Modelling for Globalisation

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INTRODUCTION

The world is getting smaller and smaller. All participants to this conference are the best example for that: we come from all over the world to discuss themes related to our daily food. Living in a small world has great advantages but also some drawbacks. We like to think we are ready for a major up scaling of our food supplies, but are we really?

What do we need to answer to this challenge? How can we manage these large scale operations? Where do we get useful information? How do we discriminate useful information from misinformation?

All these questions need to be answered and the answers incorporated into our skills for managing these global chains. In this lecture, we will try to answer some of them, at least put the questions behind the issues in a proper perspective and a proper framework of thinking.

WHY GLOBALISATION

Globalisation is a still expanding omnipresent development in our food supply chains. Developing countries like Thailand and other South East Asian countries are trying to get a piece of the Western pie and develop distribution chains to transport their tropical fruit to Europe, US and Japan. And these western countries are indeed very willing to accept these products, if and when these products are up to the Western standards. African countries are already producing for quite some years fresh vegetables for Europe (e.g. green beans) in winter and early spring. Apples are shipped around the world from one hemisphere to another to provide fresh fruit in wintertime. Looking further then the mere horticultural products, meat and fish are more and more transported all over the globe: sheep from Australia and New Zealand, beef from Argentina etc.

Benefits of Globalisation

The benefits for globalisation are obvious. Products of all kind are imported at prices well below the own production costs. Continuous inflow of fresh fruit and vegetables in the northern hemisphere, while enhancing economics in developing countries. That is more money is going around in these countries. If and when the quality of these products, despite them being shipped around the globe, are still satisfying customers, the customers will continue to buy these goods. Repeated buys will drive the supply chain further and further, and will make everybody happy: traders have more to trade, consumers have more choice, transporters have more to transport, retailers have more on offer, and producers can produce more.

Draw-backs of Globalisation

Each of the advantages of globalisation as describe in previous section has its own draw-backs. Money generated by enhancing local economics most of the time ends up in the revenues of large scale western companies. In fact, as long as the economic paradigm does not change from a growth oriented system (increasing sales, increasing revenues) to a sustainable economic system, that is more oriented to encourage the customer to repeated buying (Schepers et al., 2004, Batt, 2005, Duffy, 2005), the consequences of globalisation could turn out detrimental in the long run, especially for the these global areas that are now trying to catch up with the Western world. Especially the long distance transportation will induce depletion of natural resources and environmental damages.

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The organisation itself of a supply chain can pose a problem for its eventual success. The importance of transparency within the chain (who benefits from which action) is a well recognised and discussed item (Hofstede et al., 2004).

But not only economic factors are considered decisive for the success of globalised supply chains, also the quality of the product eventually has a major impact on the behavior of consumers (repeated buys) in the receiving countries. Perishable products do perish continuously resulting in a decrease in quality and economic value. The quality of the product is likely to decay pretty fast during the (long) transport. Technical specifications regarding e.g. cooling temperatures in large scale freighters do pose a continuous problem, as can be taken from the numerous papers and presentations on temperature set points and temperature distributions in pallet, containers and freighters (e.g. Tanner and Amos, 2003; Villeneuve et al., 2001).

One item that has been out of focus too much, however, is the need to understand how the different regions and different seasons all over the world do affect quality and quality behavior. For that type of understanding and integration a different approach is necessary that incorporates the relevant behavior of the product, both in the preharvest as in the postharvest realm. Differences induced by different cultivars, growing sites, soil types, climate and weather etc. have to be merged and combined into one description. Traditional approaches in modelling are unsuitable to accommodate this integration of knowledge. We have to turn to modelling that is based on available knowledge on the processes that occur in the produce and initiate or cause the phenomena observed.

WHY MODELLING

In modern society with the large time and spatial distances between the region of food production and the region of food consumption, production facilities, distributors and processing lines need some guidance and rules to accommodate large groups of consumers with one and the same product and to accommodate the same consumers with a large scale of produce type and provenance. To stay in the market, to stay competitive, it is no longer sufficient just to provide some food, no matter how good the taste and flavour is. The wishes, preferences and buying behavior of consumers have to be taken into account. (Sloof et al., 1996; Tijskens, 2003). Local markets are vanishing rapidly, globalisation is the magic strategy.

Product properties, quality attributes and consumer behavior are the three aspects that have to be considered when it comes to providing reliably and repeatedly produce to the market. And for all three accounts process oriented fundamental modelling can provide some answers and applications.

The ultimate goal of modelling is to predict future behavior of any product, in any circumstance, from any region, grown in any season. Modelling is the modern version of analysing and understanding laboratory and practical experiments (Tijskens, 2004). It allows, or at least should allow, the transfer of experimental results into practical applications. The world of food supply chains, however, and especially that the globalised supply chains, gets more and more complicated. The quality of produce from different origins and growing conditions behaves sometimes different from what we expected. The habitually applied rules for quality control are no longer generally applicable. Traditional models, mainly statistical and/or empirical models, will no longer be reliable enough to predict quality. We have to include all available knowledge, both for the preharvest realm (food production) as for the postharvest phase (distribution and processing). The barrier between both phases desperately needs to be broken down. Communication however between both realms is very problematic (Tijskens et al., 2006a). Ideas and information have to be exchanged. Process oriented modelling, mainly based on the knowledge we have on the occurring processes is a system of modelling that can deliver that (Tijskens, 2004).

Process Oriented Modelling

To achieve the ultimate goal of modelling: predicting future behavior in any circumstance, from any region, grown in any season while generating more knowledge about the process under study, we need to include all available fundamental knowledge that is at our disposal. The results of this kind of approach are the so-called fundamental, process oriented models. Research on the modelling effects of globalisation is, as far we are aware of, none existing. Effects of different batches, seasons (both within one year and over the years), harvest maturity and field management conditions are more abundant. When these differences are taken into account, we are basically dealing with biological variation. Lately reports were published dedicated to that subject (Hertog, 2002, 2004; Schouten et al., 2004; Tijskens et al., 2003, 2005a). Hertog (2006) will speak more dedicated to that subject.

However, the principles of this type of modelling and the existing models and quality aspects of various products do provide some information what could be achieved with dedicated research. In this paper some examples will be presented which could eventually be extended to modelling for the globalised supply chain.

Modelling Examples

1. Harvest Maturity. The effects of harvest maturity on product behavior can be manifold. In its simplest form it induced a mere shift in the biological time, without altering fundamentally the behavior of the aspect studied (Tijskens et al., 2005a). Based on a simple exponential decay (Eq. 1), the system of biological shift factors allows to standardise graphical representations (Fig. 1).

$$y = y_{0,stand} \cdot e^{-k \cdot (t+\Delta t)} \qquad \text{Eq. 1}$$

Where t is the time, y0, stand is the initial condition at some standardised time, k is the rate constant of the process, depending on temperature according to Arrhenius' law and Δt is the biological shift factor for each individual fruit or batch. This principle has been applied in practice on firmness (Lana et al., 2005) and colour (Lana et al., 2006) of fresh and cut tomatoes, the colour of growing bell peppers (Tijskens et al., 2005b) and Granny Smith apples (Tijskens et al., 2000, 2005a). This system has the additional advantage that the values of Δt (in all cases encountered up to now) are distributed according a normal distribution.

A new and exciting development is described in Tijskens at al. (2006b) indicating that the actual biological shift factor of nectarines could be measured directly by time resolved spectroscopy.

2. Seasonal Effects. On many occasions, seasonal effects have been studied, both within one year of production and over many years of production. Most of the time however, the data obtained are not suitable for developing models that include these effects. The reason is a good and solid scientific principle for experimental research: keep all circumstances as constant as possible, except for the target issue, in order to be able to draw any conclusions at all. Sometimes but very rarely, a model can be developed nonetheless.

In a study on cold induced sweetening of potatoes, Hertog et al. (1997) reported a model where the effect of maturity at harvest, over various seasons and for various cultivars, could be solely ascribed to the initial condition of a single enzyme system (Fig. 2). These findings were confirmed on an independent dataset focussing on harvest maturity in one season (Fig. 3).

Another intriguing example of seasonal variation was reported by Tijskens et al. (1997, 2004) on the activity and dynamics of methyl pectin esterase in peaches during blanching. Over two seasons, completely different with respect to weather conditions during growth, the same quite extended model could be applied with exactly the same values for the kinetic parameters, while allowing different levels of initial conditions (Fig. 4). The only exception was a rate constant for the denaturation of one of the configuration of iso-enzymes.

3. Variation within Cucumber Batches. Schouten et al., 2004 analysed colour behavior of cucumbers from two growing seasons and three cultivars. All colour data were analysed using the (calibrated) colour model (Schouten et al., 2002, Fig. 5) and the precursor at harvest was statistically (non linear regression) estimated ($prec_0$). Interestingly, batches from the same cultivar can be described with the same maximum value for the maximum precursor concentration ($prec_{max}$). The skewed prec0 distributions for the autumn batches are always on the left side and the spring batches on the right side, indicating that the precursor build up differs over the different seasons (Fig. 6). The shape of the distribution curve as dependent on the time in the season, was linked successfully to the intensity and/or quality of the light during production (Schouten, 2004). In other words: in the case of the postharvest colour behavior of cucumbers the effects of cultivar and within season (early – late season) can be separated analysing the biological variance present in the precursor distributions. The observed variation can be linked to conditions during growth.

4. Oscillations in Sweet Pepper Yield. Another example of process oriented modelling can be found in the presentation of Schepers (2006). The problem of oscillating yield was modelled based on assumed or proven mechanism at work, and extended to the complete supply chain.

CONCLUSIONS

From these examples the power of process oriented modelling becomes clear. The specific knowledge of experts and specialists, whether scientific (theory), practical (empirical) or commercial (application) can be used and is being used to develop models on product quality and behavior that span the complete range of global supply chains. It is possible to include effects of seasonal (within and between), regional and managerial variation. Provided the mechanism upon which the models are based, do reflect (more or less) the processes occurring in the produce, the parameters estimated are valid over the seasons and the regions of provenance. That really put the door wide open for modelling and optimising global supply chains. Of course, a lot of work still needs to be done to achieve that goal of modelling: predict future behavior in any circumstance, from any region, grown in any season. More research is necessary, more experiments have to be conducted, but from these few examples we can deduce the frame work for these new experiments. And they have to be quite different compared to the traditional research setups applied up till now.

More attention needs to be devoted to the study of mechanisms, to the dynamics of enzyme systems, and to the development and application of non-destructive measuring techniques.

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Figures

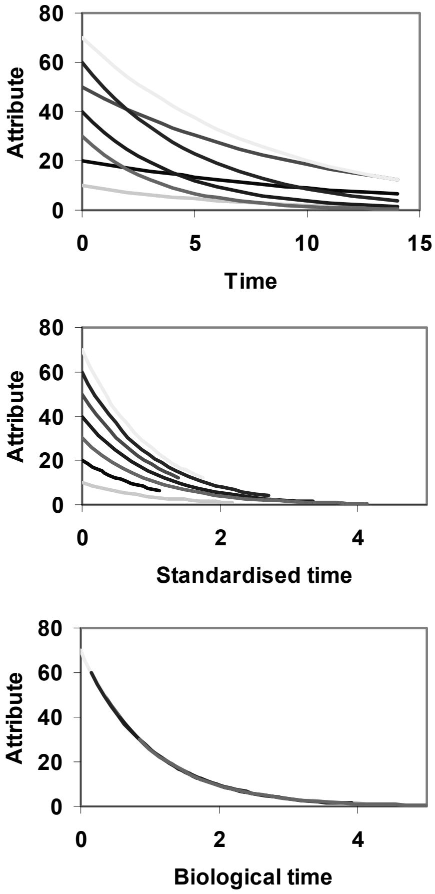

Fig. 1. Example for the system of standardised time, combined with the biological shift factor. Top: measured, middle: standardised for temperature, bottom: standardise for time and temperature.

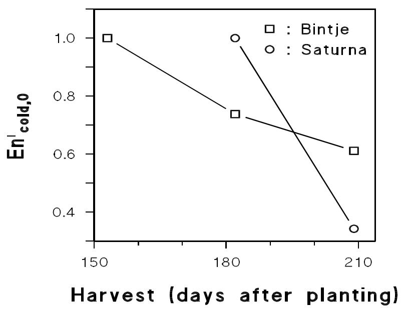

Fig. 2. Enzyme levels causing cold induced sweetening in two potatoes cultivars as a function of maturity at harvest over two and three seasons.

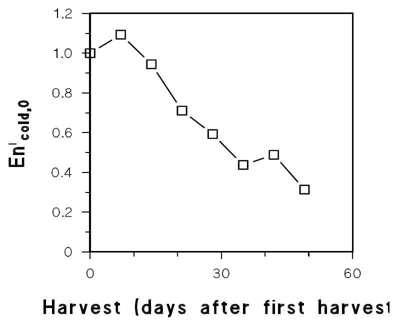

Fig. 3. Estimated enzyme levels causing sweetening in potatoes with increasing maturity at harvest. Samples were gathered at the same field in one season, reducing the variability considerably.

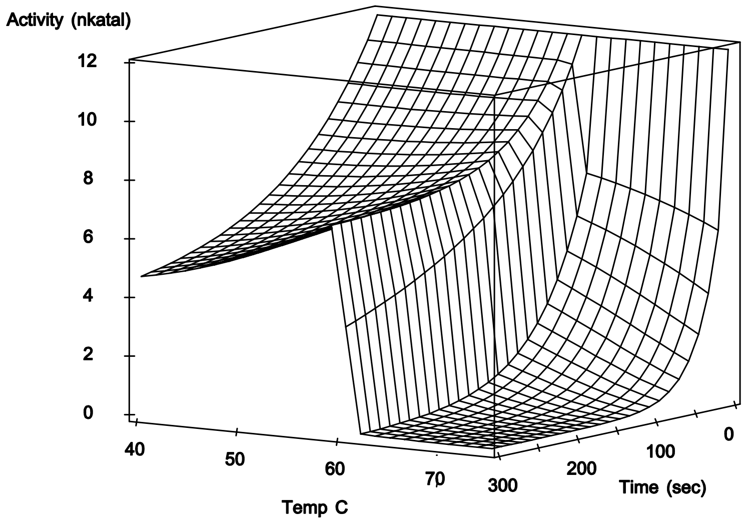

Fig. 4. Effect of blanching on the PE activity in peaches at different time-temperature combinations, in a combined analysis over two seasons (1994 & 1995). Clearly the existence of two iso-enzymes can be observed, each with separate sensitivity to heat denaturation.

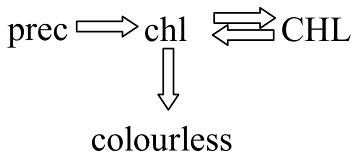

Fig. 5. Model scheme for postharvest colour behaviour during postharvest dark storage. colour = chlorophyllide (chl) + chlorophyll (CHL).

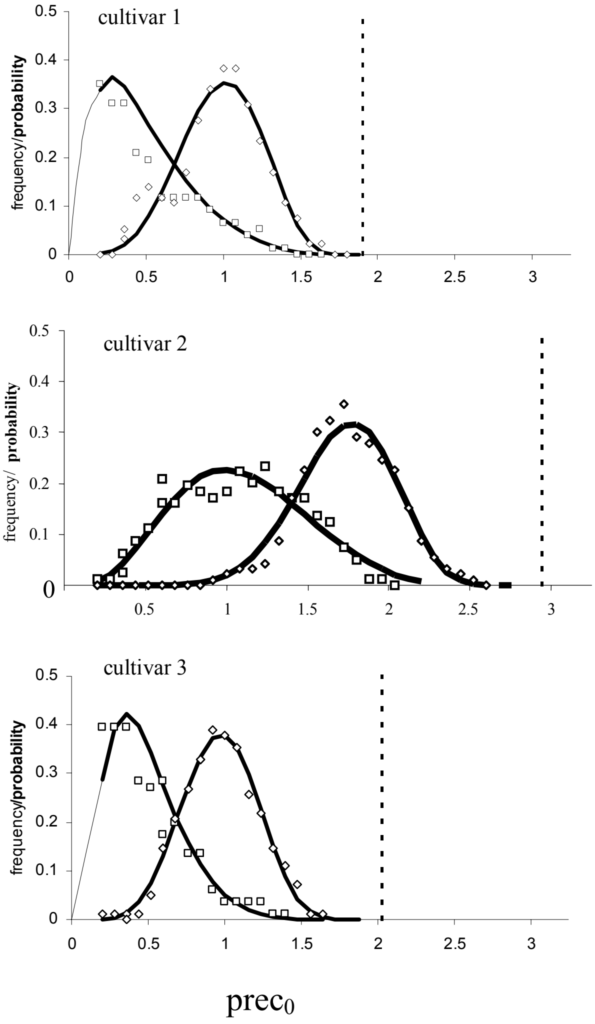

Fig. 6. Distribution of cucumber precursor concentrations at harvest for two cucumber batches per cultivar. One batch was harvested in the autumn season (□) or the spring season (◊) per cultivar. Symbols indicate the $Pchl_0$ batch distribution obtained from colour data and the lines the distribution from batch model estimations. $Pchl_{minvar}$ is indicated per cultivar by the dashed line.