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Fresh logistics; product waste versus out of stock!

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The concept 'fresh' is in the limelight. One often asks, for example, what is considered fresh and what not. 'Fresh' is a multi-faceted concept. To the retailer, fresh is a product segment, while it actually also connotes quality. In logistics, fresh has a uniform message: a fresh product is perishable. It is this that makes the work of a fresh products purchaser for a retailer so special. The purchaser has to buy products of the right quality which a) cater to market demands, and b) fit the timing necessary for distribution and marketing. Orders of fresh products for the shopfloor have to be estimated correctly because empty shelves are a no-no, on the one hand, while product waste due to decay has to be minimised, on the other. Value decrease due to quality loss can result in price reductions, or even result in products being thrown away. If product waste in a retail outlet is too low, this could signify a risk of empty shelves and an inability to offer fresh products to the consumer (nil sales). This smaller assortment will lead to drop both in turnover and customer service. If product waste is too high, one could increase the returns of the fresh segment by counter measures.

Wageningen-UR brings together its expertise in the area of fresh products and agrologistics to enable product waste in the chain to be visible. A software tool named 'Aladin' is developed to simulate, visualise and analyse the behaviour of fresh product chains. Aladin has an added indicator -- shelf life -- in addition to traditional indicators such as costs, stock levels and delivery reliability. Aladin can simulate product waste in the chain up to and including shelf activities. The effect of shelf-life prolongation, for example by a new packaging, can now be charted. In this way, Aladin is an aid in setting up fresh product chains. In addition, consumer behaviour can also be brought into the picture. It is known that the consumer buys selectively, i.e. the consumer prefers products with the longest shelf-life indications. The following example illustrates how chain simulation can be brought into the set-up and optimisation of fresh chains.

Example: A ready-to-eat mango chain

It is well-known that consumers finger certain products, like mangoes, to decide whether to buy them or not. These consumers do not only want to know how long the fruit will stay good, but also: are the mangoes ripe to be eaten now or do I have to wait; if the latter, how long do I have to wait? While these questions are justified, the retailer will not have the good answers. How can we help them to find these answers, without making the work of the purchaser even more complex?

In New Zealand, a label has been developed which indicates on the packaging how ripe the fruit is. In this way, the consumer can choose between fruit which is ripe enough to be eaten the same day or fruit which has yet to ripen in the next few days. Another solution lies within logistics. By sorting and ripening, more uniformity in ripeness of products can be obtained. In this way, a ready-to-eat concept for, eg. mangoes, can be set up. We will use this example to demonstrate the power of logistics modelling.

The chain which we will formulate -- with elements of turnover, product waste and out of stock -- comprises five links: production location, importer, distribution centre, retail outlet and consumer. We will work with a demand-responsive chain, i.e. the product flow of mangoes go from producer to consumer, while the demand for mangoes go from consumer to producer. We will simulate three situations where the selection based on ripeness of the mango increases down the chain, i.e. the consumer has less need to search for the required ripeness of the mango.

- Chain 1 charts the current traditional situation, as much as possible. The distribution logistics in the chain is based on first-in-first-out (FIFO). A consumer who wants a mango which can keep the longest will shop on the basis of last-in-first-out (LIFO), while the consumer who wants the most edible mango (ready to eat) will shop on the basis of first-expired-first-out (FEFO).
- The logistics set-up of chain 2 is on FEFO basis. This involves the importer selecting the mangoes on perishability and then supplying first those with the shortest shelflives.
- In chain 3, the concept from chain 2 is extrapolated to the retail outlet, i.e. the shelf is divided into two, with one part offering ready-to-eat mangoes and the other part offering mangoes with longer shelflives.

Before calculations can begin, two situations have to be made. On the supply side, variations in the quality of the mangoes are described (situation 1), and on the demand

side, the demand for the degree of perishability/edibility has to be documented
(situation 2)

Situation 1

At the importer, the mangoes are divided into three categories: with 50% unripe and 10 days to perishability, with 30% almost ripe and 5 days to perishability, with 20% ready-to-eat and 2 days to perishability.

Situation 2

The consumers: 20% wish to buy mangoes 10 days to perishability; 40%, 5 days to perishability; 40%, read-to-eat mangoes. The consumer in search of ready-to-eat mangoes will not buy any other mangoes if his choice is not available; if this happens, an out-of-stock scenario arises.

The model can further be fine-tuned with the addition of, eg. opening hours, chain conditions, order- and deliver-frequencies and the existence of a safe-stock at DC- and outlet-level with a minimum order quantity. Calculations for the chain are then made for a period of 52 weeks. The results are shown in tables 1 and 2.

Table 1: Product waste versus out of stock results

Chain	Purchase (#)	Sale (#)	Waste (%)	Demand (#)	Out of Stock (%)
1 Traditional	2286	2144	6.3	2804	23.6
2 FEFO	2549	2397	6.0	2804	14.5
<i>3a</i> shelf: longer shelflife	1531	1513	1.2	1687	10.3
<i>3b</i> shelf: ready to eat	1151	984	14.5	1117	12.0
3 total (<i>3a</i> + <i>3b</i>)	2682	2497	6.9	2804	10.9

Table 2: Turnover versus costs

Chain	Price mango (€)	Turnover (€)	Turnover- index ¹	Costs- factor	Costs- index ²
1 Traditional	0.85	1822	1.00	1.00	1.00
2 FEFO	0.85	2037	1.12	1.00	1.11
3a shelf: longer shelflife	0.85	1286		1.00	
3b shelf: ready to eat	1.25	1230		1.15	
3 total (3a + 3b)		2516	1.38		1.25

¹The turnover index[chain n] = sales[chain1]/(sales[chain n] x price mango[chain n])

²The cost index[chain n] = sales[chain1]/(purchase[chain n] x cost factor[chain n])

The difference between chains 1 and 2 lies primarily in the out-of-stock percentage, which is much lower in chain 2 than in chain 1. This is caused by the FEFO concept in chain 2 which now delivers more ready-to-eat mangoes than in chain 1 and in so doing, finds a better match to the consumer demand for ready-to-eat mangoes. The higher delivery reliability in chain 2 makes the turnover bigger there than in chain 1. In chain 2, the returns increase in volume compared to that in chain 1, but remains the same percentage-wise compared to chain 1. The difference between chains 2 and 3 is that the consumer has less need to search for ready-to-eat mangoes since he/she can take these out from a special assortment (chain 3b). The extra value-added can be translated in higher pricing, eg. 40 euro cents extra per mango (see Table 2: €0.85 compared to €1.25 per mango). It may be stressed that the product waste in this assortment is bigger (14.5%) since the shelf life of the product is only 2 days. The higher pricing and more reliable delivery for consumers who specifically want to buy ready-to-eat mangoes, results in a strong rise in the number of mangoes sold (chain 3 in Table 1). The costs also rise, but at a lower rate than the turnover, such that the returns in volume also increase in percentage in relation to chain 2 and chain 1 (Table 2). For the cost increase, it is presumed that a sorted, ripe, specially packed and distributed ready-to-eat mango costs a factor of 1.15 more than a mango in chains 1 or 2. The cost level is also determined by the number of mangoes which are not sold (%-waste). The following paragraph explains how this comes about.

Modelling of shelflife

Aladin can model the (remaining) shelflife of fresh products. This is being done for every link in the chain. Firstly, the chain is configured in the computer. Figure 1 shows this fictitious mango chain. The individual chain links are connected to one another. Parameters are attributed to every link, such as logistic parameters (input and output strategy, cycle-time, cost-price, etc.) and product parameters (temperature profile, initial quality).

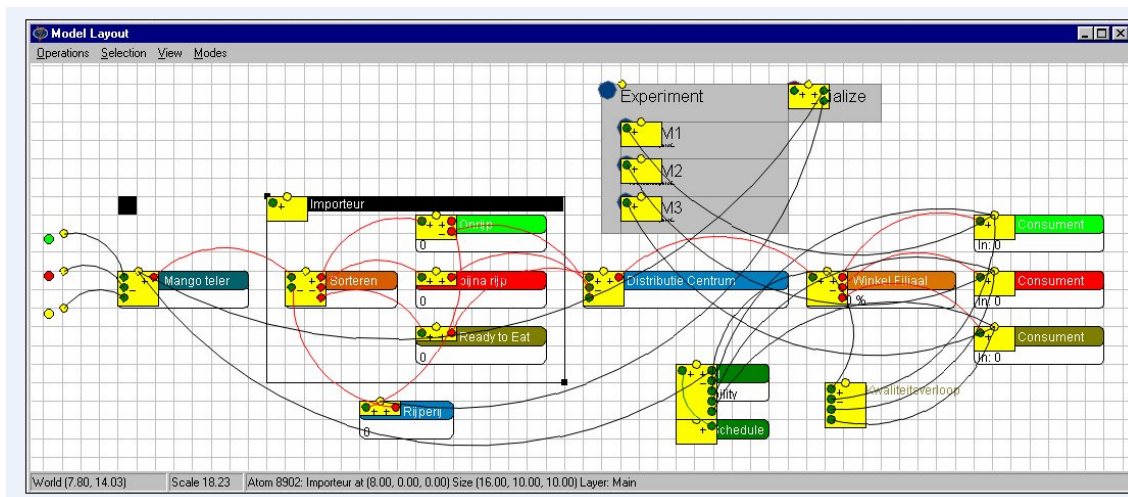


Figure 1: Configuration of the fictitious mango chain in Aladin

Based on product parameters, the shelflife for every link is continuously being calculated. For this, mathematical equations are used which describe the quality loss in time as a function of, for example, temperature. The perishability is determined by three elements: quality aspects, surrounding conditions and acceptance limit. For the mango, the most critical aspect is ripeness. The rate of ripening is dependent on the temperature. Products which are too ripe and not edible anymore are not accepted. The quality loss model is set up by measuring the speed of ripening at different temperatures. These results are plotted in Figure 2, in which the temperatures in three chain links are shown as examples, namely: a relatively high temperature during ripening in a riping house, a relatively low temperature during distribution, and a temperature between the 18 and 20 °C in the shop and at home.

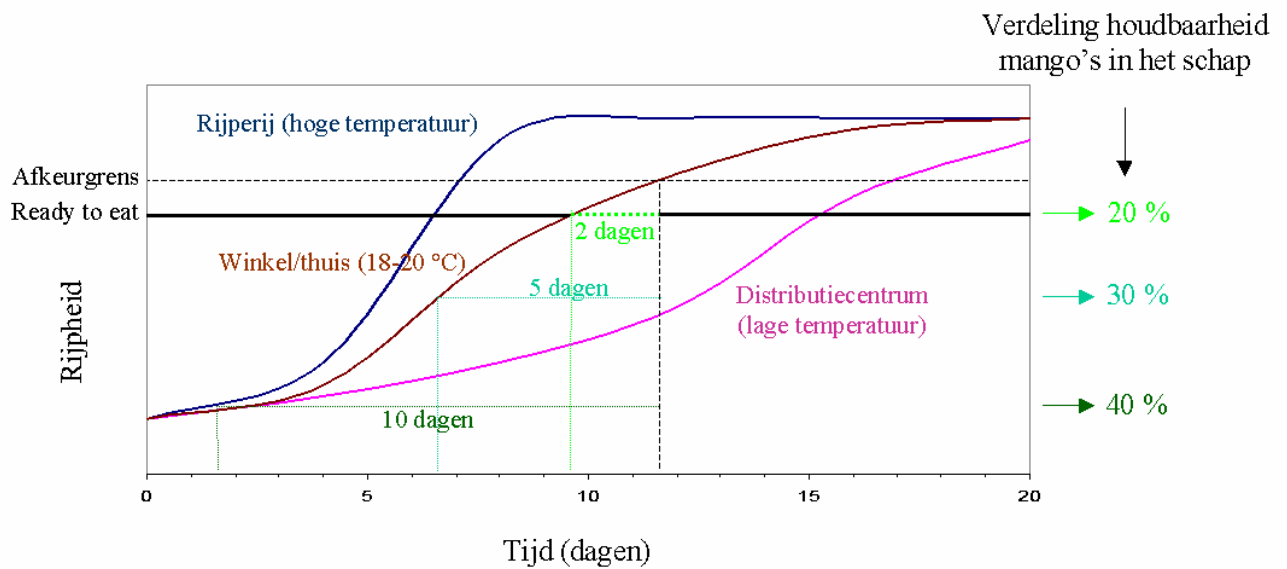


Figure 2: Speed of ripening of mangoes in three chain links. At right is the assumed percentage distribution in perishability of mangoes in the shelves.

Between the acceptance limit and the ready-to-eat moment is a shelflife of 2 days.

Figure 2 shows the assumed division of mangoes in relation to ripeness. The process of ripening can also be calculated by other than the three named temperatures in the model by making use of the temperature-dependence of the parameters of the model. In simulation, any desired temperature can be inputted for every link. The system integrates the duration of each temperature traject and sums up the quality loss. The remaining 'keepability' is then translated to 'keepability' per shelf so that a uniform display can be obtained, namely of the shelflife.

Palmtop application

Aladin is an application for specialists, but there is also a much simpler application which is very accessible and works on a Palmtop. The shelflife is determined by recording the time and the temperature of fresh products in the chain. The recording takes place with tiny sensors which also store the measurements. By using a Palmtop-computer (Figure 3), the data can be read and made product-specific. This is done by using the models mentioned above.





Shelf life over de meetperiode vergeleken met de referentie.  → Shelf life wordt berekend over de meetdagen.  → Temperatuurprofiel in de tijd over een specifieke meetdag.

Figure 3: Palmtop application based on quality-loss models which calculates the perishability of mangoes using the recorded temperature profile in the fresh chain.

Conclusion

The examples above of modelling fresh logistics processes give an insight into product waste and out-of-stock situations in existing or fictitious chains. New logistics or marketing concepts can also be charted and quantified. In so doing, the calculated ready-to-eat concept shows more product loss, but also more returns. Choices which have to be made within the chain can in this way be easily and clearly quantified along established parameters, such as delivery reliability, costs, returns, etc..

Aladin is a product of Wageningen-UR and is in a continuous state of development to facilitate this insight into the effects of specific choices made within the fresh product sector.