Parameters for apple quality and an outline for a new quality concept

Parametern für Apfelqualität und ein Entwurf eines neuen Qualitätsbegriffes

Joke Bloksma[1]

Abstract

The basis of the first 'Food, Quality and Health' project was formed by many conventional and holistic quality parameters of the same samples of Elstar apples. All these aspect of quality are collected and brought together in a preliminary overall quality concept 'vital quality'. The new concept is based on the life processes 'growth' and 'differentiation' of the growing crop. Beside both processes, it seems meaningful to add integration (both balance and amount of interaction) as a third aspect between these two processes.
The quality concept must be communicated to both the producer and the consumer, who have a different reference index. The producer, who works with growing plants, thinks in terms of life processes, which can be stimulated, reduced and balanced. While on the other hand, the consumer and retailer think in terms of controllable and recognisable product aspects. Therefore the quality concept has two sides; life processes and product aspects. Both sides are related to one another. For the life processes we speak about 'growth', 'differentiation' and 'integration' and for product properties we speak about the corresponding 'vitality', 'structure' and 'coherence'. Amongst the experimental parameters, notably the crystallisations and biophotons were of great value for the development of a new and coherent quality-concept.

Keywords

organic product quality, vital quality, growth, differentiation, integration, vitality, structure, coherence, apples, taste, firmness, brix, acid, vitamin C, phenols, minerals, amino acids, copper chloride crystallisations, bio-photons, electro-chemical, self-decomposition.

The Food, Quality and Health programme

The commonly used quality-concept, with the emphasis on external appearance and nutritional content, is not sufficient for organic products and their market. Organic growers and their consumers strive to a product with 'vitality', 'life-force', 'coherence' or terms of similar wording. These terms are expected to play a role in wholesome nourishment and to distinguish between living food products and a solution of nutrients.
The mentioned terms are interpreted very diverse, mostly based on a single test, while a quality concept with operational parameters was still lacking.
The objective of the international 'Food, Quality and Health (FQH) programme' is to develop a contextual quality concept with testing parameters that corresponds

[1] in co-operation with PJ. Jansonius, M. Northolt and M. Huber and partners from other international institutes. Louis Bolk Institute: Hoofdstraat 24, NL-3972 LA Driebergen, the Netherlands, tel. 0031-343-523860 or www.louisbolk.nl or j.bloksma@louisbolk.nl

to the needs of the organic producers. The first step to this is the development of a quality concept and parameters. This resulted in the preliminary concept of 'vital quality'. Eventually we strive to examine the effect of high vital-quality food on human health.

During this first FQH-project with apples, we studied the possibility of introducing this new concept, 'vital quality' linked to testing parameters. We stress however the orientation character of this project as the introduction of a new quality concept with experimental parameters entails the lure of circular reasoning, as validation is performed with new and experimental parameters. The new quality concept and parameters are 'preliminary' and evaluation of the consistency and usability requires several years of testing with various products. Eventually this will inspire confidence whether 'vital quality' is a meaningful and operational concept.
In this first project the concept will be developed and adjusted in a very limited context. Namely, apples from a single variety (Elstar) that were grown under different conditions (in picking time, bearing, light, shelf life), at one orchard (southwest of NL) and in one season (2000).

Quality concept 'vital quality'

We mention a number of requirements that apply to a quality concept for organic agriculture. Firstly, a relationship with the central paradigm of organic agriculture: to sustain life processes. Growth and differentiation can be considered the two basic life processes, whether or not balanced and integrated. Therefore growth, differentiation and their integration are the three aspects upon which the new quality concept is based.
Secondly, the quality concept must be communicated to both the producer and the consumer, who have a different reference index. The producer, who works with growing plants, thinks in terms of life processes, which can be stimulated, reduced and balanced. While on the other hand, the consumer and retailer think in terms of controllable and recognisable product aspects. Therefore the quality concept has two sides; life processes and product aspects. Both sides are related to one another.
Thirdly, the quality concept must relate to the holistic health view of physicians and dieticians to facilitate the initiation of health assessing research projects during the programmes second phase.
All three requirements combined, resulted in a quality concept indicated as 'vital quality', based on the life processes growth, differentiation and integration processes and the corresponding product aspects; vitality, structure and coherence, see figure.

Vitality is only one aspect of 'vital quality'
In the quality concept 'vital quality'; vitality has been defined as the result of growth processes. Thereby corresponding to the usage of vitality in the sense of growth-full, young and lively. It does not correspond however, to the usage of vitality in the sense of health related due to a harmonious balance between growth and differentiation, and strong resistance and self-regulating abilities. In the new

quality concept the latter is incorporated in the integrated or contextual aspect of vital quality.

Method

The basis of this research is formed by sets of 20 Elstar apples, specifically cultivated for this research in a bio-dynamic 'orchard ter Linde'. We attempted to grow the apples in such a way that only one of the life processes would increasingly be affected between the two extremes within each series, whereas all other factors were standardised as much as possible. The series differed in picking date, bearing, sun exposure, Bd-preparations and ageing after storage.
We chose traditional parameters that are commonly used to assay the quality of apples, and experimental parameters which we expect to be relevant for vital quality.
All the data and the link from parameters to quality concept is described in details in the basic report.

Parameters and partners in this project

- soil, growth, bearing, diseases and plagues, leaf series, next years budding (LBI).
- traditonal parameters: crop size, ground colour, blush colour, shine, firmness, starch, Brix, acid, N, P, K, Mg, Ca and dry matter (Lab. PPO and lab ZVI)
- vitamin C (LBI), phenolic compounds (TU-München, D), amino acids and protein (Kwalis Qualitätsforschung, Fulda, D).
- self-disintegration (LBI), taste (LBI), copperchloride crystallisations (LBI), capillary pictures (LBI + R. Mandera).
- two different methods with biophotons (Meluna Biophotone research, Wijk bij Duurstede NL, and Kwalis Qualitätsforschung, Fulda, D).
- electrochemical parameters: pH, redoxpotential, electrical resistance, combined in the P-value (H. Heilmann, D).
- Bovis-value (this is an intuitive observation technique, which was added for evaluation, LBI).
- quality concept development: LBI, R. van Wijk (NL), J.O. Andersen (Hertha, DK), F. Weibel (FIBL, CH), J. Strube and P. Stolz (Kwalis, D), H. Heilmann (D).
- funding: LBI, Meluna Biophotone research (NL), Kwalis Qualitätsforschung, (D), Stichting Triodos Fonds (NL), Software AG Stiftung (D), Zukunftsstiftung Landwirtschaft (D), Stichting Klaverblad (NL).

Repeats and reliability

We collected samples of 120-apples each, originating from minimal 10 different trees, and are divided in subsamples for the different laboratories. To cut back expenses in this preliminary research, we chose not to perform independent repetitions in the field. For the experimental parameters we predominantly chose for repetitions within the sample to demonstrate the variation of the method. A number of traditional parameters acted as reference and control for the homogeneity of the sample.

To a certain extent treatment series compensate the lack of independent repetitions. The strict standardisation of apple size and location of growth in the tree aided to minimise the variation within the samples. Practically all parameters showed a consequent course within the series by which means we judged, in retrospect, the uniformity of the series and the reliability of the quality measurements as satisfactory.

1. Ripening series

For comparison within one treatment series, we chose to perform the analyses on the same day. For the series with 5 different picking dates (between September the 1st and October the 9th) this means that early picking is related to a several weeks longer cold storage period. So this series actually shows the difference between ripening on the tree versus ripening in storage. As the conversion of starch into sugar and loss of firmness occur both on the tree and during cold storage. For many other aspects of ripening like colour, size, taste, biophotons, crystallisation, capillary pictures and Bovis-value, ripening on the tree is essential.
Determining all these parameters aided us to regard the process of ripening as a successive process in which continually different compounds change from a solid state into a soluble state or evaporate. For example firm fruit with starch, acid and phenolic compounds ripen into juicy fruit with soluble sugars and aromatic compounds.
The holistic methods show an increase in openness and 'facing-outwards'. The ripening process can be characterised as a transition from vitality into structure and coherence, see figure. Which is contrary to the ageing process in cold storage, during which also a loss of vitality occurs, but without an increase in structure and coherence. various parameters related to coherence have a maximum (or optimum) value at the second or fourth picking date.

2. Bearing series

In June the trees were pruned to the desired bearing level: 35, 75, 100, 125 and 140 fruit per tree. This corresponds to 14, 30, 40, 50 and 60 tons of apples per hectare. Previously, we estimated the third bearing to be optimal but due to the favourable season for apple cultivation the fourth bearing level turned out also to be optimal for satisfactory taste and flowerbud formation.
A well-known phenomenon, which we also encountered here, are the relations between a higher bearing and: decreased twig onset, lower leaf/fruit ratios and reduced flowerbud formation for the next season. The impact of high bearing on fruit quality was demonstrated by the dilution of all parameters involved with assimilation and mineral uptake: dry matter, sugar, sourness, aroma and the various minerals. However, the opposite was found for Ca. Ca levels and the Ca/K-ratio as a measure for storage potential actually increased at a higher bearing, as is also found in the field.
The copperchloride crystallisation images of apples from low bearing trees gave a powerless and vegetative impression, whereas apples from high bearing trees gave poor, sharply outlined impressions. Average bearing gave rise to the most

vital and differentiated images. The capillary pictures were sharper at a high bearing. The taste was more or less constant and only decreased at the highest bearing. The biophotone level decreased directly after excitation (a measure for vitality) and the hyperbolicallity (a measure for the differentiation/growth ratio) increased.
In conclusion, a higher bearing resulted in a decrease in vitality and an increase in structure, see figure.

3. Sun exposure series

During harvest, separate apples were picked, hanging either in full sunlight, complete shadow or in between these two extremes. We harvested two sunlight series, one with and one without Bd-preparations. The sun exposure levels of both series were comparable. Apples grown in the sun gave rise to increased colour, phenolic compound, biophotons (all three a measure for the differentiation/growth ratio), a broader colour spectrum with biophotons (a measure for fruit-typicality), higher protein/amino acid ratios, more coherence and transparency in copperchloride crystallisation images and more round, open shapes in the capillary pictures (all measures for increased integration). Surprisingly, no difference was found in taste, firmness, calcium or acidity. New for us were the much higher levels of N, P, K, amino acids and proteins in the shaden-grown fruit. This resulted in the higher Ca/K ratio for the sun-exposed fruit, which corresponds to the experience that sun-exposed fruit stores better and have less fruit rot. Seemingly, sun-exposure stimulates differentiation, resulting in an increased structure and coherence, see figure.
We did not find consistent differences between with and without Bd-preparations. First, we want to repeat this series before discussing.

4. Shelf-life series

The apples of the fourth picking date remained in cold storage for three months, and were taken out at different time intervals. This resulted in a shelf-life series of 1, 4, 8 and 12 days. As is commonly known, and found here too, firmness and acidity clearly decrease during ageing while the sugar level remains constant for some time due to remobilization. Practically all parameters indicated a limited ageing, but not as severe as we had anticipated. The series wasn't extreme enough and, in retrospect, should have contained longer shelf-lives to obtain a real image of decay. As the apples grew older the needle structure of the crystallisation images developed more and more towards the periphery.
Surprisingly, apples only one day out of cold storage were judged by a lot of parameters as being less good than apples 4 days out of cold storage. Apparently, apples need to acclimatise to altered conditions after cold storage (and/or transport) for a couple of days.

Further elaboration of the concept 'vital-quality'

Research indicates that besides the two life processes, growth and differentiation, it is meaningful to add integration as a third aspect between these two processes.

Distinguishing the two life processes, growth and differentiation, can only theoretically be done. As soon as a living organism starts growing, both processes are apparent, albeit in a certain balance. Sometimes with the emphasis on growth (vegetative life stage, luxurious, cancer growth), sometimes with the emphasis on differentiation (generative life stage, poor emergency flowering). Some of the characteristics of 'vital-quality' are described below based of apple parameters, and more general in the figure.

Vitality is the result of growth

Growth can be described as the process of the expansive filling of space with unformed mass, growth of organs, cell division and, in the case of plants, the production of primary metabolites by photosynthesis. A vital tree has a lot of green leaves and a considerable apple yield. A vital apple has a good size, is firm, crisp and juicy. The product contains a high amount of starch, sugar, acid, amino acids and proteins whereby the ratio between the two is determined by the degree of ripeness. A vital apple is still building up biomass, whereby a lot of transportable compounds are formed (amino acids, sugar). The acidity is low, the turgor is high, the amount of biophotons directly after excitation is high and the crystallisation images are filled with a dense needle structure.

Structure is the result of differentiation

Differentiation is the process of specialisation in form and function, cell differentiation, refinement of form, flavour, gloss and colour, ripening into maturity, flowerbud formation, forming pollen and seed formation. Organisation of structure is initiated and secondary metabolites are formed, e.g. the wax on the skin, phenolic compounds, vitamins and aromatic compounds. Well-structured fruit contain a lot of pits, a high calcium level and store well. The amount of biophotons decreases after excitation in a hyperbolical manner. The crystallisation images are clearly arranged, have a high degree of one-centeredness and the sharp side-needles have a large angle.

Coherence is the result of integration

The growth processes must take place on a medium level to allow the differentiation process to proceed well. Too luxurious growth will inhibit ripening to full maturity. Whereas with a trifling growth, differentiation will result in poorness, emergency flowering and 'conservation', resulting in hard, dry and small apples.
When growth and differentiation progress simultaneously and balanced, possibly in a rhythmic alternation, we refer to this as an integration process. A dynamic balance between growth and differentiation that depends on the context, like species, variety, development stage, season, soil and orchard management.
However, integration is not only about a certain balance between growth and differentiation, but also about the degree of interaction. Sufficient integration allows an apple to combine a good taste with a reasonably good storage potential. The taste is aromatic, juicy and crisp, and has a well-balanced sweet/sour ratio. The biosynthesis is completed, which is expressed in the fairly low free-amino acid,

and relatively high protein levels. Such apples are resistant to self-disintegration, stress and disease. The flesh is elastic and retains tension a while after picking. The electrical resistance is high and the redoxpotential is low. The amount of biophotons starts of on a high level after excitation, decreases hyperbolically and expresses a broad, fruit-typical colour spectrum. The crystallisations show a coherent and apple-typical image. The Bovis-value is high.

The aspect 'coherence' appears to be a relational feature

When judging vitality and structure, the observer can remain detached and objective. At this level even the crystallisation images can to a certain degree be judged by image analysis software. When judging coherence, the observer is expected to be related to, and be involved with the subject, and to express an aim as a reference for quality. The fruit grower adds his own aims. He chooses the target values in the relation between growth and differentiation by determining the balance between a high yield and a good taste.
A lot of the tests relate to coherence, depend on an active participation of the researcher, for example the sensory properties and 'empathical observations' when judging the crystallisation images. When developing these parameters, specific attention must be spent on the (inter-subjective) judgements, to allow the tests to be scientifically sound. The development of tests to determine coherence is of great importance for the new quality-concept; because the coherence aspect is the most essential aspect of 'vital-quality'.

Assessment of the usefulness of the quality-concept for fruit growers

Recognising and judging the balance is of great importance for growers to deploy cultural measurements which will restore the balance in good time. After presentation of this quality-concept, fruitgrowers were capable of pointing out the cultural measurements they could deploy to limit surplus growth or differentiation. Most fruitgrowers were however uncertain on how to actually stimulate the integration of both processes. Biodynamical growers presume Bd-preparations play a role in this event, although this has not been proven yet.

Assessment of the used parameters for the quality-concept

The traditional parameters are indispensable as they allow us to verify the series and the homogeneity, and form the link with literature. Amongst the experimental parameters, notably the crystallisations, biophotons and Bovis-value were of great value for the development of a new and coherent quality-concept. Perhaps in the future, the low cost parameters can be used routinely, albeit interpreted in respect to the entire quality-concept, like for example the sweet/sour ratio and the protein/amino acid ratio.

Literature

A literature list is to find in the basic report. To order at LBI or book store.

Bloksma, J.; M. Northolt and M. Huber, 2001: Parameters for Apple Quality and an outline for a new quality concept. Louis Bolk Institute, Driebergen. publ. no. FQH 01, 200 pages in 2 parts, ISBN 90-74021-22-0.

Parameters for quality of various crops clustered in the 'vital quality'-concept

Vital Quality

communication with the grower about PROCESSES in the growing crop	communication with consumer and retailer about PROPERTIES of the harvested product
1. Growth	**1.**
Vitality	
• forming mass • forming primary metabolites through photosynthesis • anabolic processes • hormones auxin, gibberellin, cytokinin	• green vegetative mass, size, yield • sugar, acid, starch, amino acids, protein • tension, juiciness, crispness • metabolic energy • germination power
2. Differentiation	
2. Structure	
• ripening, refining • ordering • forming secondary metabolites • hormone ethylene • catabolic processes	• differentiated refined forms • order, calcium, firm cell walls • colour, aroma, bitterness, wax, vitamins, phenolic compounds, • storable