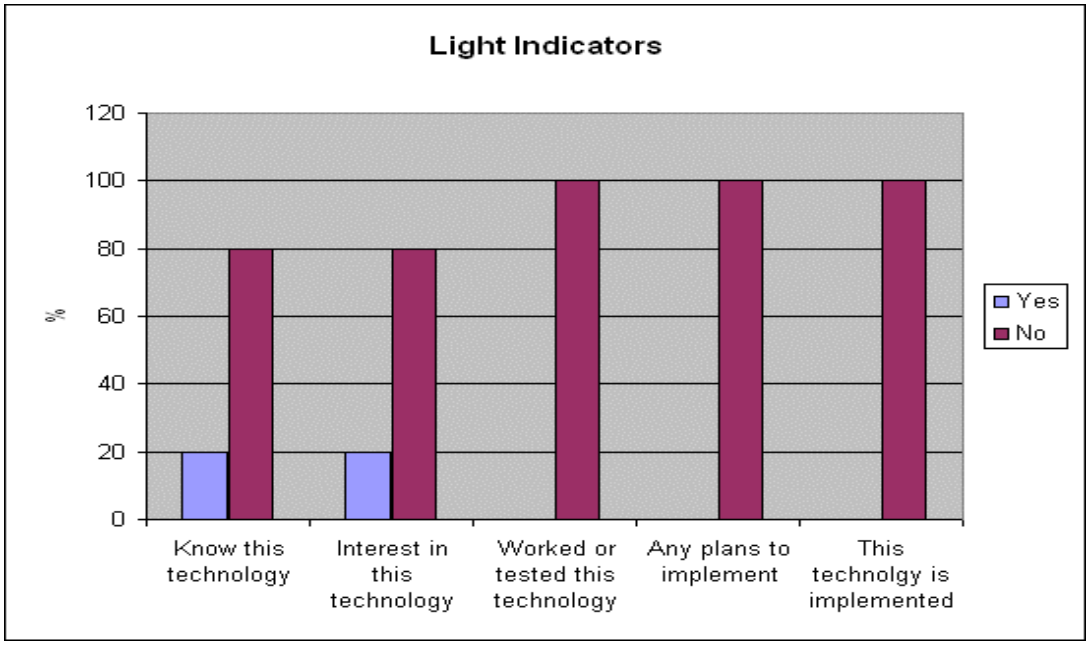

Figure 12

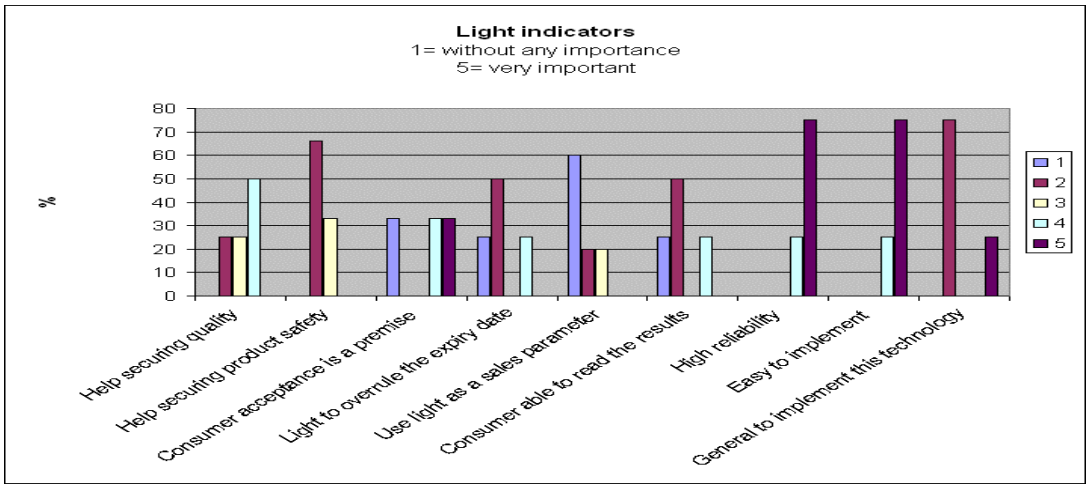

Figure 13

3.7 Logistics indicators (RFID)

This technology will be able to carry different logistics information used for track and trace and other logistics purposes – examples are barcodes and RFID.
All the retailers knew about the logistics indicators and 50% had worked or tested this technology – figure 14.
Quality, reliability and easy to implement were important, while the consumer acceptance was not important – figure 15.

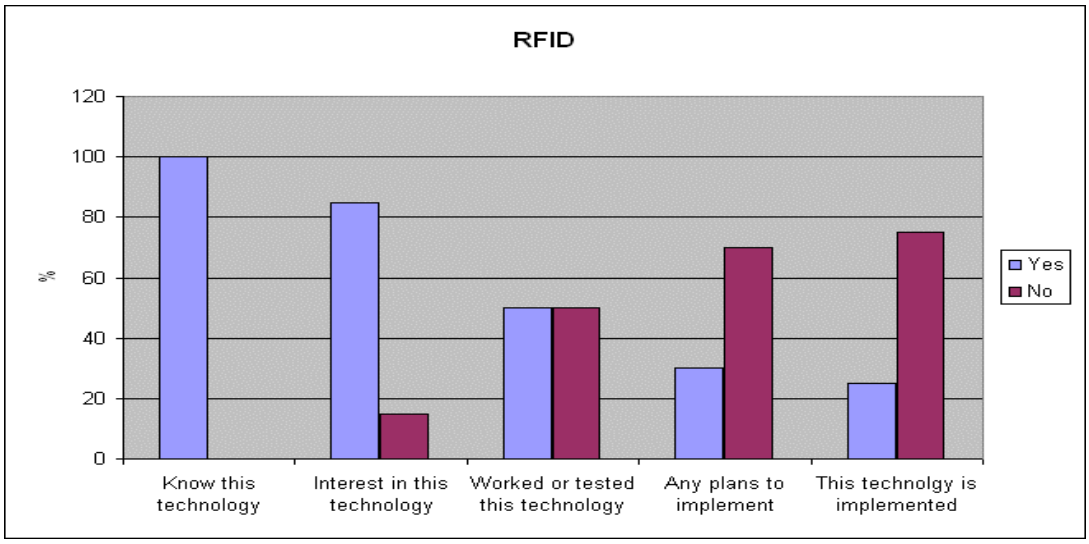

Figure 14

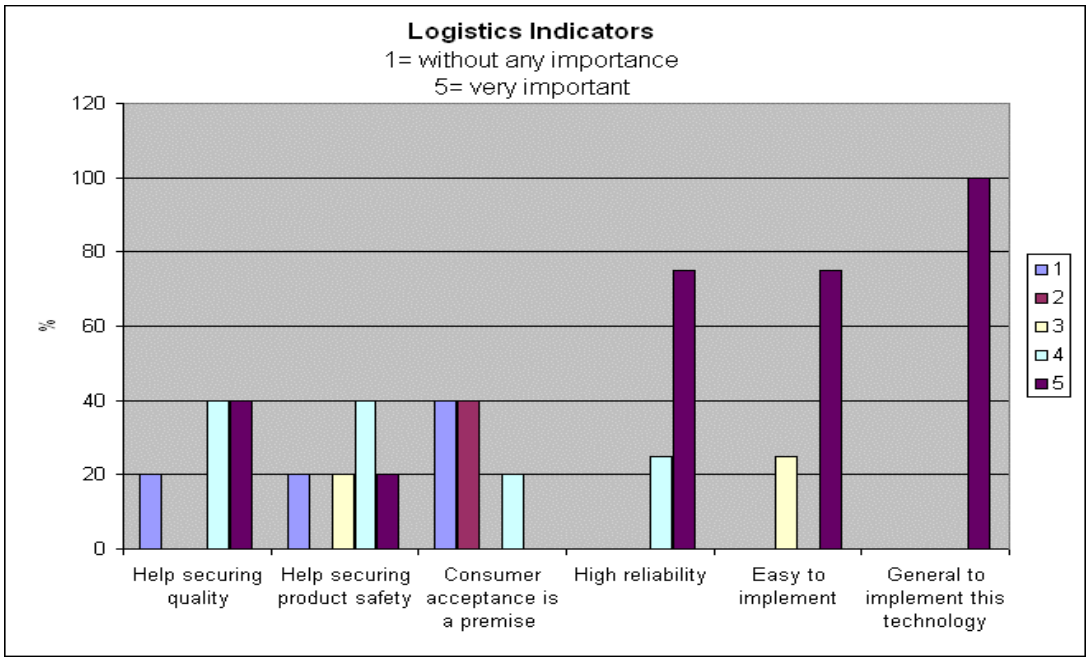

Figure 15

3.8 Relative Humidity Sensors (RH)

This technology can be used to detect, if a product has been kept within the correct relative humidity – example could be fruit.
Only 40% knew this technology and none had interest to work or test this technology – figure 16.
The remaining results of the importance were very similar to the previous technologies – figure 17.

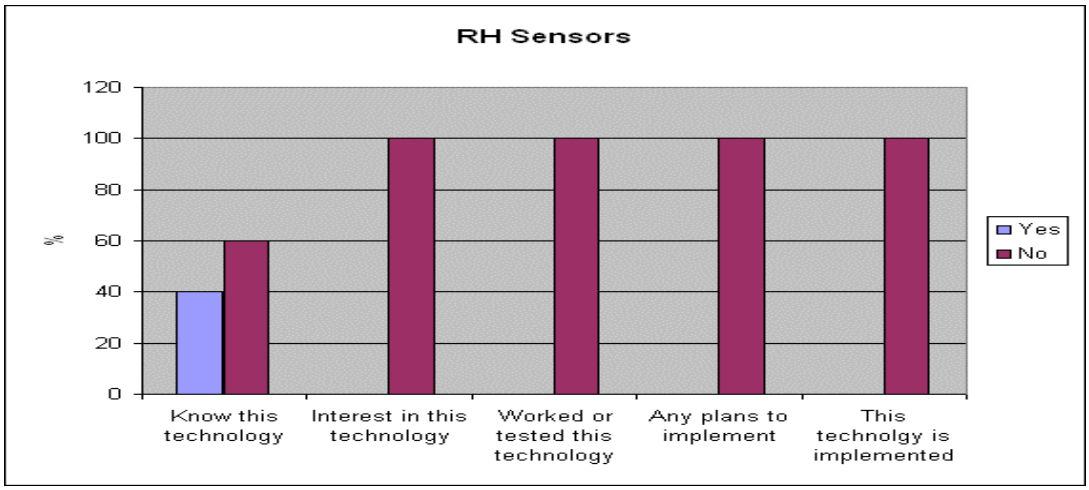

Figure 16

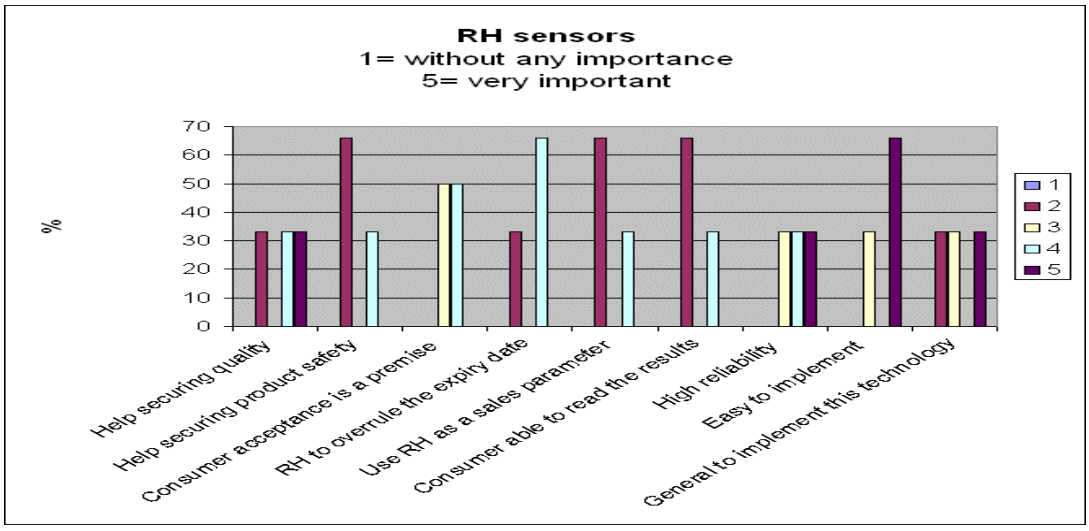

Figure 17

3.9 RFID – extended use

Use RFID tags to incorporate temperature indicators, RH sensors and combine these data with the logistics information.
80% knew this technology, but very few had worked or tested it – figure 18.
The remaining results of the importance were very similar to the previous technologies – figure 19.

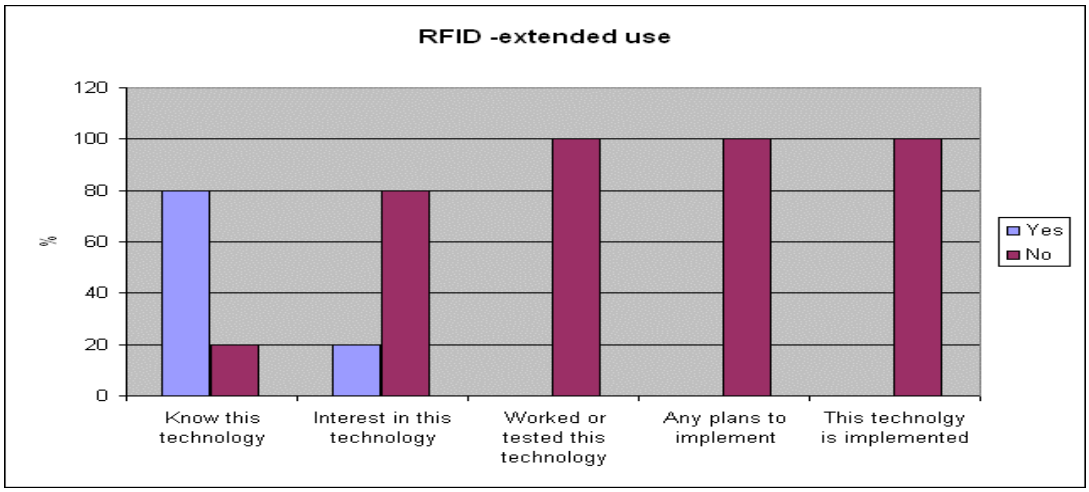

Figure 18

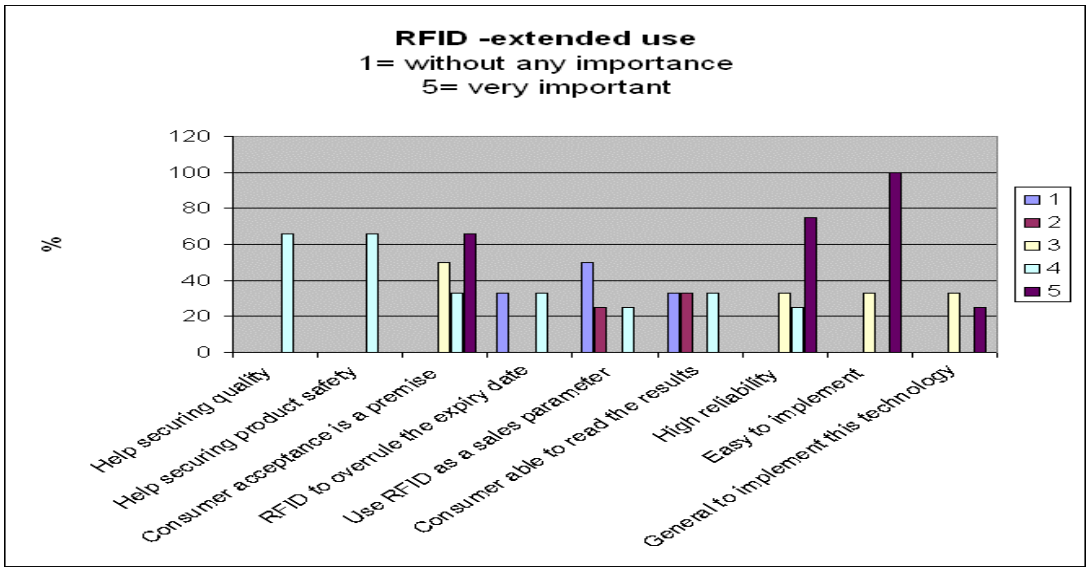

Figure 19

3.10 Maturity Sensors

These sensors will indicate, if the fruit is mature or not. This will avoids that the consumer squeezes the fruit to check it.
50% knew this technology and had an interest, but none had worked with the technology – figure 20.
The remaining results of the importance were very similar to the previous technologies – figure 21.

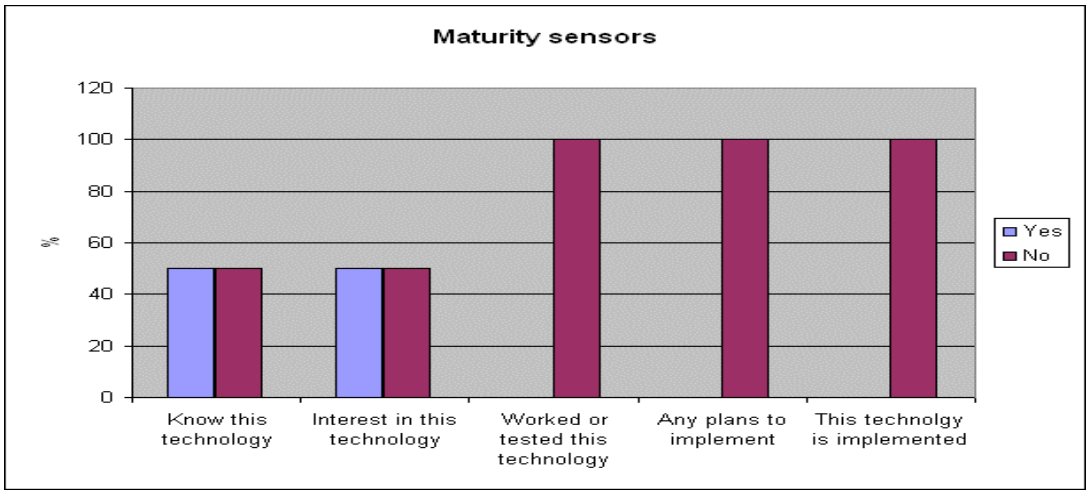

Figure 20

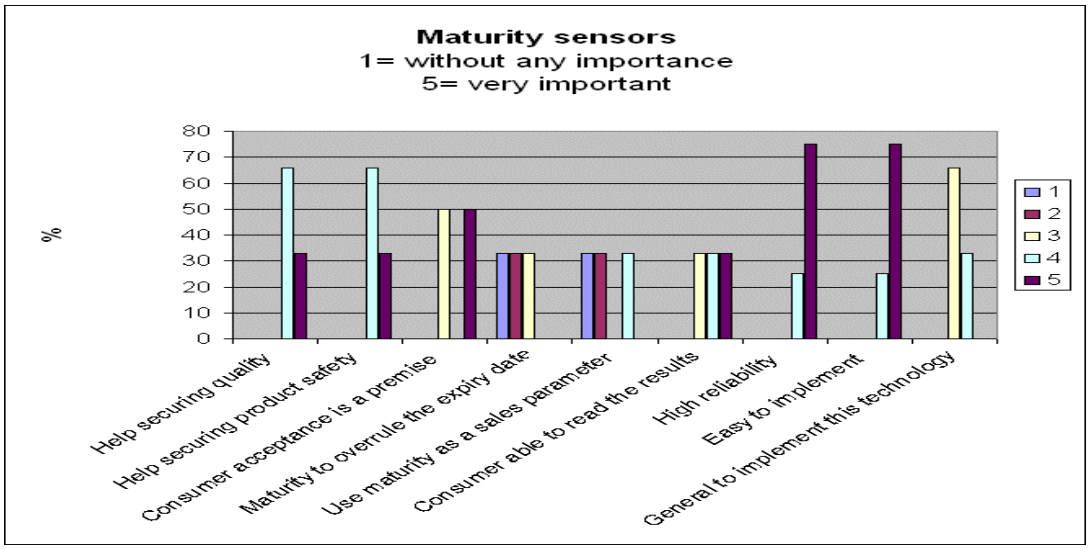

Figure 21

3.11 General assessment

In this assessment each of the technologies were evaluated according to importance against each other – figure 22. In a ranking sequence after importance, the results were as follows:

1. Logistics (RFID)
2. Leak
3. Freshness
4. Bio
5. Time Temperature Indicators
6. RFID extended use
7. Maturity
8. Light
9. Relative Humidity

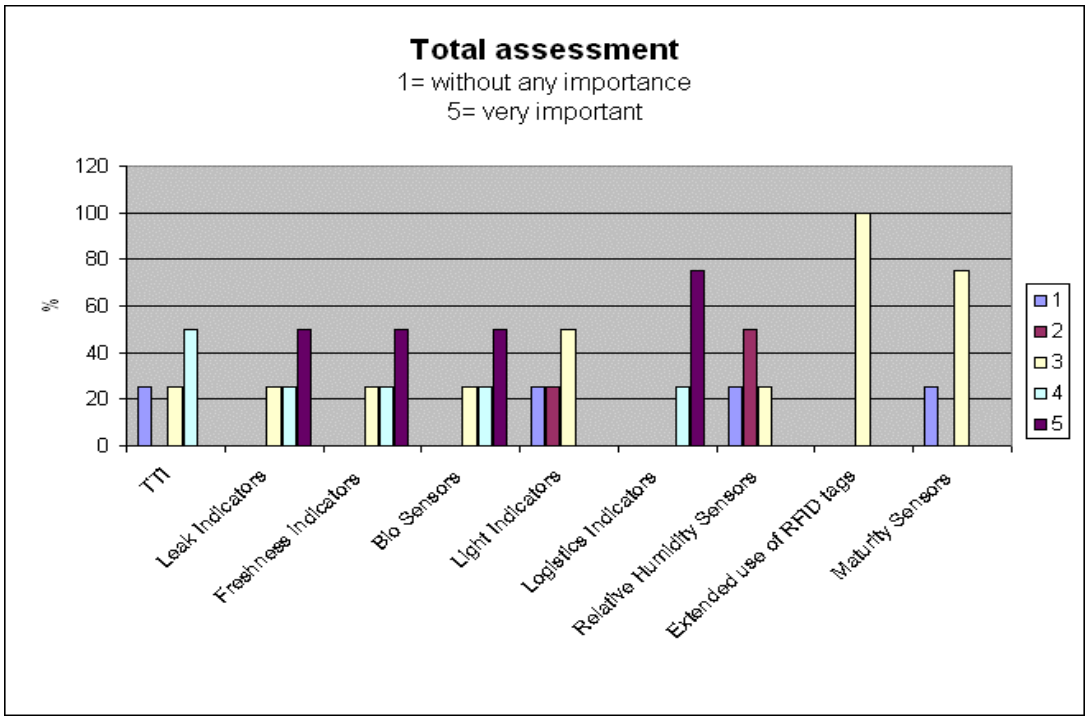

Figure 22

3.12 Passive technologies – electronic and marketing

These technologies are focusing on the communication with the consumer (marketing / branding) and for trade mark protection (counterfeiting).
Concerning the electronic part the findings were unclear – not a strict picture – figure 23.
Focusing on the marketing features – fig 24, the results were clearer. Carriers of information, branding purposes and quality information were ranked as important. Counterfeiting was ranked as not so important.

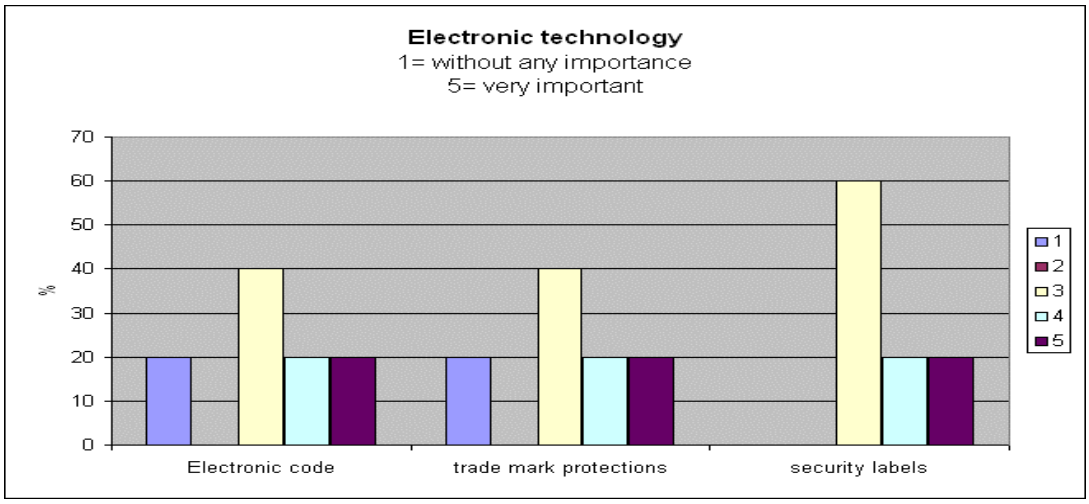

Figure 23

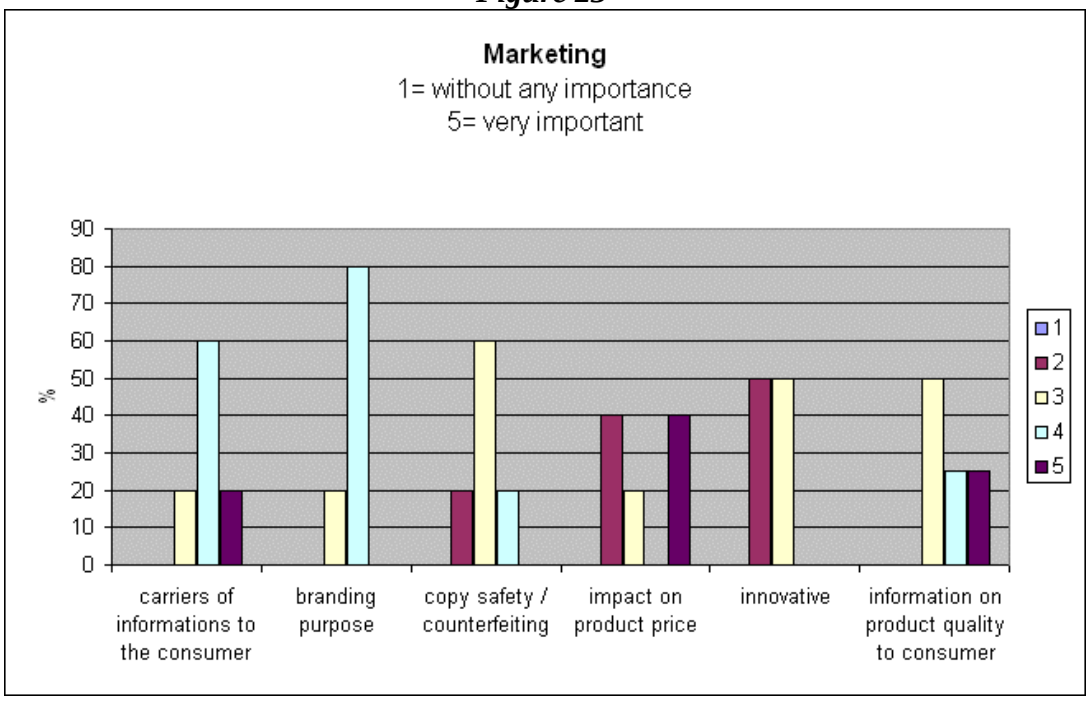

Figure 24

4. Conclusions

The conclusions from the retailer survey divided into following main groups:

1. General retailer attitudes concerning sensors and indicators.
2. Retailer attitudes versus the specific technologies.
3. Assessment of the importance of the statements and the technology ranking.

4. Final conclusions.

4.1 General retailer attitudes concerning sensors and indicators

The most significant findings concerning the general retailer attitudes were that the retailers don't want the consumers to be able to read the results from the sensors, but only for retailer use and that the technology should be sustainable.
The retailers were divided into two equal blocks concerning, if they want the technology on the consumer package and the willingness to pay extra for the technology.

4.2 Retailer attitudes versus the specific technologies

Concerning Time Temperature Indicators, Leak, Bio and Logistics indicators (RFID), a majority of the retailers knew these technologies and had interest and plans to implement them.

In contrast to this a minority of the retailers knew about the Freshness, Light and Relative Humidity indicators and had plans to implement these technologies.

4.3 Assessment of the importance of the statements and the technology ranking

In the survey the retailers were asked to rank by importance the different statements versus implementation of the technologies.

Following statements were ranked **very important** concerning implementation of a given technology:

- the consumer acceptance
- the technology should support securing of product quality and product safety
- the technology must be reliable
- the technology should be easy to implement

Following statements were ranked **less important** concerning implementation of a given technology:

- to use the technology as a sales parameter
- that the consumer should be able to read the data from sensors
- the conflict between the expiry date and the actual sensor information

The retailers were also asked to rank the different technologies according to importance. The conclusions from these answers were ranked according to importance:

1. Logistics (RFID)
2. Leak
3. Freshness
4. Bio
5. Time Temperature Indicators
6. RFID extended use
7. Maturity
8. Light
9. Relative Humidity

4.4 Final conclusions

In general the retailers had a "wait and see" attitude against communicative packaging based on the 9 different sensor technologies as mentioned in section 4.3. The retailers would not accept that the consumers should be able to read the output from the sensors. On the other hand it was important for the retailer that the consumer accepted the technology – a paradox. A reason for that could be that the retailer wanted to use the technology to prove for the consumer that systems for quality control internally were in place.
Maybe this also could explain the high rating on the logistics and quality indicators, while indirect indicators as maturity, light and RH had a low rating. This conclusion also confirmed by the statement that retailers only accept indicators on trade units only.
The benefit for the retailer should be a possibility to optimize the supply chain by using communicative packaging from the supplier to the store, but not in the store.

Attachment 1

Companies participated in the Survey:

COOP Denmark
COOP Sweden
COOP Norway
Dagrofa Denmark
ICA Sweden
Stockman Finland
KESKO Finland
Marks & Spencer UK
Can products Netherlands
JUMBO supermarkets Netherlands
John Lewis UK
"Dutch retailer" Netherlands