AGRI SUPPLY CHAIN MANAGEMENT

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Summary

Europe is becoming a more open market for all kinds of food resources and offers opportunities to increase the import of Asian fruits. It is a competitive market with high requirements regarding safety and quality of the products. Understanding the market and its consumers and building up business relations are basic requirements. Fruit consumption could benefit from the current consumer trends. Health, well-being and consciousness are gaining importance as drivers for consumers to decide on which products to buy. It is generally agreed that increased consumption of fruits contributes to a healthier lifestyle. Easy to use and convenience also are important aspects in new product introductions. The growth in sustainable and fair trade products is an opportunity that could still be further exploited. Creating added-value products should be based on the upper levels of the food pyramid: consistent high quality, chain quality and ethical values. To be distinctive other added value aspects are also important, like efficiency, pricing, flexibility, branding, marketing, diversity, year round delivery and consolidation power. The key to be successful will however be driven by the capacity to establish seamless partnerships that serve customers.
In setting up an efficient and robust supply chain, the use of the latest technology, knowledge and protocols in post-harvest management can be important. In the area of research and development in post-harvest technology several new concepts and innovative technologies are being examined. In for example the areas of long time storage, packaging concepts, cold chain management, controlled ripening and quality measurement several innovation projects are running. These innovations lead to opportunities for better quality products, lower energy consumption, lower transportation costs, flexibility in using transportation modalities, etc. An integral supply chain management approach is essential to develop robust solutions. Simulation tools using quality decay models and knowledge management systems are powerful exploration and scenario analysis tools. Certification systems and the use of protocols are important for operational management of the production and supply chain. New certification systems are being developed, like QACCP, to ensure quality attributes throughout the entire chain.

1. Introduction

There have been major changes in the supply chain of agro & food products over the last decades. Nowadays the complex is addressed as “the global food system”. A more liberalized international trade system, globalization and the transition towards a consumer driven market have empowered this development. International trade in fruits and vegetables has expanded at a higher rate over de past 25 years than trade in other agricultural commodities (Huang, 2004). This global food system means opportunities for

further growth of the import of Asian fruits in Europe. This will not be an easy challenge; world wide competition in fruit supply is high. Understanding the market and its consumers and building up business relations are basic requirements. There can be only profitable business for those who meet the high demands for quality and safety of the products. Furthermore in specific consumer segments other added-value concepts are needed, like healthy convenient products produced in a sustainable manner. Since chain performance is important to be competitive, the supply chain needs to be organised is an effective and efficient way. The use of state of the art post-harvest technology and supply chain management concepts contributes to "making the difference".

This paper is written from a European perspective, and in some cases addressing the specific situation in the Netherlands. In the first part of the paper attention is given to characteristics of the European market. Also the main trends and drivers for consumers and society are addressed. The opportunities and challenges for increased consumption of imported fruits are described. Second part of this paper focuses on recent developments in post harvest technology and supply chain management for fresh produce.

One of the major developments in the worldwide transport is the increase of the volume in reefer container transport of perishable products. For fruits like apple, citrus, banana, avocado, mango and melon overseas container shipment is the standard manner of long distance transport. Because of technological innovations in combination with the integral development approach several products have been added to the list of products that can be transported by ship instead of by airplane. Other reasons for shift to container transport are the higher costs for air trade because of high energy prices, the consolidation in logistics and more contracts based delivery. And who would have thought ten years ago that flowers like tulips and even cut roses could be transported transatlantic with a reefer container?

The Netherlands has a strong tradition in the agro & food business. Activities are in the total chain, with strong activities in breeding, processing and trading. For some products the Netherlands has a leading position in the global trade: 84 % of all flowers and 83% of all flower bulbs are traded via this country. The main ports Rotterdam harbour and Schiphol airport serve as excellent bases for an orchestrating role in trade and logistics. They serve as a transit port for imported fresh produce from all over the world. The Netherlands also has a strong tradition in education, business training and research in the agro&food area. Wageningen-UR is an international knowledge institution, with about 6000 research staff members and over 9000 students.

2. Characteristics of the European Food Market

The EU is the leading destination as well as source of supply in the global fruit and vegetable trade. During 1999-2001 the EU countries accounted for nearly half of the world's imports and over 40 percent of the exports. Though the EU is importing almost one-third of its fresh fruit imports from the banana-exporting and Southern Hemisphere countries, the imports from Asia is low: 0.5% of the fresh fruits, 3.3% of the fruit and vegetable juices (Huang, 2004). The European agro-food industry itself is a leading global exporter and it affords significant added value and offers scope for growth within new EU Member States, development of regional economies and exploitation of cultural diversity and tradition.

Two key factors play an important role in the changing food market place in Europe. Firstly economic development, movement from an industrial economy to a service economy,

brings with it new employment patterns, time-usage attributes, consumer segmentation and eating habits, all of which exert an impact on food consumption. Secondly, consumer evolution and awareness has turned a somewhat predictable body of consumers into small groups, each requiring that their own agenda and behavioural patterns (which are both more selective and less predictable) can be met by the market (ETP, 2005). This is included in consumer related trends like individualisation, demographic trends (more elderly people, smaller households, higher level of income), more focus on ethics and values, new ways of communication (less persuasive with traditional marketing campaigns), and consumer concern (food safety, food terrorism, GMO). In an updated version of the food pyramid, derived from the Maslow pyramid, bottom-line are availability, food safety and a minimum threshold for food quality. All food products should comply with these criteria. Next is added value on supreme food quality. On top is chain quality (transparency, trust, and image) and "ethical value" at the top of the pyramid (animal welfare, planet, people, organic and fair trade) (source: Ahold).

Product innovation is seen as the solution to meet with the changing consumer demands. The preferences of consumers for quality, convenience, diversity and health, and their justifiable expectations of safety, ethics and sustainable food production serve to highlight the opportunities for innovations (ETP, 2005). The fruit sector in the Netherlands is trade oriented, with the main opportunities in fresh and convenience product development. The Dutch fruit sector however is relative conservative with regards to product innovation (Timmermans, 2006). The grower-association Fruitmasters is calling on the sector to innovate with new products that connect with perception and lifestyle of consumer segments (Fruitmasters, 2006). Since consumer trends and preference for foods differ between countries and regions in Europe, local variations in product introduction are needed.

The growing power of retail organisations in Europe has an effect on the total supply chain. And retail is forcing requirements backwards to every single link in the chain. In Europe today only 90 large retail organisations are responsible for supplying most of the food that European consumers can buy in the supermarket. They will further control the quality management of the total chain and keep on putting pressure on achieving more efficiency in the chain. The amount of private labelled products has increased recently; the consumer is not willing to pay a high premium price for A-brand products. In Europe today, 40% of packaged foods have supermarket names rather than manufacturer labels (Bell, 2006). To be able to guarantee quality and safety of products several procedures have been installed, like HACCP, EurepGAP, GMP and recently the General Food Law (traceability). This has led to the overall perception, by consumers, government agencies and chain actors, that our food has never been as save as it is today. The first signs are visible that attention from the governmental agencies is shifting from safety only to also food quality aspects. Some retail and purchase organisations, also in the discount segment, are setting higher standards then obligatorily to be distinctive towards consumers.

One of the undesirable side effects of the transition towards a consumer driven food chain is the inefficiency in the supply chain resulting in huge product losses: spoilage. Rough estimates are that in developed countries 45-50% of the total fresh product volumes end up in the waste stream, mainly because of quality deterioration. Estimates are that in retail and food service 5-6% of the total volume of fresh products is subject to spoilage. For some of the recent fresh product innovations, like fresh-cut vegetables and fruit salads spoilage percentages can be as high as 15%. Quite alarming are the spoilage figures for the consumer segment. In the Netherlands an average household spills 10-15% of the fresh food, about

165kg a year. The spoiled products consisting of unused products (27%), leftovers of opened products (48%) and rest of prepared meals (25%) (Milieu Centraal, 2001).

Further vertical integration of the food chain is needed to get closer to the customer and become more responsive to their needs. Retailers will be more integrated with their suppliers, and suppliers must become more integrated with the farmers. The time between identifying a consumer demand and being able to grow, process, and put it on the shelf needs to be much shorter. This means that chain actors will work more as partners than competitors. And because of the more integral approach, the increased transparency and thrust between actors, efficiency can also be improved. And issues like spoilage in the chain up to the consumer can be better controlled and reduced dramatically with an integral approach. In the Netherlands currently a consortium of retailers, food service companies, suppliers, producers and enabling technology suppliers is working on reduction of spoilage in an initiative called "Fresh on Demand". Global success will be driven by the capacity to establish seamless partnerships that serve customers (Bell, 2006). The real challenge for the future is the transition to get from transaction to trust.

3. Consumer Trends

3.1 Major Trends

The major drivers for innovation in food products in Europe are health (16%) and well-being (12%) (CIAA, 2004). Other important drivers are easy-to-use and price. In the evaluation of the top-20 of the most successful food introductions in the Netherlands over the last 4 years show that health is gaining importance, while well-being also scores high (source: IRI). Ethical values/conscience and "on-the-go" are believed to be two drivers that are gaining importance. There is an increasing societal awareness of the opportunities to improve the quality of life through healthy eating and of the contribution that sustainable production can make to improvement of the overall environment (ETP, 2005). The trend that people tend to get heavier in developed countries (obesity) supports the healthy choice. Product introductions that score on a combination of drivers have a better change of being successful.

3.2 Effects on Fruit Consumption

Low fruit and vegetable intake is currently among the top 10 selected risk factors for global mortality (WHO, 2002). European consumers tend to trust fruits and vegetables without any doubt. Despite of this, fruit and vegetable consumption in many European countries is below the recommended daily intake. A recent elaborate survey in the Netherlands on eating habits showed that fruit and vegetables intake even decreased by 15 to 20% during the last 10 years and it is expected that this trend will continue over the coming years (RIVM, 2004). Similar trends are apparent in other EU countries. In recent years the issue of sustainability has been given much attention and increased amounts of products from organic or sustainable production systems have entered the market. This development has, however, not led to an overall increase in fruit consumption.

The different consumption patterns through Europe and the different behaviour of consumer subgroups may partly be explained by the different availability of high quality products and the socio-economic status. However, other cultural, behavioural and psychological factors of which we know almost nothing about may play an equally important role. These data are of major value for relating dietary habits with health and underwrite the importance of fruits

and vegetables but do not give clear directions on possible strategies to increase consumption (Woltering, 2005).

The turnovers in both organic and fair-trade products have grown significantly in fruit products in the last ten years. Specifically the sales of organic tropical fruits are expending rapidly, especially organic bananas which are popular with consumers seeking organic and fair-trade products. There are large differences in sales of organic in different EU-countries; the average sales of organic fruits comprise only a few percents of the total sales (Organic Monitor, 2005). In non-organic produce there is a growing demand for residue-free products, in accordance with the trend for more sustainable production methods.

The first fair trade label was established on coffee by Max Havelaar in the Netherlands in 1988. Now there are 14 European countries, plus the USA, Canada and Japan that sell fair trade labelled products. The "Fair-trade" and "Max Havelaar" labels guarantee consumers that certain standards were met in the production and trade of the products where the labels appear. Fair trade certification guarantees not only fair prices, but also the principles of ethical purchasing. These principles include adherence to ILO agreements such as those banning child and slave labour, guaranteeing a safe workplace and the right to unionise, adherence to the United Nations charter of human rights, a fair price that covers the cost of production and facilitates social development, and protection and conservation of the environment. The fair trade certification system also promotes long-term business relationships between buyers and sellers, and greater transparency throughout the supply chain.

Many food producers have taken the initiative to introduce new products over the last years, trying to be successful with the translation of the consumer trends into product innovations. There has been a large growth in de fresh cut vegetable segment (healthy and convenient). Packed fresh cut fruits products have been introduced, but are not as diversified and voluminous yet. Ready to eat fruits (mango, avocado and pear) have been introduced, and are sold at premium price level. In some niche areas large growth percentages are perceived. For example the sales of blue berries in the Netherlands have grown with over 850% in 3 years time. Sales of raspberry have increased with over 250%. Both products fit in the healthy trend (vitamins, antioxidants) and are convenient to eat.

The most successful fruit innovations come from the processing industry. Two of the most successful product introductions in the Dutch consumer product market in the last few years are the “Breaker” and “Fruit2day”. Both products contain (processed) fruit. The “Breaker” is a combination of yoghurt and fruits in a flexible bag. The “Fruit2day” is a bottle with printed fruits design that contains the same ingredients as two pieces of fruits. It flirts with the slogan: “two ounces of veggies and 2 pieces of fruit a day keeps the doctor away”. The reasons for their success are the combination of multiple consumer requirements: “healthy”, “easy to use” and “on the go”. As a result of their success, the two most successful product introduction in 2005 are another combination of dairy and fruit (Mona boordevol) and Knorr Vie: a small bottle containing processed fruits and vegetables. Behind all these products are A-brand companies: Royal Friesland Foods, Hero, Campina and Unilever. A strong marketing effort to promote their products is an important reason for success.

3.3 Opportunities and Challenges for Tropical Fruit

The previous chapters showed that there could be reason to be optimistic about the opportunities to increase fruit consumption. Health and well-being, but also consciousness offer opportunities. It is generally agreed that increased consumption of fruits greatly

contributes to a healthier lifestyle. Easy to use and convenience is something that need to be kept in mind when developing or introducing new products. Consuming fresh products needs to become more attractive and trendy. The growth in sustainable and fair trade products is also an opportunity that could still be further exploited. Creating added-value products and marketing will be important. Added-value can also be based on the different levels of the food pyramid: consistent high quality, chain quality and ethical values.

Food tastes are still very local even though production capabilities are global. It is important to learn how to build global type production economies, yet to be able to market into countries where food tastes are local. One issue, for example, is simply packaging. Labelling requirements are different from country to country, so what people expect to see on packages also differs (Bell, 2006). Local endemic products, that are to some extend unknown to the European consumer, could be an opportunity. Since many people travel to other countries to feel the local culture and try the local food, this could lead to buying these products at home. Marketing and organising the supply chain to ensure good quality products are crucial aspects.

One of the results of the growing interest in sustainability can be the preference with specific consumer groups for products that have used less energy in transport. If in the product labelling the “foodmiles” will be introduced, this could lead to change in buying behaviour. Since tropical fruits can only be imported, it is more a matter of using the right transportation method, like reefer transport and to communicate about this.

4. Post Harvest Technology

4.1 Introduction

In the area of post harvest technology still progress is made in extending the storability and shelf life of perishable products by improved and innovative technologies. Some relevant developments and research projects are described in this paragraph. The description of developments, techniques or innovations is not limited to the application of tropical fruit products. Issues and solutions for other fresh product can be an inspiration for the tropical fruit sector.

4.2 Long term storage of fresh products

The dynamic control system (DCS) is an interactive, patented storage concept, which can be regarded as the successor of the traditional controlled atmosphere (CA) storage for some commodities. Instead of using static, fixed set-points for gas conditions like in CA, the oxygen concentration in the DCS storage facility is controlled upon product response. When applying DCS, the oxygen concentration is slowly lowered until the product emits a stress signal. More specific, DCS uses an ethanol sensor to detect low level ethanol concentrations, the product of fermentation. DCS was initially applied for apples (variety Elstar). Experiments with Elstar show that apples are firmer after DCS storage and have a better colour retention compared with traditional CA. Furthermore, apples tend to develop less skin spots under DCS (Veltman, 2003). Based on these results on several Elstar storage locations in the Netherlands the DCS control system has been installed. Research and experiments with other products like ox-heart cabbage and soft fruits showed good storage results. For example a reduction of fungal growth in red currants has been shown after a storage period of 8 months.

A development of the last five years is the use of Smartfresh as an additive to improve post harvest quality during storage. The active component of Smartfresh is 1-MCP, which blocks the sensitivity of the product for ethylene and inhibits production of ethylene. Smartfresh is applied in damp phase in the storage room. It only needs a single application treatment in the storage room. Worldwide experiments and commercialisation have been started on several products, like apples (Europe and USA), avocado (South Africa), banana (USA and Europe), kiwi (Chile) and also vegetable products. In general Smartfresh gives for many products a better quality after storage, less spoilage, longer storability and improved consumer preference. Extensive registration procedures limit its direct worldwide application.

Another new technology that has potential to change the possible storability of fresh produce is the area of ultra fast cooling and freezing. For example the company Supachill developed a new patented technology to freeze vacuum packed products almost ten times as fast as with blast freezing methods. Cell walls and tissue are not broken down and texture, taste and colour are maintained (more info: www.supachillusa.com). The product after defrost is of a good quality, for many products consumer panels cannot identify difference between the fresh and the freeze-fresh product. For soft fruit, like strawberry, some tissue-degradation is visible. Most promising are applications for added-value products, like prepared fresh meals and expensive meats. This technology could have impact on the scale of global sourcing of semi-fresh products.

4.3 Packaging technology

Packaging is important, and serves multiple functions: guide for usage and handling, marketing display and the information carrier for chain actors and consumer. Especially for fresh product the package protects the product against physical, chemical and biological decay. Longer shelf life can be achieved with optimal packaging. Still a lot of entire fruit products are on display in supermarkets with no packaging on item level. Products that have a limited shelf life, like pre-cut fruits, definitely benefit from packaging at item level during the whole chain, up to the consumption moment. In traditional packaging a plastic film is used to create a gas barrier, so optimal CO_2, O_2 and H_2O levels can be achieved at equilibrium stage. The gas diffusion characteristics of the film are product specific. In the last decennia for several products the concept of Modified Atmosphere (MA) packaging is applied. The initial gas atmosphere is actively created. Air is replaced by a new mixture of 'protective' gasses. These gasses delay product quality loss by preventing oxidation and microbial decay.

A new research area to improve the MA-concept is Active Packaging. The basic idea is that when required an active element is released in the packaging, which influences product quality by absorbing undesirable components or releasing desirable components. Application areas are:

- Controlling moisture and gas composition in the packaging
- Release of anti-microbial components
- Absorbance of ethylene (delaying ripening)
- Absorbance of 'off-flavours'
- Release of flavours

The market for packaging materials is very competitive. Therefore the price of the material is a key factor. Specifically for specific barrier films research is done by producers on e.g.

new coating materials and nano clays. Current developments are seen in micro-perforated packages, where small micro-pores are made in the packaging films. The amount and size of the micro perforations is determined by the type of product and should be optimised for the actual respiration rate of the product. These efforts will result is cheaper specific barrier films. Also the speed and flexibility of packaging equipment will increase further.

For packaging of fresh products there is a trend to use more biodegradable packaging materials. The performance of the materials has improved the last few years (e.g. PLA based materials). The price performance ratio for barrier films is still far lower as with plastic films. The increased costs of oil-based resources for plastic films production helps to push introduction. Sustainable development is the main reason why biodegradable packaging materials are used. It is believed that a major collective effort is needed (from governments, producers and consumers) to achieve significant use.

4.4 Cold Chain Management

In post harvest handling it is generally known that maintaining a low temperature, optimal for the commodity, is essential to maintain a good storability and shelf life. Less is known about the necessity and advantages of for example pre-cooling and the effects of short higher temperature intervals. Because of the trend for flexible and high-speed logistics the configuration of the chain needs to be optimised based on specific needs. In 2002 Wageningen-UR has executed a three year lasting project called “Keepability and Cooling of food horticultural crops”. The Productboard for Horticulture financed the project and chain partners participated in the research activities. The case products were crops from Dutch origin: strawberry, peppers, tomato, chicory and lettuce.

The main research questions were:

- Is speed of logistics more effective than cooling?
- Where is the break-even point?
- What is the effect of slow cooling?
- What is the effect of temperature change and condensation?

The results of the project are in some cases different from current practice in the pre-cooling processes. Cooling is always needed. But there was no effect of fast pre-cooling of these products, as long as within 48 hours after harvesting the optimal temperature has been achieved. Also condensation has no effect on the quality. And temperature changes can be tolerated, as long as it falls within certain limits. The unavailability of cooling facilities in supermarkets has a disadvantageous effect on quality. These conclusions are only valid for produce with an acceptable initial quality. All products with low initial quality showed several product specific artefacts. The conclusion of the research project is that the initial post harvest quality is the most important factor. With bad product no sufficient treatment recipe for cooling is effective, resulting in spoilage (van den Boogaard, 2004). An essential tool for analysing the cold chain is technology to record and analyse the time-temperature profile during transport (info: www.e-faqts.com).

4.5 Energy efficient reefer transport

Long distance transport of perishable products with a reefer container is using a factor 100 less energy per kg of product as with airline transport. Since large and increasing world-wide volumes of fresh agro-products are transported the total energy use is huge. About 30

Million tonnes of agro-food products were transported in sea containers in 2000. Energy consumption used for climate conditioning of sea containers is often higher than needed for the quality control of the product. The project Quest started in 2000 and aimed at development of a new agro-container concept with reduced energy use and optimisation of product quality. One of the products developed in the project is the "Quest regular" control system, developed to reduce power consumption of reefer containers. The Quest Regular concept was tested in a real-life shipment of mangoes from Brazil to the Netherlands in December 2005. The test results were positive because it is demonstrated that the power consumption of mango shipping in reefer containers can be reduced to a high extend without any negative effect on product quality.

A second part of this project was to develop a "ripening on board" concept for climacteric products. One of the deliverables is a computer model that can be used to control the ripening of avocado, the case product used in this research project. Fruit ripening of avocado is strongly related to ethylene. The main control mechanism available to influence the ripening and prevent ethylene production is storage temperature. The ultimate control of the storage environment can be used to ripen avocados during transport, in such a way that a desired ripening stage is reached at the wished moment. The research showed that theoretically and technically the concept of "ripening on board" is possible. Some practical issues need to be solved and are subject to further research. A low-budget and easy-to-operate ethylene measurement system is under construction and being evaluated. Another aspect is the influence of the variability in the batch on the ripening process. It is expected that product already in climacteric phase will affect other individuals. But the use of temperatures higher than optimal to initiate ripening will enhance the variance (Tijskens et al. 2003).

4.6 Quality Measurement

Initial post harvest quality of a product batch and the biological variation in the batch are considered to be the most important factors in the market potential of a crop. Determining the quality status of the product is of major importance to be able to take the right decisions. Quality of fresh produce is in general being measured with the help of biochemical, physiological, instrumental optical, electrochemical or mechanical equipment and human visual inspection methods. With these methods direct or indirect several intrinsic or extrinsic quality parameters can be measured. Some methods are invasive techniques and require the destruction of the product. Others, like human perception, are less objective. There has been extensive search and research for methods that can determine the initial quality that also can be used to predict post-harvest behaviour. Molecular diagnostics, based on genomics, is a potential candidate that can fulfil this requirement. Gene expression is related to the basic physiological processes, and therefore expresses the actual status of a product, given its genetic profile and including the history in environmental aspects. In the medical diagnostic research area this technology has been applied with the first successes being reported.

For assessment of initial quality of plant based products the "proof of concept" has been delivered for a few crops. For crops like carnation, iris, roses, apple and potato research has been done at Wageningen-UR to identify gene expression profiles that are indicative for a specific quality aspect. For carnation and iris the development stage of flowering has been selected as quality aspect. For roses the quality aspect of research was the sensitivity for botrytis infection during transport. For apples the optimal harvesting moment, and for potato the storability in relation to the sweetening processes. As an intermediate step cDNA

microarray plots have been made to monitor the expressions of thousands of candidate genes. Using pattern recognition techniques from the bio-informatics area, for each product a subset of genes has been selected with the highest prediction scores for that specific quality aspect. A real-time PCR method has been used as platform for the diagnostic predictive tests. The results are very promising, in a way that for all crops a subset of genes could be found that could predict with acceptable accuracy the quality aspects. Further research and development will be done in the coming years to validate these findings and design an easy to use protocol and test method for practical applications.

5. Supply Chain Management

5.1 Integral approach

Several definitions for Supply Chain Management can be given. Here SCM is defined as the integrated planning, coordination, and control of all logistic business processes and activities in the supply chain to deliver superior consumer value at less cost to the supply chain as a whole while satisfying requirements of other stakeholders in the supply chain (e.g. the government or NGOs). SCM should result in the choice of a supply chain scenario, i.e., an internally consistent view on how a supply chain should look like in terms of production and distribution processes and their coordination. An essential product attribute in food chains is product quality. The way in which product quality is controlled and guaranteed in the supply chain, is considered of vital importance for supply chain performance. Apart from being a performance measure of its own, product quality is directly related to other food attributes like integrity and safety. Furthermore, product quality is tightly coupled to logistical decisions, because the use of specific resources at specific environmental conditions in processing and distributing steps influences product quality. In fact one of the keys to food SCM is an integrative view on logistics and product quality (van der Vorst, 2005).

5.2 The role of modelling and simulation tools

Simulation tools are often used for supporting decision-making on supply chain (re)design, building on their inherent modelling flexibility. However, food supply chains set some specific requirements to simulation models. To address these demands a new discrete event simulation environment called ALADIN (Agro-Logistics Analysis and Design INstrument) has been developed. It is based on a generic modelling framework that offers the analyst guidance in modelling, and provides model transparency to problem owners. An essential feature of the new tool concerns the integration of reusable process building blocks and quality decay models (van der Vorst, 2005).

The models describing (a) quality aspect(s) in relation to its process and distribution chain are so-called quality decay models (QDM). These models incorporate all variation that can occur, i.e. variation in initial quality due to seasonal variations, variation in process conditions, etc. The developed models must be able to incorporate these sources. An example is the model to predict the shelf-life of fresh-cut vegetables. With this model insight can be gained into the role of condensation and micro-perforations in quality decay of minimally processed vegetables (Top, 2005).

5.3 Certification systems and protocols

Certification systems and the use of protocols are important for operational management of the production and supply chain. QACCP (Quality Analysis of Critical Control Points) is a – at this moment still theoretical – system approach to visualize the effects of chain processes on the quality of products and make it useful for decision making. With the help of concrete tools and instruments, in which practical knowledge and scientific models are combined, critical decision points are made visual, the band width set at a specific point, and the effects of possible corrective actions determined. Based on a QACCP analysis decisions can be taken to optimise a chain process, redesign a configuration or reallocate different product streams in the chain. The idea of QACCP is not yet formalised into rules like HACCP is; it is still under investigation. Its purpose is to show quantitatively via Quality Decay Models which factors have an effect on food quality attributes for each element in the food chain (van Boekel, 2005).

5.4 Integral project cases

Fruitful is an example of an integral international supply chain project with multiple goals. The objective of Fruitful was to study the possibilities for investments in an integrative supply chain information system. With the assumption that enhancement of information exchange improves logistic performance and fruit quality. Partners in the project came from South Africa and the Netherlands with participation from industry (Capespan, FTK, Hagé, Seabrex, Seatreade, e.o.); knowledge institutes (Wageningen-UR, TNO, CSIR) and other stakeholders (Klict, Ministry of Agriculture, e.o). The project started in August 2001 and continued until October 2002. The project's aim was to identify promising opportunities for improvement of the supply chain for fruit from South Africa to the Netherlands using a participative approach, in a setting where all the key actors in the chain are represented. Pilot consortia were set up for grapes, citrus, avocado and mango. Some results and conclusions from the project were:

- Pilot partners agree on importance of the usage of standard codes
- Codes must be maintained by a authorized third party
- Electronic booking gives advantages
- Better understanding of each others functions within the chain
- First steps have been made towards more integrated information exchange

A project that has just started in 2006 is the ISAFRUIT project. ISAFRUIT is an integrated research project funded by EU under the Framework 6 programme. The total activity amounts to more than 21 million €. Both research institutes and private companies also fund part of the activities. 40 universities and research institutes and 20 companies are partners in the integrated project. The partners come from 17 countries, including two research institutes from developing countries, and 21 SME's.

The idea of ISAFRUIT is to fulfil the consumer needs and expectations and increase fruit consumption through consumer satisfaction. Awareness of the health effects of fruit may be a driving force for the consumer. Thus consumer-linked sciences are the starting point of ISAFRUIT giving input to the other RTD activities. Research on human health and fruit consumption is part of the project. Activities on quality and health effects of fresh and processed fruit shall stimulate consumer interest in a wider range of healthy products.

Sustainable chain management and production methods including organic production are addressed by a number of work packages dealing with the post harvest and pre harvest quality of the fruit in the supply chain. The goal is to stimulate the availability of a wider range of fruit and fruit products from sustainable production on the market (www.isafruit.org).

6. Conclusions or Recommendations

The European market offers plenty of opportunities for Asian fruits. It is a competitive market with high requirements regarding safety and quality of the products. Understanding the market and its consumers and building up business relations are basic requirements. Fruit consumption could benefit from the current consumer trends because consumption fits in a healthy lifestyle. The growth in sustainable and fair trade products is an opportunity that could still be further exploited. In banana import a positive track record has been build and this could serve as an example for other commodities. The real challenge is to build up partnerships with importing companies to innovate and create added-value products and concepts: convenient, easy-to-use products. To be distinctive other attributes are also important, like sustainability, efficiency, pricing, flexibility, diversity, consistency, marketing and branding. The key to be successful will however be driven by the capacity to establish seamless partnerships that serve customers.

In setting up an efficient and robust supply chain, the use of the latest technology, knowledge and protocols in post-harvest can be important. In the research and development in post-harvest technology several new concepts and innovative technologies are being explored. In for example the areas of long time storage, packaging concepts, cold chain management, controlled ripening and quality measurement several innovation projects are running. An integral supply chain management approach is essential to develop robust solutions. Simulation tools using quality decay models and knowledge management systems are powerful exploration and scenario analysis tools. In the scenario analysis the use of the standard and state-of-the-art post harvest technologies can be simulated and performance indicators can be compared. Performance indicators like costs, shelf life and sustainability can be determined for each supply chain scenario. Certification systems and the use of protocols are important for operational management of the production and supply chain. New certification systems are being developed, like QACCP, to ensure quality throughout the entire chain.

Entrepreneurship and finding a business strategy are crucial aspects in being successful in setting up an export chain. Selecting the right partners in the chain and build up a network of relevant stakeholders are important factors. Depending on the stage of development and business strategy different types of information and knowledge could be needed to take the right decisions. Besides the actors in the chain relevant knowledge can be found at government institutions and knowledge institutions. Our food system has more and more a global orientation. The trend in research and development is that it is moving towards a more open global network system. It is important however that the arenas will be created to build and strengthen networks for communication and interaction between the different actors.

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