Quality in the Market – Technology Push versus Market Pull

Hannemieke Luyten
Wageningen University and Research Centre
Agrotechnological Research Institute (ATO)
P.O.Box 17
6700 AA Wageningen
The Netherlands

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Abstract
To meet the changing demands of consumers, food technologists have to alter the way they are working. Instead of pushing new technologies and ingredients, they have to design the processes and formulations based on input from consumer, legal and nutritious wishes. This article presents a conceptual model for the flow of information leading to new products, processes or ingredients based on consumer wishes, demands and preferences. Results for different kinds of projects are shown and discussed with respect to the model. These results show that the knowledge of technology-push based projects can be used for market-pull design. The way the research is performed and the type of knowledge gathered are important. Emphasis is on the part of the chain concerning the work of food technologists.

INTRODUCTION
The quality of a food product depends on many factors (Oude Ophuis and van Trijp, 1995; Sloof et al., 1996). It deals with the degree of excellence of the food and how this achieves the purpose of use and the expectations of the consumer (Luning et al., 2002). In first instance, quality is related to the properties of the (food) product itself. Besides this, both the user of the product as the market affects the assigned quality. Important for the latter are for example the intended use of the product, the user’s attitude and experience, and price and availability of the product.

The different features of quality are perceived by the consumer as quality attributes. One can distinguish between intrinsic and extrinsic attributes (Luning, 2002). Intrinsic attributes concern the appearance, texture, colour, shape, microbial safety, etc. of the product and can be related to the microbial, physical and chemical properties of the product. Extrinsic attributes on the other hand refer to the price, environmental aspects, the information, brand, etc.

Most research that is focussed on quality is in reality focussed on the properties or attributes that are believed to represent an aspect of the quality, and especially on the intrinsic properties. Sometimes clear descriptions of the desired properties can be made, like the maximum amount of spores or the colour. It is more difficult to define the desired texture or health quality in measurable properties. Research is performed on how to achieve, optimise or keep these objective measurable physical, chemical or microbial properties of the product during growth, harvest, processing and storage. The knowledge of food technologists or ‘common generally accepted knowledge’ in many cases establishes the criteria for the quality. But how sure are we that the desired properties defined in the way described above are really representing the quality view of the consumer?

The consumer expects tasty, healthy, safe, nutritious and high-quality food. Convenience and freshness are other emerging demands. To meet these demands and wishes, we need a thorough knowledge and understanding of the relations between these and food processing, recipe, properties etc. Starting point for food research thus is the consumer and his wishes and demands, and no longer the technological possibilities, and ingredient novelties.
This article emphasizes how research performed on food processing, texture, sensory properties or recipe development can be changed to be able to contribute to a consumer-pull oriented design of new products, processes etc. while still increasing the general knowledge on food products and technology. First we will describe a model on product and process design which originates from consumer wishes and demands. The different relations and disciplines involved will be discussed. After this, some examples of research in food science and technology and how they can contribute to product design will be discussed.

THE CONCEPTUAL MODEL

Description of the model

To meet the changing demands of consumers, food technologists have to alter the way they are working. Instead of pushing new technologies and ingredients, they have to design their processes and formulations based on input from consumer, legal and nutritious wishes. Figure 1 shows a conceptual model on the flow of information leading to new products, processes or ingredients. In this model consumers are able to describe more or less accurately the nutritional and safety demands, wishes regarding the sensory properties, raw material properties, packages, storage possibilities, distribution and new technologies. These demands, wishes and preferences have to be translated into intrinsic and extrinsic properties of the food product. This is in contrast to the usual way of working, where innovations and new products are based on new technological opportunities or new ingredients. Consumer research to describe the wishes and demands indeed exist (Luning et al., 2002), but results are rarely quantitative.

As can be seen in figure 1, (sensory) attributes are used to translate the wishes of consumers into intrinsic product properties. Consumers use descriptions like hard, creamy, thick, etc. to describe the behaviour important for eating and the liking of food. Although relations to food physical and chemical properties can be guessed, exact relations are very difficult to make, because of the complexity of both the attributes and the eating process (Lillford, 1991). Examples of terms used to describe food attributes and properties are shown in table 1. Besides the lack in knowledge on the relation between sensory attributes and intrinsic properties, the lack in quantitative information hinders the translation of consumer wishes to product properties. This relation therefore is a large bottleneck in the development and use of the model presented in figure 1. In contrast to the description possibilities of sensory attributes, it is much more difficult to obtain clear insight into consumer wishes and demands regarding other attributes, like the source of food ingredients, the way a food product is processed or grown (organic food).

The last part of the model includes the actual preparation of the food product with all the properties as demanded. This implies a choice of recipe and process. The food structure is generally regarded as an important key in understanding how certain properties can be obtained. Structure engineering is the discipline that concerns the tailor made generation of structures by processing (Hermansson, 2000; Hermansson, 2003). An exact knowledge of the relations between product properties and functionality of the ingredients is crucial. By understanding the effect of unit operations in processing, interactions among ingredients and between ingredients and processing, technologists have to be able to fulfil all new demands. An even larger knowledge of interactions and complexity is necessary when one has to meet the need for more variation in products, while reducing the amount of ingredients and unit operations at the same time. Also this knowledge is developing, but most research has been performed in the other direction than the arrows in figure 1, for instance research on the effect of a certain change in process circumstances on food product properties.

Applying the model and bottlenecks

Important aspects of the model presented in figure 1 are:

- Most scientific work, especially the work performed by food technologists, is opposite directed to the model presented.
The different relations that are important, are studied by different disciplines. Integration of the different types of knowledge, gaps between results of these different disciplines, different goals and the use of idiom are bottlenecks.

Results of different disciplines not always quantitative. Attributes as well as properties, and the relations between them have been found to be very complex. Applying only simple associations has both advantages as disadvantages. The chance of success is higher, and relations are easier to use in practise. Often you only have to concentrate on one parameter. On the other hand results are not general applicable but restricted to a single product, set of consumers, processing circumstances, year of production. Also it is not possible to enhance the general understanding of the mechanism involved.

EXAMPLES AND DISCUSSION

Structure engineering of heated vegetables

Processing affects the texture of fruits and vegetables considerably. For several products it has been found that the circumstances during blanching and pre-heating largely affect the texture of the finished product. This is of special importance for products with a high pectin concentration. Knowledge has been gathered about the role of pectin, pectin changing enzymes and the effects of process circumstances on these changes in texture. A fundamental and generic model was developed (BRAM, Blanching Response amplification Model) based on the biochemical processes involved in the textural changes of vegetable processing (Tijskens et al., 1997; Van Dijk and Tijskens, 2000). An example of a typical result is shown in Figure 2.

Nowadays, however, consumers like to be served at their wishes. The development of new products asks for a different type of information. Reversed engineering can give us that information and provide the recipe and process parameters that satisfy the wishes of consumers. An example of such a reversed model applied to carrots can be seen in figure 3. Since the model is based on a fundamental understanding of the processes involved as well as on generic biochemistry, reversing not only was possible but also provided a broad range of new and useful results (Luyten en Tijskens, 2003). With this technique of reversed engineering, it is now possible to define the properties of raw material and the processing parameters necessary to obtain the texture quality that corresponds to the demands of consumers.

Processing to improve the health of the consumer

One of the most important wishes of consumers is that food products have to be healthy. This demand is of great importance when making choices in the development of new processes for food preparation. Examples are microwave heating and more recently pulse electric field (PEF) and high pressure processing (HPP). Especially the development of the last two technologies is directed by consumer demands regarding both safety and health. The new technologies are still expensive, but acceptable when food quality would be improved (Matser, 2003).

Microwave heating does not have specific effects on food constituents (Ponne, 1996). Heating profiles can be calculated using models that included the electrical and physical properties of the food, their shape and characteristics of the process. Torringa et al. (1998) and Erle and Schubert (2001) used such models combined with generic knowledge on the breakdown of vitamin C to judge and review different possibilities for processes used for drying fruits. Combined osmotic and microwave drying gave the best results, mainly because both drying temperature as processing time could be reduced. Because these model are based on generic processes and reaction kinetics, and because the vitamin C concentration is generally accepted as a chemical indication for health, the models generated can be transformed into models that describe quantitatively the processes and circumstances that are most useful to increase the health effect of a particular food product.
Glucosinolates in *Brassica* vegetables are important constituents in the prevention of various diseases. The content, however, does not only depend on the amount in the raw food (type of food, genetic factors, and environmental factors) but also on the conditions during processing and storage. Recently Verkerk (2002) unravelled the different sub-processes and reaction involved in the breakdown of glucosinolates and constructed a model. Since this model was based on the knowledge of the mechanisms responsible for the changes in glucosinolate content, Verkerk could use it as a predictive model for consumer demands, for instance to facilitate product and process development towards an optimal healthy product, but also to refine epidemiological studies by correcting the content of functional constituents due to differences in treatment.

The demands and wishes of consumers initiated the different studies described, but the actual approach still is technology-push. Because several relations are still black-box type relations, it is difficult to mirror the results and use them to design the best process to achieve for instance a certain health effect. Only when the processes were understood, scientists could use the results for a consumer-pull model.

**Processing and product flavour**

Conventional processing of herbs has the disadvantageous consequence of loss of flavour. Since for these products smell and taste are the most important reasons for usage, retaining the flavour components contributes largely to quality assessment. Krebers et al. (2002) showed that the decrease in flavour concentration in basil is very much dependent on the type of processing used. High-pressure sterilisation can be an interesting alternative for conventional techniques like drying and freezing. The content of essential oils was preserved (see figure 4), while the microbial reduction of spores was comparable to other processing techniques. Although this knowledge is still technology-push, results can be important to increase the possibilities for designing processes according to consumer wishes.

**Relation sensory attributes and physical/chemical properties**

The eating of food involves complex processes, including deformation and mixing with saliva in the mouth, changes in food properties due to this mastication (Brown et al., 1998), but also the psychological reaction of the eating person (Hutchings and Lillford, 1988). The total effect is a sensory sensation leading to the perception of the sensory attributes involved, and ultimately to the liking or disliking of the food product. To understand these relations, the insight into the different processes involved has to be enlarged. Various studies looked at the attributes important for the appreciation and perception of certain products, only few studies are known yet that gives attention to the oral process and understanding of the relations between attributes and properties, but efforts are increasing (van Vliet, 2002). De Wijk et al. (2003) studied the perception of custard desserts, mayonnaise’s and sauces and used both sensory sciences as oral physiology and physical studies. A preliminary overview of the interactions between attributes and objectively measurable physical and chemical properties is shown in figure 5. The complexity of the interactions is very clear. Comparable studies have recently been started for the attributes crispy and crunchy (Luyten et al., 2003; Luyten et al., to be published).

**Food and quality genomics**

Attributes and properties, as well as the relations between them are often very complex. Application possibilities can be introduced much faster when only simple associations are established. In this way results may be very easy to use, but no casual relations are found. Also, the results will be only applicable to the products, attributes and circumstances used for the study. Recently this approach was followed in a preliminary study to relate genetic product properties with consumer demands. Van Wordragen et al. (2003) showed that some genetic properties could be identified that were clearly related to the sensory mealiness of apples and changes therein due to different storage conditions.
The activity of the genes gave insight into the properties of the apples at that moment, but also into the possible changes in the properties during storage. Although the results at this moment give only statistical relations, it is possible to enlarge the study to causal relations, taking the activity of defined genes as the starting point of gathering knowledge.

**CONCLUDING REMARKS**

Establishing statistical relations between some measured consumer wishes and measurable properties that can be influenced easy, gives fast applicable results. The disadvantage however is that the knowledge is not general applicable. One has to repeat the whole research when some small aspect has been changed. For example the results of the quality genomics research as presented above can not be used to model the mealiness of another type of apples. Although methods are available now and the new experiments will cost less time, they have to be repeated with the other food products.

A complete understanding of all the steps in the model presented in figure 1 can prevent a large part of these repetitions and also gain understanding of new or not yet existing products. However, this includes a complete understanding not only of texture-property relations, but also of human eating physiology and psychology. A nice goal for scientific work, but one can imagine that results will not be applicable soon. So establishing relations only, without gathering generic results still is necessary.

**ACKNOWLEDGEMENTS**

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**Literature Cited**


**Tables**

Table 1. Some examples of properties and attributes of food products.

<table>
<thead>
<tr>
<th>Physical/chemical properties</th>
<th>Sensory attributes</th>
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<tbody>
<tr>
<td>Viscosity</td>
<td>Thickness</td>
</tr>
<tr>
<td>Colour</td>
<td>Hardness</td>
</tr>
<tr>
<td>Particle size distribution</td>
<td>Taste and aroma</td>
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<tr>
<td>Concentration of aroma compounds</td>
<td>After bite</td>
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<tr>
<td>Porosity and density</td>
<td>Crispness</td>
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<tr>
<td>Fibre content</td>
<td>Creamy</td>
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<td>Water holding</td>
<td>Fatty taste</td>
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<td>Sugar content</td>
<td>Stickiness</td>
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<td>Acid content</td>
<td>Sweetness</td>
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<td></td>
<td>Sour</td>
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</table>
Fig. 1. A model showing how consumer wishes, demands and preferences guide food design.
Fig. 2: The effects of blanching time and temperature on the firmness of carrots.

Fig. 3. The collection of processing circumstances suitable to obtain a firmness of ‘4; based on the same results as Figure 2.
Fig. 4. The effects of a high-pressure treatment (PHPP) and conventional treatments on the methyl chavicol content and linalool of basil. Results are shown in % of the initial content of the fresh material, after Krebbers et al. (2002).

Fig. 5. An illustration of the complexity in the attribute-property relation for mayonnaise and custards. Based on the results of de Wijk et al. (2003). Not complete.