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Bundesprogramm Ökologischer Landbau und andere Formen nachhaltiger Landwirtschaft

Analysis of the state of knowledge on quality, consumer protection and processing of organic food
- Final Report -

Wissensstandsanalyse zu Qualität, Verbraucherschutz und Verarbeitung ökologischer Lebensmittel

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FINAL REPORT

Analysis of the Current State of Knowledge of the Processing and Quality of Organic Food, and of Consumer Protection

Editors:

Alexander Beck, Johannes Kahl and Boris Liebl

BÖLN
Bundesprogramm Ökologischer Landbau und andere Formen nachhaltiger Landwirtschaft

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1 Objectives, tasks and contents of the project

About 20 years ago, politics in Germany started to support the organic food sector in Germany and it has been supported politically ever since. From these origins, the organic food sector has developed from a hardly recognized niche segment into a sustainable as well as an economically and societal relevant market as can be seen not only from organic food sales today which amounted to 5.9 bn Euros in Germany in 2010, but also from the wealth of products now offered by most food retailers and the presence of these products in the media.

However, the constantly increasing range of organic food brings with it continual new processing and quality challenges. In line with the market growth, the issue of consumer protection has also gained in significance. Correspondingly, the requirements for organic agriculture and, in particular, for downstream processing are increasing.

The objective of this project is to give an overview on the current state of research into the quality and processing of organic food and to evaluate the findings. The current state of knowledge on organic food processing and quality in Germany and internationally will be described for selected topics.

Classification of the fields for the purpose of analyzing the current state of knowledge

Field of quality:	Field of processing:
❯Sensory properties	❯Grains and grain products
❯Nutrition and health	❯Meat and meat products
❯Authenticity and traceability	❯Milk and dairy products
❯Specific organic properties	❯Fruit, vegetables and products made thereof
	❯Sustainability
	❯Packaging

The project team identified relevant knowledge gaps and/or developments by subjects and processes which will be discussed in the following based on the literature. Possible solutions will be indicated and suggestions made on how to close the knowledge gaps with further research and transfer efforts. Consumer production issues have also been considered.

The report provides reasons and arguments on how to handle and manage the subject fields of “quality” and “processing”, as examined here, in the future. Based on that, optimization strategies for the production and assessment of organic food can be compiled to support the further development of the organic food industry.

1.1 Why the division into processing and quality?

The topics “quality of organic food” and “processing of organic food” required a different approach within the scope of this analysis of current state of knowledge. Even though the topics intersected in some aspects, the scientific reference material available on organic food quality is much more comprehensive than on organic processing. Furthermore, the processing of organic food is rather application oriented. This was the reason why the fields “quality of organic food” and “processing of organic food” have been separated in this analysis of current state of knowledge and why the results are also documented separately.

2 Quality of organic food

Consumers buy organic food because they believe in better quality (Zanoli 2003, Magkos et al. 2003). They are also willing to pay a higher price for such products (Zanoli et al. 2002, Wier et al. 2002). This begs the question: Is the quality of organic products really different and higher compared to products made with other methods and can this be scientifically proven? Kahl et al. (2012) suggested a definition for the quality of organic products. For that, they relate to the IFOAM principles and the objectives from the EC Organic Regulation. National associations in Germany, e.g. Demeter and Bioland, even exceed these objectives and raise the quality requirements for the products by applying stricter rules (e.g. a ban on certain additives and/or technologies).

A study conducted by Kretschmar & Schmid (2011) shows that organically operating companies also identified quality requirements which shall offer “more value” to the consumers of organic products.

In their definition on quality, Kahl et al. (2010 and 2012) tried to structure the quality of organic food in terms of process and product related aspects and to link them to other criteria and indicators. This structured approach, applied in the execution and evaluation of scientific examinations on the quality level of organic products, is helpful in relating quantitative indicators and quality.

For this analysis of the current state of knowledge, the project team defined five criteria in the project application which are essential indicators and parameters for describing process and product related quality. The identification of these criteria is based on the expertise provided by the project partners.

The following criteria have been defined:

- Sensory properties
- Nutrition/health
- Specific organic properties
- Authenticity/traceability

Contrary to the traditional quality determination that is based on physiological (nutrients, digestibility) and psychobiological (sensory experience) factors, the immediate influence of specific organic parameters on psychobiological and physiological parameters as well as the specific organic claim for authenticity and traceability have additionally been reviewed.

Sensory properties are product related. They are the first quality criteria perceived by the consumer. In this context pleasure plays an essential role. Therefore, individual sensory properties can also be considered as indulgence indicators. The taste of a food product is an important purchasing factor for many consumers. For organic food, too, the focus is increasingly placed on sensory properties which will influence the purchasing decision. By using the knowledge about objective sensory properties, consumer expectations and preferences, and the influence of organic specifications, organic food companies will be able to optimize their products.

When assessing the nutritional value of food it is important to know which parameters are influencing the nutrition and health quality of a food product and that they should be more closely examined for that reason. Scientific approaches and political requirements can result in changes over time that may lead to a paradigm shift. For this analysis of the current state of knowledge, nutritional indicators and parameters have been chosen that were determined in the reviewed studies, independently of the question of how much they actually contribute to nutrition and health. Only such studies have been considered for this analysis in which individual substances or material groups have been analyzed, following Regulations (EC) No 178/2002 and No 1924/2006. This limiting condition may possibly result in a biased evaluation. Added to that, only comparative studies have been selected in which organic food has been compared to food from non-organic production. Furthermore, only studies published in peer review journals were taken into consideration because it can be expected that the determination methods used (including sampling and statistical evaluation) were internationally recognized (standard).

Analogously to the principles of organic agriculture, criteria for the assessment of organic food and its production are being discussed and applied by some stakeholders already. Additional quality parameters such as naturalness and integrity are also mentioned in the EC Organic Regulation and the guidelines of IFOAM and some other associations (Kahl et al. 2010 and 2012). However, their application in practice requires definitions, methods and indicators. Once elaborated, these may serve for further development of the principles for organic production. The specific organic terms have been reviewed accordingly.

Regarding the parameter “authenticity and traceability” there was some discussion among the project partners because this criterion does not necessarily describe the quality directly but can be used to find out the degree of compliance with the promised quality. The production of organic food is process oriented as is its certification. The risk of deception persists in this growing, international market. This means that the product related verification of process related certification makes sense in order to determine such risks early on or to prevent them completely. In this analysis of the current state of knowledge, authenticity and traceability are defined as a verification tool for certification. In this aspect, the period after Regulation (EC) No 178/2002 came into effect has been taken into consideration. Since then, the traceability aspect has gained specific relevance in organic agriculture. Besides the simple review of existing literature, which is also summarized in the studies by Kelly et al. (2005) and Landau et al. (2011), current projects and initiatives from the organic food industry have been examined here.

2.1 Methods

2.1.1 Sensory properties

The literature review focused on the influence of organic agriculture and processing on the quality and sensory properties of organic food and the resulting sensory differences compared to conventional food. Other parts of the literature search included the perception of the sensory properties of organic food by the consumers. In order to identify the knowledge gaps in these fields, so called “gray” literature, for example, publications by associations or on behalf of the trade which were available on the internet have also been considered next to peer reviewed publications. Moreover, specific organic online information portals, e.g. www.oekolandbau.de, have also been included in the research. The literature databases used for the scientific literature search were Organic Eprints (www.orgprints.org), Science Direct (www.sciencedirect.com), Scopus (www.scopus.com) and Google Scholar (http://scholar.google.de). Basis of the research were publications from the years 2008 to 2011. This time frame was chosen because literature on sensory properties published before 2008 was collected and evaluated within the scope of the EC project Ecropolis in the literature database at http://www.deiagra.unibo.it/ecropolis:

Maurizio Canavari et al. (2009): Summary report on sensory-related socio-economic and sensory science literature about organic food products.

The literature search was carried out for publications in the German and English languages. The following key words were used in combination with organic, sensory and/or food:

- Sensorische Qualität – sensory quality
- Geschmack – taste; Geruch – odo(u)r, smell; Textur – texture; Aussehen – appearance; Aroma – flavo(u)r
- Einfluss Richtlinien – influence regulations
- Einfluss Anbaumethode – influence production method/growing system
- Produktinformation – product information
- Konsumenten – consumers; Präferenzen – preference
- Prüfmethode – test method; Akzeptanztest – acceptance test

When publications from authors were found that fitted the topic, more publications from these authors were systematically searched for.

2.1.2 Nutrition/health

The production of organic food is stipulated in both Regulations (EC) No 834/2007 and No 889/2008 and occasionally in the standards provided by national organic associations. From all of these, a number of factors have been identified that may affect the nutritional and health quality of food. These factors include the prohibition of mineral nitrogen fertilizers, the use of synthetic pesticides and GMOs. In plant production, the varieties must be of organic origin and in animal husbandry, for example, feeding must follow certain rules. Therefore at first sight, it can be presumed that the food products produced in this way have some unique features: The amount and type of nitrogen fertilizers affect the protein and secondary metabolites levels, the ban of synthetic pesticides influences the residues, and the increased feeding of cows with green fodder has an effect on the unsaturated fat content in milk – just to name a few. Thus, for example, Brandt et al. (2001) postulated a higher amount of secondary metabolites in organically produced food of vegetable origin. Since then, this has been verified for certain substance categories but not for others (Dangour et al. 2010). Butler et al. (2011) linked an increased level of unsaturated fatty acids in milk to the production method while Molkentin & Giesemann (2007) used this finding to prove the authenticity of organic milk samples. A comprehensive survey intended to verify whether organic food contains more valuable compounds and is, in general, healthier than conventional products was provided by Dangour et al. (2009). The analysis of the current state of knowledge presented here is based on this work. Value-decreasing compounds, residues and contaminations were explicitly not included in the examinations here. The analysis is divided into four parts: Milk, meat, fruit and vegetables as well as grain. The analysis is limited to the results from quality determinations of the products as documented in the peer-reviewed articles. For the fields of milk and grain, it is only works that were published after the article by Dangour et al. (2009) that have been considered and which were therefore not included in that study. For the milk review, a meta analysis was used to evaluate peer-reviewed literature on the quantitative comparison of nutritional and health quality published over the past three years. For the evaluation of the meta analysis, Hedges' d effect size method was applied. For the literature search, the following databases were used in the period from March 2008 to April 2011: ISI Web of Knowledge (http://apps.isiknowledge.com) and Science Direct (http://www.sciencedirect.com) with the following key words: “comparison”, “conventional”, “organic”, “milk”, “dairy”, “compare”, “label”, “claims”, “farm*management”, “production*management”, “nutrition”, and “quality”. Added to that, we searched for literature published by authors known to us. For further processing, all publications had to be available in a full version in the English language and contain the comparison of at least two production methods with the organic production method clearly identified at least according to the relevant EC regulation. Also, only such studies have been considered where the comparison was made based on nutrition and health parameters (macro and micro nutrients and secondary metabolites). 994 hits in 945 citations were rejected because “of lacking relation” to the subject. After reviewing the abstracts, 20 articles have been selected, 13 of which were then included in the meta analysis. The others were not considered because they were either not available as full text, did not include nutrition relevant parameters or were insufficient in terms of statistical evaluation or presentation of data. From these 13 articles, 29 studies have been identified. The studies were conducted in different countries (the UK, Italy, Poland, the United States, Greece, Sweden, Denmark, Germany, the Netherlands and Switzerland). The meta analysis presented here has been submitted to the Journal of the Science of Food and Agriculture (JSFA) and accepted for publication.

Similar to milk, a meta analysis was used for meat to evaluate peer-reviewed literature on the quantitative comparison of the nutritional and health qualities of organic meat samples. However, there was no timeframe in terms of publication date. For the evaluation of the meta analysis, Hedges' d effect size method was applied. For the literature search, the following databases were used in the period from March 2008 to April 2011: ISI Web of Knowledge (http://apps.isiknowledge.com) and Science Direct (http://www.sciencedirect.com) with the following key words: “comparison”, “conventional”, “organic”, “meat”, “compare”, “label”, “claims”, “farm*management”, “production*management”, “nutrition”, and “quality”. Added to that, we searched for literature published by authors known to us. For further processing, all publications had to be available as a full version in the English language and contain the comparison of at least two production methods with the organic production method clearly identified at least according to the relevant EC regulation. Also, only such studies have been considered where the comparison was made based on nutrition and health parameters (macro and micro nutrients and secondary metabolites). 660 hits in 594 citations were rejected because “of lacking relation” to the subject. After reviewing the abstracts, 29 articles have been selected for the meta analysis. From these 29 articles, 30 studies have been identified. The studies were conducted in different countries (the UK, Italy, Canada, the United States, Spain, Sweden, Denmark, Germany, the Netherlands, Belgium, Switzerland, Slovenia and Turkey). 72% of these studies focused on agricultural businesses (the others on supermarkets, slaughterhouses and butcheries). Subject of the studies was meat from cattle (7 studies), pigs (11 studies), chicken (6 studies), sheep (4 studies) and rabbits (2 studies). Process and methods used are comparable with the ones used for the milk quality analysis. The meta analysis presented here shall be submitted to a peer-reviewed journal for publication.

While working on this project, a comprehensive review on the quality of fruit and vegetables was published by Brandt et al. (2011). It will be discussed here.

For the grain review, a meta analysis was used to evaluate peer-reviewed literature on the quantitative comparison of the nutritional and health qualities of organic grain samples published over the past three years. For the evaluation of the meta analysis, Hedges' d effect size method was applied. For the literature search, the following databases were used in the period from March 2008 to April 2011: ISI Web of Knowledge (http://apps.isiknowledge.com) and Science Direct (http://www.sciencedirect.com). with the following key words: "comparison", "conventional", "organic", "grain", "compare", "label", "claims", "farm*management", "production*management", "nutrition", and "quality". Added to that, we searched for literature published by authors known to us. For further processing, all publications had to be available as a full version in the English language and contain the comparison of at least two production methods with the organic production method clearly identified at least according to the relevant EC regulation. Also, only such studies have been considered where the comparison was made based on nutrition and health parameters (macro and micro nutrients and secondary metabolites). 8 articles were selected for the meta analysis. From these 8 articles, 9 studies have been identified. The studies were conducted in different countries (the UK, France, Iran, Czech Republic and Switzerland). Except for one study (comparison of companies with different production methods), all studies were field tests. The examined grains were soy, wheat, barley and buckwheat. Process and methods used are comparable with the ones used for the milk quality analysis.

Feeding studies, intervention studies and epidemiological studies on organic food were not included in this analysis because of the complexity of the subject and the lack of publications in this field. In this context we refer to the works of Dangour et al. (2009), Huber et al. (2010), Velimirov et al. (2010) and Huber et al. (2011).

2.1.3 Food quality characteristics specific for organic food

Organic agriculture is based on the principles: health, ecology, fairness and care (IFOAM 2005a). Inherent elements of organic agriculture are the use of natural cycles, the consideration of crop rotation effects, and a nutrient cycle that is as complete as is at all possible. Therefore, the definition of organic agriculture is not limited to the non-use of pesticides and synthetic fertilizers.

There are different approaches to describe the quality of organic food. They transfer the systematic approach from organic agriculture to the food products and the way they are produced. Accordingly, organic food comprises of more than merely the use of organically grown raw materials and the non-use of certain additives. However, compared to the principle of organic agriculture, the system-related terms and quality characteristics of organic food are less distinct.

Aim of this research was to collect specific organic terms used to describe the quality of organic food and to review them based on the following criteria:

- Use by organizations
- Significance in the literature
- Assessment by experts
- Presence of a definition
- Availability of an indicator/method

Based on the article by Kahl et al. (2010), the most important attributes/terms from the EC Regulation, the guidelines of IFOAM and German organic associations have been taken into consideration for the examination of the specific organic food quality. The attributes including their primary source are listed in Table 1.

Table 1 Attributes for the examination of specific organic food quality

Attribute	Primary source
Vital quality	IFOAM 2005b
Naturalness	IFOAM 2005b, EU834 2007
Organic integrity	IFOAM 2005b, EU834 2007
Careful	EU834 2007, IFOAM 2005b
True nature	EU834 2007
Integrity	Baars & Baars 2007
Animal welfare	IFOAM 2005b, EU834 2007
Holistic	IFOAM 2005b
Fairness/fair	IFOAM 2005b
Biodynamic	Demeter 2011
Organic-biological	Bioland 2011

The scientific literature was scanned for the attributes listed in Table 1. The literature found was then checked for its reference to organic food quality. The definition scope of the terms and the presence of indicators and methods have been reviewed. The references were weighted according to the publication “citation index”, if available.

For the expert interviews, between two and four experts from science and industry per criterion were queried on the phone. Based on a questionnaire, they were asked about the application in practice and whether a definition or indicators are available. The most important statements have been included in the report. Detailed results from the survey have been stored electronically.

Based on the investigations, the current state of knowledge as well as the need for further research and transfer has been evaluated. The results were summarized for each attribute from Table 1 distinguished by evaluation criteria.

2.1.4 Authenticity/traceability

Specification of the topic reviewed and the time frame regarding the subject of traceability: Focus of investigation was the traceability of organic food “across the different stages”. This aspect is of high significance in organic agriculture not only for the individual company but also for the entire industry. The period spans from the time Regulation (EC) No 178/2002 on food came into effect, which was in early 2002, to today. With this Regulation, the traceability of food and feed products across all production, processing and distribution stages became mandatory as per 01.01.2005.

With regard to authenticity, focus was placed on identifying methods that can be used to prove whether the product properties, in particular, origin or production method, as stated by the producer on the label or in advertising are conform with the actual product properties. So this is all about the verification of certain product properties or statements regarding the product and/or the production process. This may concern the question on whether the product is of organic origin or on supplemental information as to the origin of the food or statements on specific production methods (e.g. hay milk/pasture milk, maize-free feed).

In the authenticity review, the detection methods for special quality features of organic products and how they differ from the quality of conventional products were not considered.

Processes and projects which are currently under development and for which preliminary results are available have been taken into consideration here.

The literature search was carried out based on the following key words “traceability”, “authenticity”, “comparison”, “distinction”.

These key words were then sometimes combined with the search terms “organic” and “food” to limit the number of hits.

2.2 Sensory properties

Ursula Kretzschmar, Franziska Espig

2.2.1 Influence of organic agriculture on raw material quality and sensory properties of organic food

Current state of knowledge

Fruit and vegetables

Studies carried out on the sensory difference between organic and conventional fruit and vegetables, conducted with trained panels and consumers, showed a wide variety of results. While in some studies, significant differences in terms of taste, smell, texture and appearance were found (Reganold et al. 2010, Peck et al.2006, Weibel et al.2004, Weibel et al.2000), other studies did not detect any differences at all (Zhao et al.2007, Roth et al. 2006). These studies were carried out on apples, tomatoes, potatoes, carrots and strawberries. The analysis of the studies shows that it is difficult to find a test arrangement that excludes other influencing factors, e.g. the time of harvest or soil condition, when interpreting the results. Furthermore, it was shown that the cultivation method has very little impact on the sensory quality of the raw materials compared to the effect that natural climatic deviations and the wide variety therein have (Kihlberg et al. 2006). Currently, a study is underway that deals with the optimization of cultivation parameters for enhancing the sensory quality of organic potatoes.

Grains

The influence of organic growing methods on the quality of the grain is more decisive for the sensory properties of baked goods than conventional cultivation methods (Kihlberg et al.2006). Research focused on the protein content and its effect on the baking properties (Langenkämper et al. 2007).

Meat

As with fruit and vegetables, studies performed on the sensory differences between organic and conventional meat products also yielded differing results. Jahan et al. (2005) determined differences in appearance and texture of chicken meat. Moreover, in a study by Castellini et al. (2002), organic chicken meat was found to be juicier than conventional chicken meat. According to a study by Angood et al. (2008), organic lamb was also juicier and richer in taste than conventional lamb. On the other hand, Pla (2008) described in a study that organic rabbit meat is less juicy and has a firmer texture than conventional rabbit meat while the taste and juiciness of organic pork did not differ significantly from the taste and juiciness of conventional pork (Hansen et al. 2006, Olsson et al. 2003).

Milk

Different studies have analyzed the influence of different production/cultivation systems (organic versus conventional) on milk. Focus was placed on milk quality and milk components including linoleic acid and antioxidants (Butler et al. 2011a, Butler 2011, Slots et al. 2009, Pradini et al. 2009) and not on sensory properties. A detailed analysis of the milk quality is given in chapter 2.3.1. Fillion et al. (2002) looked into the sensory properties of pasteurized organic milk versus conventional milk. In this study, neither trained panelists nor consumers detected a sensory difference between the two types of milk.

2.2.2 Influence of organic food processing on quality and sensory properties of organic food

Current state of knowledge

It has only been in recent years that studies have started to compare the quality and sensory properties of processed organic food and conventional food. The products were not only tasted by a trained panel, but also by consumers. The largest sensory differences between organic and conventional products in terms of taste and appearance were found for sausages and fruit yoghurt (Buchecker et al. 2003). Trained panels also detected differences in the taste of fruit juice (Fillion et al. 2002), the texture and appearance of bread (Annett et al. 2008), and the texture of baked potatoes (Gilsenan et al. 2010). The reasons for the sensory differences and the question as to whether the differences may be related to the regulations and guidelines on organic products were not further elucidated. This question is examined in the current project Ecropolis (www.ecropolis.eu). The regulations and guidelines that potentially influence the sensory properties and authenticity of processed organic milk, meat, grain, oil, vegetable and fruit products have been assessed in a project study by Schmid (2009). Within the scope of a subsequent study of the project, the influence of regulations and guidelines, e.g. because of a limited or non-use of additives and some production methods, could be proven. In particular, the limited use of nitrite curing salt in salami, colorants and flavorings in fruit yoghurt and the limited use of processing steps in the refining and steaming of oils proved to be influencing factors.

The limited use of additives and the identification of suitable additives in organic convenience products were the subject of a study by Landsmann et al. (2009). The issue of the limited use of additives in organic foods has had little discussion in publications but has been debated in information portals for consumers and processors, e.g. on the website www.oekolandbau.de. Here, in particular, the different appearance and the taste of organic foods are being analyzed.

2.2.3 Consumers sensory quality perception of organic food

Current state of knowledge

The purchasing decision of consumers is governed by a number of internal (e.g. value, personal experience) and external (e.g. price) factors. One decisive purchasing criterion, in general, and also for organic food consumers, is the sensory quality of the products and here predominately the taste (Hjelmar 2011, Buder et al. 2010, Gilles et al. 2009, Pohjanheimo et al. 2009, Annett et al. 2008). In blind tastings, consumers found only minor or no differences between organic and conventional products (Gilsenan et al. 2010, Zhao et al. 2007). The study results differed regarding the preferences for organic or conventional products. It was either that the consumers liked both food products (organic and conventional) the same (Gilsenan et al. 2010, Zhao et al. 2007, Gieland et al. 2007) or preferred either the organic or the conventional product (Buchecker et al. 2011, Annett et al. 2008). However, even when consumers do not find sensory differences in blind tastings, they still expect that there is a sensory difference between organic and conventional products, e.g. in the size and appearance of apples or the taste and appearance of sausages. Sensory differences will then be perceived as an indicator for organic production (Stolz 2010).

2.2.4 Research and transfer needs

Related examination of the influence of regulations and guidelines on the sensory properties of raw materials and processed organic food

Current literature shows that the integration of sensory properties not only as a quality parameter in product development, but also in communication, is a key aspect for the success of the product on the market. The current published results from available studies on the sensory differences between organic and conventional food show a lot of deviation. Studies that have detected differences only provide very little information on what may have caused these difference, e.g. whether organic production guidelines may have had an impact. There is still a need for research to determine the influence of guidelines, e.g. the limited use of additives and how this influences taste, texture and the appearance of organic products, so that product development can improve its handling of the limiting specifications for organic production.

In particular, the following knowledge gaps have been identified:

- In-depth identification of the influence that guidelines have on all organic product groups
- Development of a Europe-wide monitoring system for the further development of the sensory quality of organic food
- Linking sensory research, agricultural research and consumer research in terms of, for example, the selection of varieties and cultivation methods, processing methods and consumer preferences
- Development of technological solutions for optimizing the sensory quality of organic food

Furthermore, there is a need to transfer this knowledge to producers and marketers so that they can use the sensory characteristics of organic products better in product development and communication with customers.

2.3 Nutrition and health

Johannes Kahl

2.3.1 Influence of organic production of milk on the quality compared to milk from non-organic production

Current state of knowledge

The meta analysis shows that organically produced milk is significantly higher in proteins, ALA, Omega-3 fatty acid (total), cis-9,trans-11 conjugated linoleic acid, trans-11 vaccenic acid, EPA, and DPA compared to milk from conventional production with a cumulative effect size (±95% confidence interval) of 0.56±0.24, 1.74±0.16, 0.84±0.14, 0.68±0.13, 0.51±0.16, 0.42±0.23, and 0.71±0.3. Added to that, organic milk samples show a significantly ($p<0.001$) increased Omega-3 to Omega-6 ratio (0.42 compared to 0.23 for conventional milk) and a higher Δ9-desaturase index (0.28 compared to 0.27).

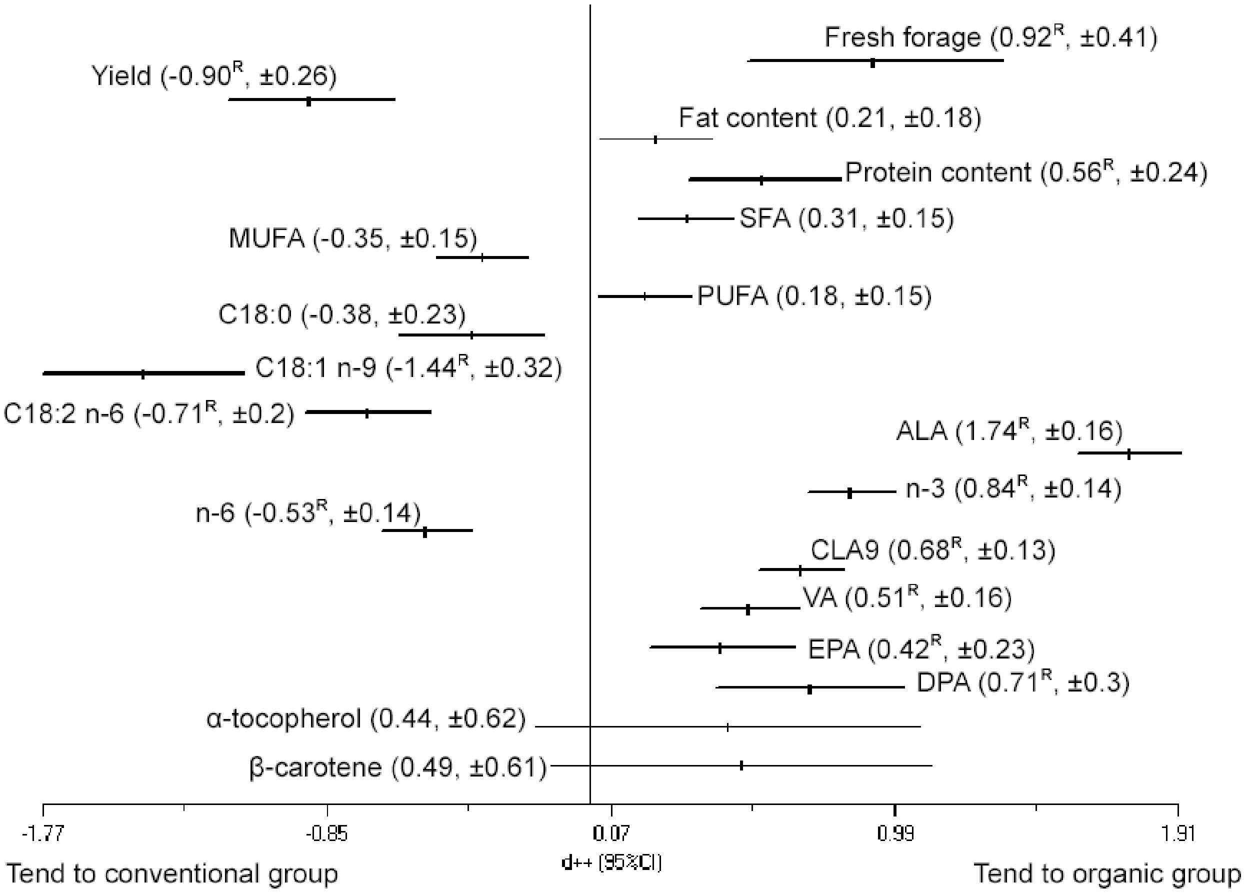

Figure 1 Forest plot of cumulative effect size (d++) and 95% confidence interval (CI) for some nutrition related parameters comparing organic milk with conventional milk (bold type indicates that the model is robust).

The analysis shows that the higher amount of valuable ingredients is due to the type of feeding. In organic husbandry, the amount of green forage is higher. Therefore, a direct relationship between controlled production and the quality of the milk produced in this way can be verified.

2.3.2 Influence of organic production of meat on the quality compared to meat from non-organic production

Current state of knowledge

The meta analysis shows that organically produced meat is significantly higher in PUFA, n-3 fatty acids, ALA and DHA compared to conventionally produced meat with a cumulative effect size (±95% confidence interval) of 0.73±0.15, 0.72±0.22, 0.81±0.28 and 0.70±0.36. Furthermore, organic meat samples are significantly ($p>0.001$) lower in MUFA (39.36 compared to 41.15) and have less fat (2.44 compared to 3.26) than meat from other production processes.

Carcass yield and muscle surface are significantly less in organic meat production while the lean to fat ratio is significantly higher compared to meat from non-organic production.

2.3.3 Influence of organic production of fruit and vegetables on the quality compared to fruit and vegetables from non-organic production

Current state of knowledge

Brandt et al. (2011) examined the nutrition and health related quality of organic fruit and vegetables. In order to do so, they conducted a meta analysis of more than 60 original publications. They investigated the influence on agricultural practice (organic versus non-organic production) on the amount of secondary metabolites. The work is not only an update but also a re-assessment of the results presented by Dangour et al. (2009). According to the results by Brandt et al. (2011), organically produced fruit and vegetables contain, in general, 12% more secondary metabolites than conventionally produced fruit and vegetables. However, this is a rather general statement as there are thousands of such substances which are very different in their content. Substances used by the plant for defense increase by up to 16% in organic agriculture while the group of carotenoides decrease by 2%. Roose et al. (2010) showed that in carrots, in particular, secondary metabolites are dependant on factors that are not controlled or are not controllable in organic agriculture. The variety has a dominating effect. Kahl et al. (2010) discussed that differences between organic and conventional agriculture can be determined but not guaranteed for the customer. Brand et al. (2011) tried to deduce the health significance of organically grown fruit and vegetables theoretically from the results of the meta analysis (modeling). They concluded that an increase in secondary metabolites may prolong human life expectancy by up to 25 days.

2.3.4 Influence of organic production of grain on the quality compared to grain from non-organic production

Current state of knowledge

The results from the meta analysis confirm the work by Dangour et al. (2009). The raw protein content is significantly lower in organic grain compared to non-organic grain (-5.879±2.847). For the secondary metabolites, no significant differences between both agricultural approaches were found in this meta analysis. Roose et al. (2009) stated that the changes in secondary metabolite content may be due to the physical changes of the individual grain kernel (volume/surface) which, at least in this trial, has been altered by the agricultural method.

2.3.5 Research and transfer needs

In terms of meat quality, different animal and varieties and, for grain, different grain varieties should be further investigated.

As both raw materials are, in general, consumed in a processed state, the factors with the largest impact within the processing chain should be further examined. Up to now, only cultivation methods have been documented and evaluated. Tests on the influence of organic processing on nutritional and health specific product properties are lacking. In this field, results on conventional processes and technologies have already been published and can be referred to.

Investigation of the influence processing has on the nutritional and health related quality of organic food that has been “carefully” processed (see EC Organic Regulation)

The scope of knowledge in practice should be further investigated. There might be a transfer need to familiarize producers and marketers with the current knowledge in order to improve the utilization of nutritional and health related properties of organic products as a control factor in cultivation, animal husbandry and processing.

2.4 Food quality parameters specific to organic food

Tabea Meischner, Nicolaas Busscher, Uwe Geier

Current state of knowledge

Vital quality

The term "Vital Quality" is mentioned in IFOAM Guideline 2005 as a control parameter in processing ("Organic food is processed by biological, mechanical and physical methods in a way that maintains the vital quality of each ingredient and the finished product"). Regulation (EC) No 834/2007 states: "Organic processed products should be produced by the use of processing methods which guarantee that the organic integrity and vital qualities of the product are maintained through all stages of the production chain". Beck (Beck et al. 2006b) and Schmid (Schmid et al. 2004) used vital quality as a means to describe "careful" processing. Added to that, this attribute has also been included in the Codex Alimentarius (Codex Alimentarius Commission 1999).

Descriptions on vital quality by Balzer-Graf (1996) can be found in the literature. The term "vital quality" is used for the "characterization of the central aspect of food vitality" which can be depicted with the help of picture forming methods. The term is derived from experiences made with plant physiology and plant analysis using picture forming methods. The concept of "vitality" was again picked up by Bloksma et al. (2007). She uses the term "inner quality" for improving the communication in scientific discourse (Northolt et al. 2004, Siderer, Maquet & Anklam 2005).

Since the term has been used in Regulation (EC) No 834/2007 and in the IFOAM Guidelines, clarification would seem to be necessary. The various uses in the literature indicate a huge need for clarification and coordination which is why the development of indicators will be rather elaborate compared to other properties specific to organic food.

Organic integrity

In the IFOAM Norms for Organic Production and Processing (IFOAM 2005b), this term is often used together with the "Organic Guarantee System" (OGS) to describe the quality of processes. In Regulation (EC) No 834/2007 this term is used for the evaluation of processing methods. Furthermore, it is contained in literature on organic agriculture in connection with harmonization of certification systems and the safeguarding of product quality in rapidly developing countries (Willer et al. 2008). The term is also used by the organic food anti-fraud initiative in Europe and the US (organic-integrity.org 2011). Furthermore, this term is also used in the psychiatry context as the "Organic Integrity Test" (Tien 1970).

In organic agriculture the property "organic integrity" has not yet been defined for products. Currently there are no indicators and methods for products available.

True nature

True nature is a term from Regulation (EC) No 834/2007; it refers to "the exclusion of substances and processing methods that might be misleading regarding the true nature of the product;" and to "substances and techniques that reconstitute properties that are lost in the processing and storage of organic feed ... or that otherwise may be misleading as to the true nature of these products and shall not be used." This property is discussed by Kretschmar, Ploeger and Schmidt (Niggli et al. 2007) using the example of reconstituted fruit juice that carries the claim "natural fruit juice". In the literature, this attribute was not mentioned any more in connection with food.

It is one of the few product-related criteria that address the definition of deceptive and/or fraudulent products through replacement.

Integrity

Integrity is a term used in Regulation (EC) No 889/2008 in connection with the effects of allopathic medicinal products "in order to guarantee the integrity of organic production". This criterion is also used in the IFOAM Guidelines. Baars et al. (2007) used this term to describe the integrity of organisms as a holistic concept. Bueren et al. (2005) discussed the term "integrity" from the ethical point of view and also with regard to the breeding of plants. In 2004, the Swiss government included the protection of the integrity of animals and plants in breeding in its funding guidelines. (Non-human biotechnology ECNH 2011). This is also discussed in the literature (Abbott 2008) with the problem of missing definitions and indicators being emphasized using the example of genetically engineered plants.

Holistic

The term "holistic" is used in Regulation (EC) No 889/2008 for the characterization of organic farming: "The holistic approach to organic farming requires..." In the IFOAM guidelines (IFOAM 2005), this approach in organic agriculture is described as follows: "Organic plant breeding is a holistic approach…" Holism is the idea that natural systems (as individual elements or as a whole) can be completely defined by their structural relationships and are not to be viewed as a combination of their individual parts. Holism is the opposite of reductionism.

This attribute is, in general, suitable for the description of approaches (holistic versus reductionism). However, no application related approaches for this attribute could be found in the literature.

Fair (fairness)

Fairness is one of IFOAM's principles that includes economical, social and ecological aspects: "Fairness is characterized by equity, respect, justice and stewardship of the shared world; both among people and in their relations to other living beings" (IFOAM 2005). In Regulation (EC) No 834/2007 this term is mentioned in combination with fair competition only. Organic associations use this term differently. Naturland and Biokreis have introduced a fair certification in addition to the organic certification and have thus defined criteria and indicators. At Bio Suisse, fairness is included in the guidelines on fair trade and social responsibility which are part of the regulations on organic certification. The guidelines of Bioland, Gäa and Biopark contain aspects on social responsibility while Demeter Germany has no rules on social aspects or fairness so far. There are some studies available on the analysis and development of fairness concepts and criteria systems for the scientific field (Schekahn et al. 2010, Schäfer, et al. 2010, Schumacher 2009). Schumacher (2009) explained that fair trade comprises distributive justice, which includes fair profit margins and pricing as well as assuming responsibility for the weaker partner, a perceived, procedural fairness with a focus on the quality and culture of trade relations, and trust. It always requires a balance between rules and principles. Other fairness criteria for

Schekahn et al. (2010) are social responsibility (enterprise and society), quality (process and product related), environmental and climate protection as well as regionality. Procedural fairness in Schekahn's concept is ensured by a code of conduct, implementation rules for members, and a mediation body in case of conflicts. Alrøe (2005) feels that the term ecological justice would be a necessary expansion of fairness and justice because it embraces all creatures and the environment.

The expert interviews also showed the strong significance of the term. Fairness has been described differently, often as being more on the social and ecological side and also including the environment and animals. A corresponding EC regulation was supported, but only in parts, because fairness and ethical values cannot be stipulated by laws. Other arguments were that terms and uniform criteria must be defined in advance. In total, this term is now being vividly discussed in science and industry; over the last few years numerous stakeholders, including private initiative, have begun to develop fairness guidelines and criteria. However, legal fundamentals, such as social minimum standards in the EC Organics Regulation, as well as a uniform measuring system are lacking.

Natural (naturalness)

In the IFOAM Guideline, the Regulation (EC) No 834/2007 and the guidelines provided by organics associations, the term "natural" is often used to describe substances and processes employed in production and processing. Regulation (EC) No 834/2007, article 3 a) states to "establish a sustainable management system for agriculture that: … iii) makes responsible use of energy and the natural resources, such as water, soil, organic matter and air". However, the term itself is not described or defined precisely. In scientific literature (Verhoog et al. 2003, 2007, Kahl et al. 2010, Padel et al. 2009, Naeem 2011) "naturalness" is often controversially discussed as an attribute/criterion for organic agriculture. Attempts at definitions have been made although some theories suggest that since "nature/natural" no longer exists as an original state of the earth, the term therefore has to be redefined for the times that we live in (Naeem 2011). For Verhoog et al. (2007), who considered naturalness to be the future ethical benchmark of organic agriculture, this principle has three aspects: the use of natural substances, the respect for and the use of self-regulating properties of living organisms and ecosystems, and the respect for the specific nature of natural creatures and units. These components are linked to three different approaches in organic agriculture: the non-use of chemicals, agricultural ecology, and integrity. Some scientists consider the concept of naturalness as a non-scientific approach because it is just an interpretation of nature limited to a certain time and culture. According to Bueren, the difference between the naturalness approach in organic agriculture and the naturalness approach in agricultural ecology is the position nature has as a partner or participant (Bueren et al. 2005). The expert interviews also showed strong diversity with regard to the term. Hence, organic agriculture and food processing does not mean nature but a natural way of living as a cultural approach – living and producing in accordance with nature. The development of a uniform definition and suitable indicators is not seen as a legislative task but rather as a necessary requirement for the organic industry to "flesh out" this term (Beck 2011). In another interview (Arbenz 2011), naturalness in organic agriculture has been associated with biodiversity, keeping the intervention into nature as small as possible and adhering to closed cycles. Gaps in the regulations and guidelines have been identified in the fields of biodiversity and climate protection.

Due to the manifold applications and discussions, amongst others in legislation, regulations and the science community, we attach high significance to the term natural/naturalness.

Animal welfare

The term “animal welfare” is often used in the IFOAM Guidelines and is also part of the definitions on organic agriculture. “Organic agriculture (...) is a whole system approach based upon a set of processes resulting in a sustainable ecosystem, safe food, good nutrition, animal welfare and social justice” (IFOAM 2005). Regulation (EC) No 834/2007 and organic associations often apply this term in connection with animal husbandry, transport, slaughter and animal protection. Numerous initiatives and projects, e.g. Welfare Quality and Econ Welfare, are concerned with improving animal welfare. Different approaches to definition and various criteria are available, e.g. provided by the Farm Animal Welfare Council (FAWC 2011), as are considerations to introducing a general animal welfare label. Apart from describing properties and measuring values, scientific literature also deals with the status quo of animal welfare in organic farming and shows possible improvements (Lund 2006, Vaarst et al. 2011, Knierim 2011, Sundrum 2011). For Vaarst et al. (2011) animal welfare in organic farming is a combination of natural living conditions and human care based on the four fundamentals of organic agriculture: ecology, health, care, and fairness. According to Knierim (2011) additional animal related parameters are needed for the assessment of animal welfare. However, their determination is more elaborate and requires more sophisticated methods. The expert interviews made it quite clear that organic animal husbandry is markedly better compared to conventional methods but still has some deficits in the animal health field. Legislation (EC Regulation) as well as the guidelines from organic associations are in parts insufficient, in particular, in terms of direct criteria for animal behavior and health. The largest deficits are in the practical implementation of already existing criteria and in the output records in the companies (Knierim 2011a, Sundrum 2011a). In summary, it can be stated that animal welfare has high relevance due to its multiple uses in guidelines, academia, and industry. Approaches for definitions and indicators are available, but there is no uniform determination for organic animal husbandry.

Biodynamic

Biodynamic agriculture is a type of farming that refers to the so-called agricultural approach by Rudolf Steiner of 1924. It is a holistic type of agriculture. The main elements are striving for an operation cycle that is as tight as possible, developing operational individuality, including natural power and cosmic rhythms, and acknowledging the high value of ruminants, in particular, the cow. The term biodynamic describes the type of farming and the quality of the products arising from this. The term is defined by process criteria and legally protected within the scope of the international and national Demeter Guidelines (Demeter 2011). In France, the Biodyvin organization certifies wineries which also work based on biodynamic farming; its guideline differs slightly from the Demeter one. In science, the term is used and described in different studies (Turinek et al. 2009, Baars et al. 2003, Joly 2007, Bloksma et al. 2004). Baars et al. (2003) describes biodynamic agriculture as a practical result of the anthroposophical focus of the world in which spirituality is an essential element. According to Bloksma et al. (2004), biodynamic apple quality is characterized by improved interaction between growth and differentiation because of the preparations used for treatment. Furthermore, the experts in the interviews also said that the specific value of a biodynamic approach is the integration of vital forces and cosmic influences that lie beyond material matters. Food processing aims at maintaining and/or enhancing the vitality of the raw materials which are also beneficial for human nutrition. This also includes the refining of raw materials with processing methods that improve quality. The interviews showed that the guidelines and criteria for controlling biodynamic processes are considered to be sufficient. However, gaps and possible improvements were mentioned for animal welfare or a more intense integration of holistic examination methods (Baars 2011, Leopold 2011).

This quality criterion is applied in science and industry. The production and processing of biodynamic food is sufficiently described via process criteria and has also been the subject of numerous studies. Product related criteria for food are still missing.

Organic-biological

Organic-biological farming is a special form of organic agriculture that is based on the considerations of Müller and Rusch. It emphasizes the specific significance of humus for soil fertility (Paulsen et al. 2009). This pioneering approach has essentially shaped organic agriculture. Organic-biological is only used today as a quality criterion by the organic associations Bioland and ORBI (Austria). This term/method is rarely mentioned in the scientific community any more except in different publications on the theory of soil fertility and recycling economy (Rusch 2004). It is only Paulsen et al. (2009) who takes on Rusch's theories on soil fertility and humus in a critical analysis. According to Bioland (2011) and as also stated in the expert interviews, the term organic-biological is a holistic synthesis of the principles of climate protection, maintenance of biodiversity and soil fertility, recycling economy, animal welfare, protection of resources, healthy and vital food as well as existential measures to ensure a livelihood for the family enterprises. The adherence to these principles is governed by process criteria contained in the association's guideline. However, direct and product-related indicators and measures for the parameter "organic-biological" are missing. The indicator system is currently under discussion.

Care, careful

Care is one of the four IFOSM principles of organic agriculture which shall be "managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment" (IFOAM 2005a). Regulation (EC) No 834/2007 (Article 6d, 7d) mentions the term "care" for the processing of food and feed without further definition. In the guidelines of some organic associations, the term "gentle/careful handling" is often used. Even the guidelines of the Codex Alimentarius on the processing of organic food indicate careful processing methods (Codex Alimentarius 2004, Codex Alimentarius Commission 1999). According to the assessment by Kahl et al. (2010) regarding the term "care", Regulation (EC) No 834/2007 contains no further limitations or an evaluation of processing technologies except for the general ban on GMOs, irradiation treatment and various additives. Furthermore, a standardized method for the evaluation of "careful or gentle" processing methods is needed. Padel et al. (2009) subdivides "care", as a fundamental ethical principle of IFOAM, in the fields of implied/practical knowledge, exclusion of GMO, responsibility, future generations, precautionary measures and prevention. According to Nielsen (in Schmid, Beck and Kretzschmar 2004), the term "care" refers to the food product, to people and the environment. For Kretzschmar et al. (2006) an improved and detailed definition of the production methods (practical guideline) would be more helpful for processors and consumers than a final definition of the term "careful processing". The experts predominantly agreed on that point in the interviews. Apart from the missing definition, the lack of a clear translation into German was also mentioned. The translation of care as "schonend" is considered to be unsuitable for some food groups. The responsibility for closing these gaps is not the task of the legislator because filling the term with life and integrating it into practice is considered to rather be an implementation issue.

In conclusion, the term care/careful (German: Sorgfalt/sorgfältig) is a highly relevant and widely used term.

Research and transfer needs

Table 2 Overview on the research need for the different criteria

Criterion/ attribute	Use by organizations	Significance (literature)	Significance (experts)	Definition available	Indicator/ method available	Research topic	Transfer needs
Vital quality	o	o	o	-	-	o	o
Naturalness	++	+	o	o	-	+	+
Organic integrity	+	+	+	-	-	++	o
Careful	++	+	o	o	--	++	+
True nature	o	-	o	--	--	+	-
Integrity	-	o	o	-	--	+	-
Animal welfare	++	++	+	+	o	-	+
Holistic	+	+	o	o	-	-	-
Fairness/fair	+	++	+	+	o	-	+
Biodynamic	-	o	o	o	o	-	-
Organic biological	--	--	-	o	o	--	--

(Rating ++ = very high, + = high, o = medium, - = low, - - = very low)

Based on the use by organizations, the discussion in the literature, and the expert evaluations, it is in our opinion that the criteria of organic integrity, naturalness and care have high application potential for the assessment of organic food (see table). Nevertheless, there are no uniform definitions and indicators available for these characteristics. This is why we see a large need for research and in parts a large transfer need for these attributes. Furthermore, these criteria are closely related to products and processing (see Figure 2). A similar assessment is given for the criteria of true nature and integrity. The criterion vital quality is assessed as having a slightly lower significance.

We determined a low to very low research need for the parameters fairness, animal welfare, holistic, biodynamic and organic-biological. In particular, the attributes holistic, biodynamic and organic-biological are superordinate principles that are rather unspecific in terms of processing, products and agricultural production (see Figure 2).

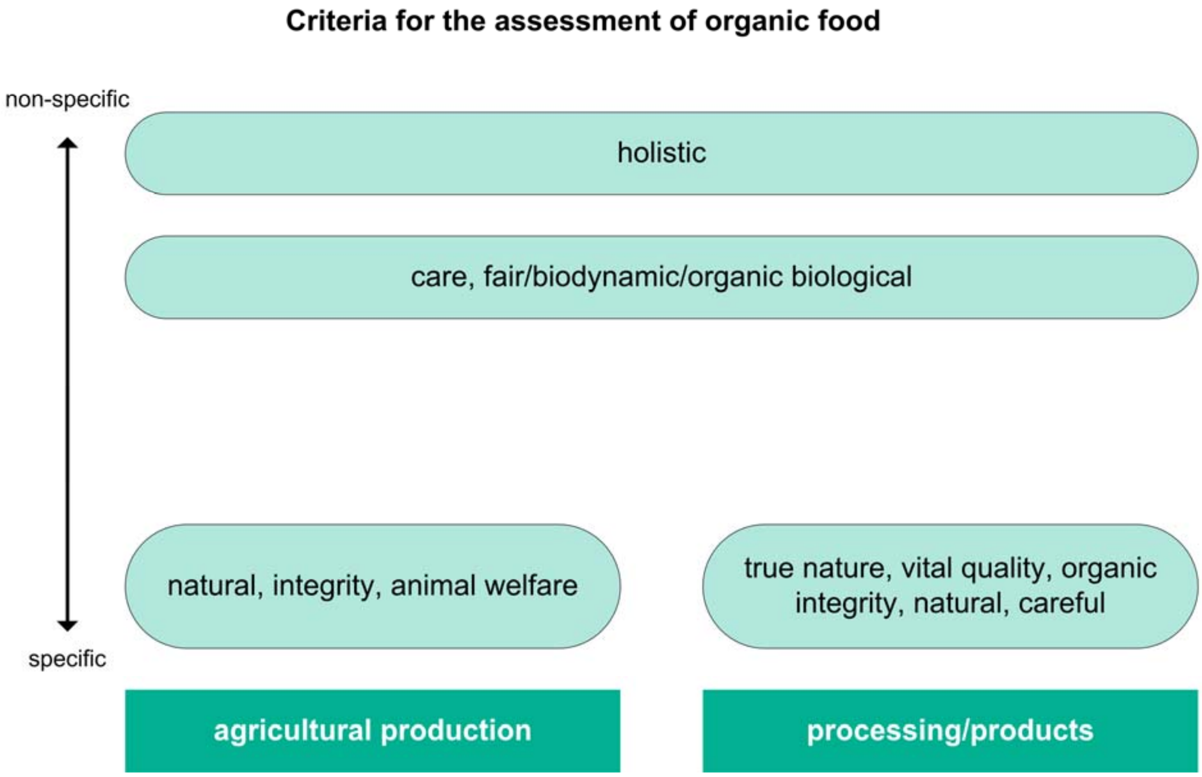

Figure 2 Criteria and their closeness to organic production/products

Conceptual substantiation and development of indicators and parameters for the attributes “organic integrity”, “careful”, “true nature”, “naturalness” and “integrity” with a focus on their possible use as quality criteria for controlling organic agriculture and processing.

2.5 Authenticity/traceability

Rolf Mäder

2.5.1 Authenticity

Current state of knowledge

Research and Development

The study on “Methods for the differentiation between organically and conventionally produced food” by Landauer et al. (2011) is a good methodology survey. Most methods mentioned in the report are based on the assumption that the agricultural practices has an effect on the material composition of the products (e.g. stabile isotopes, fatty acid composition in animal products, protein composition or content of valuable compounds such as vitamins in vegetable products). Other methods try to differentiate the products based on the presence of residues of substances forbidden in organic agriculture (e.g. pesticides or medicinal products). Other approaches follow so called holistic methods (e.g. fluorescent analysis or biocrystallization and capillary dynamolysis). Comprehensive literature is available on the verification of origin via analysis. Stable isotopes are of high significance in this respect. A good survey has been presented by Kelly et al. (2005) “Tracing the geographical origin of food: The application of multi-element and multi-isotope analysis”.

Activities within the EC are currently researched within the scope of the actual CORE-Organic II project "AuthenticFood".

Practical relevance

Most methods are hardly relevant for practice when it comes to stating whether the products have been produced organically or conventionally.

The most advanced method in this field is the isotope analysis. This method is used for the determination of the ratio of different isotopes of elements. This ratio is influenced e.g. by the growing area, the type and intensity of nitrogen fertilization, the isotope composition of feed, or the isotope composition of the water absorbed by animal or plant. However, even the isotope analysis is not able to verify unambiguously the claim organic or conventional because such a statement is based on the fact that the types of agricultural methods (organic/conventional) definitely differ in one factor.

When applying stable isotope analysis as a means of differentiation between organically and conventionally produced milk, it is presumed that in conventional agriculture the cows are fed with maize while in organic production they are not.

In crop farming the method is based on the assumption that nitrogen in conventional agriculture stems from synthetically bound nitrogen from air while in organic production it is exclusively from organic sources. However, organically produced legumes show isotope ratios similar to the ones found in conventional products. This is due to the fact that the legumes’ rhizobia also bind nitrogen from the atmosphere and make it available to the plant. The application of organic fertilizers in conventional production can also not be excluded.

However, significant results can be obtained when the methods are applied to issues that have been adapted and for which a direct causal relationship between the test result and the factor that influences the result exists. For example, isotope analysis can be used to find out whether certain ingredients are of natural or synthetic origin (e.g. vanilla in ice cream or foreign carbon dioxide in sparkling wine). Furthermore, the method is suitable for the verification of the statement as to whether a product was produced in a certain region or in a certain establishment or whether the feed contained maize.

Initiatives

Various initiatives use analysis methods to verify certain product claims. The initiatives relevant for the organic sector are introduced here in brief:

- Watermark
  Within the scope of the project of FiBL Deutschland e. V. "Watermark", the regional origin of products shall be verified using isotope analysis. Prerequisite is the set-up of an isotope reference database. Depending on the database, it is possible to verify whether the product comes from a certain country, a certain region or even a certain establishment. Such verification would not only supplement existing quality assurance systems of organic food producers, but also support organic control and certification bodies.
- KAT database (of the German association of controlled alternative types of animal husbandry)
  Since 2008, there has been a database available for eggs to trace the origin of eggs. This database is not only composed of control data from audits but also of analysis data (stable isotopes).
- Stable isotope labelling
  A large producer of organic eggs actively labels feed with stable isotopes for verification of the authenticity of the products. A carrier (e.g. clay mineral) that has been treated with water with a precisely defined isotope composition is added to the feed. This allows verification via isotope analysis as to whether the eggs or the poultry meat comes from companies that use this type of feed.
- DNA database for bovine animals
  EDEKA Nord, together with the organic associations, uses a DNA database to verify the authenticity of beef. The DNA patterns of the slaughtered animals are stored in the database which can then be used to verify the origin of the individual animal.

2.5.2 Traceability

Current state of knowledge

General information

With Regulation (EC) No 178/2002 on food, which became effective early 2002, the traceability issue also came to the fore for the organic sector. Added to that, in 2004, Regulation (EC) No 1935/2004 became effective which stipulated that traceability has to be provided for "materials and articles intended to come into contact with food".

The legal regulations, which should ensure the traceability of food, contain only general principles and hardly any details. For example, Regulation (EC) No 178/2002 stipulates that food businesses must be able to state where the products came from and to whom they sold them. The EU legislation on organic agriculture stipulates: “Traceability through all stages of production, preparation and distribution is an important factor for all products carrying the EU organic logo.” Furthermore, the German regulation on the labeling of batches (Loskenn-zeichnungsverordnung) governs that any food produced processed or packed under similar conditions must be labeled with a combination of digits and/or letters.

For some product areas, legislation stipulates in detail that the traceability must be ensured. Since 2000, the requirements for the labeling and traceability of bovine animals, beef and beef products laid down in Regulation (EC) No 1760/2000 have to be applied. It should allow the traceability along the entire supply chain starting with the individual animal or a group of animals. This regulation has been implemented in Germany as the Beef Labeling Act of 26 February 1998 and in the HIT data base (Sourcing and information system for animals).

For the marketing of eggs, Regulation (EC) No 589/2008 in combination with Regulation (EC) No 1234/2007 stipulates the continuous coding of eggs from the production site through the sale to the final consumer. The product code provides information as to which production site the egg has come from.

Private standards also contain traceability requirements. However, they are usually as general as the legal regulations. One exception to this is the GMP+ Standard of the Dutch Product Board Animal Feed (PDV). It contains detailed requirements for the traceability of feed for all sectors from purchasing and batch handling through to storage and management.

Research and Development

Within the scope of the project entitled “Development of a quality assurance system for the ecological food sector with special consideration of communicational and organizational structures” of the BÖLW (FKZ 02OE645) that ended in 2004, a working group on traceability was established. The most important results from this working group were the “recommendations for action for the implementation of measures for traceability and proof of origin in the organic food sector”. These recommendations do not contain any binding requirements for the industry in terms of traceability documentation, but they provide ample guidance for the reasonable design of reliable traceability systems.

Based on this project, FiBL Germany conducted the project “Development of a uniform database for a traceability system – analysis of the status quo and establishing of a joint platform" (FKZ 03OE457). The data standard organicXML was developed within the scope of this project. It allows for the exchange of data between different databases used in the companies. Contrary to other available data exchange standards such as UN/EDIFACT subset EANCOM® (exchange standard for non-organic food areas) or agroXML (agricultural operations documentation), organicXML contains additional information that is specific to organic companies, e.g. “responsible control body”, “organic status of the product”, etc. The integration of organicXML into existing systems simplifies the coordination with the bodies responsible for standards such as GS1 Germany (EANCOM®) or KTBL (agroXML). This standard is currently used by the initiative “Bio mit Gesicht” and in the certification database bioC.info.

The so called BNN4 interface was developed for the improved exchange of data between producers, wholesalers and retailers from the organic sector. The interface enables the companies to exchange article master data in CSV format. In addition to that, the data standard BNNXML-1 was developed in 2005. It should allow a more flexible exchange of data and give the companies that already use EDIFACT as an exchange format the chance to operate the

BNN interface. However, the new XML data standard has not been able to establish itself as yet and no BBN interface has been connected to a traceability system so far.

Initiatives

Within the scope of several projects in different countries, industrial solutions for individual organic product groups should be established. These projects were aimed at the technical implementation of a traceability system along the entire supply chain in order to allow a quick and efficient reaction in the case of complaints or a crisis. Added to that, such industrial solutions also provide for quantity verification so long as the business partners document the traded quantities in the system. The most advanced in this respect was the Agentur für Bio-Getreide (agency for organic grain) which used the biostockmanager system to monitor the majority part of organic grain trading in Austria. After the Agentur filed for bankruptcy in spring 2010, the system was taken over by Bio Getreide Austria GmbH, a subsidiary of Raiffeisen Waren Austria. In France, SETRABIO-France, the industrial association for processors and traders of organic grain, has used the system Tracerbio. In this database the entire trade of grain and grain products including imports within France could have been documented. However, this initiative failed due to a lack of willingness from the stakeholders to finance the system.

Various other initiatives are pursuing another approach. They use the traceability information not primarily or exclusively for quality assurance but rather for consumer communication purposes. Individual solutions (e.g. Zurück zum Ursprung – Hofer Austria and Nature and More – EOSTA Netherlands) as well as industry-wide solutions (e.g. Bio mit Gesicht or Follow Fish) have been developed that offer the consumer the opportunity of tracing a product back to the respective producing company. Depending on the initiative, the aspect of consumer communication is considered more or less relevant apart from quality assurance.

Activities within the EC are currently researched within the scope of the actual CORE-Organic II project "AuthenticFood".

2.5.3 Research and transfer needs

Traceability

Data standards and technical systems are available that can be used as tools for a technical traceability system along the entire supply chain. Nevertheless, it has not yet been possible to establish an overall solution for individual product groups in Germany. The reasons for this are the rather heterogeneous data collection systems as well as the heterogeneous standards for organic products. Under these circumstances, implementation is associated with a comprehensive coordination effort that cannot be financed by the initiators of such an industrial solution alone. Start-up financing of a project aimed at the set-up and establishment of such an industrial solution would be helpful. Apart from the mere traceability aspect, the verification of data by the control bodies should also be considered in this context. Such a system would significantly support fraud prevention and crisis management in the organic food sector. Grain products would be an appropriate sector for such a pilot project because these products have already been the target of deceptive practices and have experienced many crisis situations in the past that cannot be excluded for the future.

Authenticity

The need for research/development and transfer in this field is in the following areas:

Identification of indicators and parameters that allow the verification of communicated product properties.

Identification and further development of methods for the verification of issues or communicated product properties and respective parameters.

3 Organic Food Processing

Alexander Beck

In its guidelines, the International Federation of Organic Agriculture Movements (IFOAM) defines principles for all areas of the organic food trade. IFOAM's position is guided by the following principles:

- The Principle of Health
- The Principle of Ecology
- The Principle of Fairness
- The Principle of Care

(IFOAM 2010a)

Based on this position, the IFOAM Basic Guidelines define separate principles for organic processing as follows:

"Organic processing and handling provides consumers with nutritious, high quality supplies of organic products and organic farmers with a market without compromise to the organic integrity of their products."

"Organic food is processed by biological, mechanical and physical methods in a way that maintains the vital quality of each ingredient and the finished product." (IFOAM 2010b)

The EC Organic Regulation (EC) No 834/2007 states the following aim (Article 3):

"Producing a wide variety of foods and other agricultural products that respond to consumers' demand for goods produced by the use of processes that do not harm the environment, human health, plant health or animal health and welfare."

These principles are consolidated further in the quality strategies of companies or the guidelines of associations. For example, Bioland e. V. states:

"Processors of BIOLAND products continue the efforts of organic agriculture to maintain the natural living conditions for plants, animals and human beings on a long-term basis. BIOLAND products produced in accordance with these standards are characterized by their high quality in taste and their high values in health, ecology and culture. The processing standards, in the sense of high nutrition, are designed to ensure a wholesome (Vollwert), nutritional, physiological and ecological quality standard of the final products while taking social tolerance of trade and processing steps into consideration. A further objective of these standards is the creation of the greatest possible degree of transparency, in particular for the consumer." (Bioland 2010)

Employing the Delphi method, Kretzschmar et al. (2006) surveyed 250 experts from 13 European countries on the topic of organic processing. In addition to others, the study addressed the question of defining relevant core terms for the processing of organic foods. For example, initial suggestions for a definition of "careful processing" and "authenticity" were developed.

All of these guidelines address the topic of organic processing from different points of view. Process-oriented approaches typically contain guidelines for the production process. Current regulations state that raw materials must be organic, that additives are to be used only to a limited extent, and that organic production has to be segregated from non-organic production. Furthermore, issues such as environmentally conscious business management or properties such as “wholesomeness” and “transparency” of the final products are addressed. This is true in particular of private standards.

In the field of “organic processing,” no specific evaluations of consumer surveys regarding consumer expectations with respect to organic foods have been conducted. However, factors relevant for the processing aspect may be inferred from general consumer surveys regarding organic foods. The most important of these factors are: Non-use of additives, traditional processing methods, trustworthy producers, improved taste, better health value, environmentally friendly processes, and animal welfare. (Meier-Ploeger 2004).

These diverse principles of organic processing may be derived from four historical and factual fundamentals:

“Natural concept of nutrition”

In the context of the “life reform” movement, the issue of “appropriate food processing” was pondered as early as around 1900 (Kritzmöller 2010). Following a theme of “back to nature,” people were concerned with issues such as agriculture, healthy and natural nutrition, and appropriate processing methods. Even back then there were many different efforts made at developing processing concepts that were near-natural or appropriate for humans (Koepf 2001).

These efforts were mainly driven by the requirements for natural diets and, therefore, for processing practices that may be summarized as follows: “Let our food be as natural as possible” (Kollath 1942). In those times, the question of nutrition was regarded as a significant aspect of reestablishing harmony between humans and nature in the sense of the Romantic Movement (Koepf 2001). At the same time, the issue of the relationship between humankind and higher animals was addressed, leading to vegetarianism becoming yet another driving force behind a reorientation in the food sector (Vogt 2001). Over the past decades, this topic has been realized mainly in the form of “wholesome” nutrition (Meier Ploeger 2004).

“Environmentally conscious business management”

In the 1970s and 1980s, inspired by the environmental movement, an entirely new focus was put on environmental issues at the business management level as well. These efforts bore fruit in the shape of novel, environmentally conscious concepts of management that eventually were also publically regulated (Council Regulation (EEC) 1836/1993 and Regulation (EC) No 1221/2009) and were introduced, in particular, in a number of businesses producing organic foods. These businesses operate on the premise that processing organic food is only meaningful when done by companies that have been environmentally optimized. Today, this approach is developed further in the concepts of chain-wide environmental statements such as that of a CO_2 footprint (Deinert et al. 2010) or other product-oriented environmental assessments.

“Intermediate technology”

Another fundamental approach, often overlooked today, is that of “intermediate technology." This dates back to Schuhmacher (1973) and describes a strategy that combines technological, socio-economic, cultural and ecologic aspects into an overarching concept. Its cornerstones are:

- Decentralization
- Sophisticated, user-friendly technology
- Consistent environmentally conscious approach
- Social support (AGAT 1982)

The approaches developed by Schuhmacher influenced the organic sector immensely, in particular processing and trade structures. Concepts such as CSA or regional markets, but also the new establishment of farm and other small cheese dairies have their theoretical roots in “appropriate technology.”

“Careful/minimal processing”

The food industry has intensively worked on concepts of "minimal” and “careful” processing over the past decades (Nielsen 2004). For organic foods, the term “careful processing” has become of particular importance. It shares many similarities with the basic requirements of a "wholesome" diet. “Careful processing” is a “value” that forms a concept in organic processing. It is to be achieved in particular by the limited use of additives and the avoidance of certain processing methods. In the new Organic Regulation (EC) No 834/2007 in Article 19 (3), the legislature for the first time put into writing requirements for processing techniques: “Substances and techniques that reconstitute properties that are lost in the processing and storage of organic food, that correct the results of negligence in the processing of these products or that otherwise may be misleading as to the true nature of these products shall not be used.”

Knowledge gap “organic processing”

One general knowledge gap was already identified during the preparation phase of this project: The requirement profile for “organic processing” is very vague. Different concepts like those listed above are in competition with each other in some cases. A conclusive theory has not yet been developed. Although certain elements such as “organic raw materials”, “limited use of additives,” and “integrity of organic foods” have already been defined in relevant legislation, significant known requirements of consumers and industry players such as "environmentally appropriate,” "careful traditional processing," “rationality,” and “healthy foods” are not taken into account.

Due to the lack of specialized literature and the practical nature of the project, the topic of “organic product processing" for the purpose of this analysis of the current state of knowledge was addressed based on urgent practical questions that were identified and limited in interviews and discussions with experts. The questions identified formed the basis for specific literature searches and information gathering. The above stated theoretical approaches of “natural concept of nutrition”, environmentally conscious management, intermediate technology, and careful/minimal processing” formed the background for all our considerations. This report focuses on the processing technologies for the product sectors fruit and vegetables, dairy, grains, and meat and the cross-sectional topics of packaging and “sustainable enterprise.”

3.1 Methods

3.1.1 Approach for the general topic of processing by product group

The field of processing is extremely heterogeneous. Traditionally, there are 27 different trades in food processing in Germany. There are no research institutes dedicated to organic processing only. The available scientific literature on organic food processing is fragmentary and can only partially be differentiated from general food research.

Therefore, and because of the strong time limitations of the project, our approach for the analysis of the current state of knowledge was as follows:

Four project teams were named for the product groups studied, namely dairy, fruits and vegetables, grains, and meat. These project teams developed product family trees for their respective product group. These product family trees describe the individual fields according to product group and fields of activities.

Based on these product family trees, the project teams conducted interviews with experts from industry, associations, and science.

Table 3 Expert interviews on the topic of processing

Product group	Number of experts
Meat	19
Fruit/Vegetables	35
Dairy	16
Grains	21

The objective of these expert interviews was to identify relevant research and transfer challenges. Results were presented at a workshop of the entire working group. Questions that were brought up most frequently and were particularly relevant were chosen to be explored further. For these topics, the project teams conducted specific literature searches in a number of databases. In addition, other relevant sources of information were developed. As part of this process, questions were also discussed in European networks such as SGOP (Sectoral Group Organic Processing) of IFOAM's EU group.

The initial questions were presented and assessed based on the results of the literature searches and other information. From this presentation, the need for knowledge transfer and research was identified.

External experts reviewed the drafts of these presentations and the transfer and research challenges derived from them. Following this review the texts were finalized.

3.1.2 Approach for the general topic of packaging

For the analysis of the current state of knowledge the following approach was chosen for the field of packaging: As there are no legal regulations pertaining explicitly to the packaging of organic foods, research fields specific to the organic sector were identified based on the requirements of the organic producer associations and on interviews with experts. The project group searched the literature specifically for these research fields and used additional sources of information. The evaluation of the information thus obtained was assessed and presented, stating the need for research and transfer.

External experts reviewed the drafts of these presentations and the transfer and research challenges derived from them. Following this review the texts were finalized.

3.1.3 Approach for the cross-sectional topic of sustainability

The section "sustainability assessment" of the analysis of the current state of knowledge aims at compiling the level of knowledge in research and practice regarding selected aspects of sustainability, both in its role as a processes-oriented aspect of quality and as management system. Based on this, the following questions are addressed at the level of processing:

- Which legal grounds are relevant for the sustainability of organic processing?
- Which direct and indirect effects on selected aspects of sustainability can be inferred from these legal grounds?
- From the point of view of practitioners and experts, are there current general topics in the sustainability discussion calling for a more in-depth discussion?
- Are there generally accepted approaches to the analysis of the sustainability of organic processors?

Procedure

The object of this analysis of the current state of knowledge is organic processing in the four processing sectors grains, meat, fruit and vegetables, and dairy products. The analysis does not take into account the entire value chain but is limited as follows (Figure 3). The areas of raw material quality and sourcing as well as recipe design are not considered as they differ greatly depending on the sourcing situation and the individual business' philosophy. Both factors, however, influence a product's sustainability.

Figure 3 **System boundaries as employed in the analysis of the current state of knowledge**

The general sustainability consideration for this part of the project was based on the definition presented in 1987 by the “Brundtland Commission” as well as on its more precise version by author John Elkington as provided in his book “Cannibals with forks: The Triple Bottom Line of 21st Century Business." The term “triple bottom line” refers to the adherence to three interconnected requirements: ecological quality, economic prosperity, and social justice. These three concepts formed the basis for the three pillar model (or the magic triangle) of sustainability used in Germany.

Based on Seidel et al. (2010), several indicators of sustainability were selected and confirmed in telephone interviews with experts: For the ecology pillar, the indicators biodiversity, water consumption/contamination, climate impact, consumption/contamination of the natural resources soil, air, and raw materials were selected. For the economy pillar, the indicators economic efficiency, investment behavior, and ingredients efficiency/amount of waste generated were selected. For the social pillar the concepts of stakeholder involvement/fair trade relationships, qualification/continued education and social commitments/corporate social responsibility (CSR) were chosen.

A matrix was developed to compare the sustainability indicators confirmed in the interviews with statements from Regulation (EC) No 834/2007. It was determined what, if any, information the Regulation provides regarding these indicators (Table 1).

Feedback from the surveyed research experts served to further limit the selection of sustainability indicators based on their relevance to organic processing. The project team estimated this relevance and external experts confirmed these estimates.

Similarly to the approach used for the academic sector, for the practical sector the selected indicators were presented based on scientific and gray literature (keyword searches in relevant databases) and on feedback from industry experts. Possible knowledge gaps and a potential lack of knowledge transfer for organic processors were identified from the qualitative description of the current state of knowledge on the selected sustainability indicators.

3.2 General technologies

Ursula Kretzschmar, Tabea Meischner, Franziska Espig

3.2.1 Detection of foreign matter

Current state of knowledge

The industrial production of food has reached such a high degree of automation now, resulting in highly efficient production. Therefore, quality assurance is becoming more and more important. The presence of foreign matter such as nut shells in baked goods or glass particles in food packed in glass jars etc. may have serious consequences for the individual company. This includes not only the legal issue of product liability but also damages to a company's reputation which can result in hardly foreseeable severe economical setbacks. Therefore, the detection of foreign matter is an essential part of quality control for every company.

Several methods are available for the detection of foreign matter: metal detectors, color scanners as well as ultrasonic and x-ray scanners. Regarding the processing of organic food, the use of x-ray detection devices is strongly disputed according to the expert interviews. On the one hand, only a small amount of x-rays are applied producing the highest possible degree of efficiency in the control of finished food products whereas on the other hand, the irradiation of food is considered unnecessary, and sometimes unreasonable and not ecological. Bio Suisse, for example, has approved x-ray detection for baby food contained in glass jars in order to ensure the highest possible level of protection against glass particles in the food. However, the problem that many processors encounter is that there are no alternatives to foreign matter detection by x-rays that are suitable for practical application. Tests have been made with ultrasonic detection methods (Pallav et al. 2009, Yang et al. 2007) and also with glass bottles (Zhao et al. 2009), but there are no final results and evaluations available. Added to that, ultrasonic waves do not enter the product, they only scan it. Therefore, this method is predominantly used for the detection of product presence and product intactness in solid food. Camera and metal detection are not suitable for all types of materials and cannot be applied as universally as x-ray detection (Schoenrock 2008).

Research and transfer needs

Research was found to be required in two areas:

> The industry lacks a survey on all possible foreign detection methods including pros and cons for the individual types of products (unpacked/packed, solid/liquid) and associated costs.
>
> Also, there is no ecological alternative to x-ray detection that has the same efficiency spectrum.

3.3 Grains and grain products

Alexander Beck, Tabea Meischner

3.3.1 Characterization of baking properties of organic grains from the wheat line

Current state of knowledge

Wheat (Triticum aestivum) grown on organically farmed fields often shows baking properties that deviate significantly from those of conventionally grown wheat (Tauscher et al. 2003, Kunz 2000, Kempf 2002, Brümmer et. al. 1992, Brunner 2002). "Organic" consumers tend to focus on diets that include "whole food" or "health food" (Hoffmann et al. 2010). Therefore, organic baked goods are characterized by a higher content of whole grain products and by their specific requirements for raw materials and processing as compared with conventional lines (Seibel 1990).

For wheat, the methods for predicting baking properties depend significantly on protein content and protein properties (ICC 2011, Kempf 2007, Kuschmann et al. 2010). In recent years, there have been several reports stating that loaf volume, e.g., is determined much more strongly by the variety than by protein contents (Freimann 2007). Thus, the predictive power of established assessment methods for wheat qualities is deficient for organic wheat and baked goods produced from it (Linnemann 2002, Tauscher et al. 2002). Depending on the variety, e.g., baking results correlate only insufficiently with laboratory values (Kunz 2000). A high protein content in wheat depends on high nitrogen availability and is, therefore, harder to achieve in organic agriculture. In addition, high soil nitrogen levels contradict the environmental goals of organic agriculture (cf. IFOAM 2005).

For special grain species such as spelt (Triticum aestivum spelta), but also for emmer wheat (Triticum dicoccum), currently only inadequate methods for the assessment of their baking properties are available (Schober et. al. 2002, Bojnanska et. al 2002, Münzing 2007). "Methods commonly used with soft wheat for characterizing protein quantity and protein quality may be applied to spelt. However, the results of the analysis … do not allow reliable estimates of the expected baking quality" (Müzing et al. 2009, quote translated from German). For these grain species, the results obtained with established methods have to be reassessed. Alternatively, new or refined assessment methods have to be established/developed. The aim is to obtain predictions on baking behavior that can be used in practice. Furthermore, there is a lack of information regarding mixing effects in spelt (Münzing 2007, Busch 2011) and emmer wheat (Piergiovanni et. al. 1996).

Research and transfer needs

Existing assessment methods need to be reinterpreted and new, appropriate assessment methods need to be developed for the special agronomic conditions and objectives of organic wheat culture and for the requirements of the product lines of organic baked goods. For the "grain assessment" as interface between organic primary production and subsequent bread production, assessment methods need to be established that match realistic prognoses for baked goods production and the objectives of organic agriculture (e.g., with regard to nitrogen availability). For special grain species such as spelt and emmer wheat, there is a need for improved predictive methods for their baking properties as well as for the acquisition of a deeper understanding of mixing effects. Systematic investigations of harvested crops are required in order to provide suitable basic data.

3.3.2 Changes in the enzymatic properties of rye and their effects on bread quality

Current state of knowledge

Over the past 40 years, rye breeding efforts have strongly selected for high falling numbers and amylograph readings. This resulted in enzymatically inactive rye products and in baked goods with impaired quality, such as reduced specific dough leavening and reduced freshness (Brümmer 2005; Kuschmann et al. 2010). In one of the interviews, an expert pointed out that the processing of rye is increasingly problematic for the bakers because of dry and/or cracked crumb, smaller volumes and less leavening. This is because new varieties also are less and less geared towards the bakers' needs (Hiestand 2011). Organically and conventionally grown rye varieties hardly differ in their processing value (Münzing et al. 2009). In addition to changes in rye breeding, in conventional processing the impaired baking properties can be corrected by adding hydrocolloids, emulsifiers, and isolated enzymes, such as α-amylase and transglutaminase (Beck et al. 2008; Bode 2005). However, in organic food production, adding synthetic or isolated additives is not desired.

Therefore, the composition of the raw material, in particular its pentosan content, is decisive when it comes to optimizing the baking properties of whole rye flour with high falling numbers. Baking properties (in particular bread volume) are enhanced by a certain proportion of water soluble pentosans and total pentosans as well as a 1:16 to 1:20 ratio of water soluble pentosans to starch. Thus, the fiber content significantly influences the moisture content and degree of hardness of whole rye bread (Buksa et al. 2010). Mechanical pre-treatment of the grain, the so called attrition, is another way of controlling baking performance. Using a vertical ball mill (ATR), the grain's starch granules are deformed (Lange et al. 2003). In rye bread production, adding attrition flour results in an enhanced water binding capacity, succulence, improved freshness while maintaining a dense crumb (Bode 2005). Adding baking malt made from other species of grain is another way of improving baking properties. The α-amylase contained therein brings about starch degradation, improves yeast growth, proof, and oven spring, and also delays the ageing of the crumb (Seibel et al. 2006; Schieberle 2007). According to Beck et al. (2010), sprouts and/or the malt flour derived from them may be used to improve the enzymatic properties of the dough. Positive effects have been reported for wheat. However, for low enzyme rye the use of sprouts was found to be rather problematic in baking tests (Beck et al. 2010). According to Schieberle (2007), the proteolytic activity found in malt may negatively affect flours that are low in gluten, such as rye.

Research and transfer needs

So far, the interactions of starch, pentosans, and proteins from rye in dough making and baking have not been studied extensively. However, understanding these interactions is essential for the development of approaches for improving the baking properties of low enzyme rye flours. This is an area where research is needed.

Furthermore, it is necessary to test the approaches developed so far for their suitability for organic food processing, and/or to develop and establish dedicated, careful measures for organic processing.

For rye breeding it would be helpful to match breeding objectives with required baking properties. To achieve this, the requirements for varieties must be re-defined for breeders.

Also, it should be re-evaluated whether the falling number and the amylograph readings and single-purpose breeding oriented towards sprouting resistance are useful.

3.3.3 Minimizing trace contamination from batch crossover and impurities in grain processing

Current state of knowledge

Segregation in parallel production facilities

Kretzschmar et al. (2006) found that almost 70% of the experts consulted in an EU Delphi method survey are of the opinion that in organic legislation, the practice of segregation has to be regulated more precisely with regard to individual product. The issue of segregation practices became considerably more acute when GMO food and feed were introduced (Oehen et al. 2005, Beck 2006). In practice, cross-contamination with substances not allowed in organic products is a recurring event in grains (Velimirov et al. 2003, Weisshaupt 2011, Kroener 2011). Consumers expect organic foods not to contain any "chemicals," (Naspetti et. al 2006) which is taken more and more seriously by trade enterprises. Ball (2011) considers important questions of segregation practices unresolved in the field of industrial organic baked goods production. Legislation has established general requirements for separation practices in the new Organic Regulation (EC) No 889/2008, Article 26. However, these have not been phrased in a manner that would make them immediately applicable.

Several authors (Löwenstein et al. 2004, Beck 2004) suggest the development of broader requirements for optimized segregation practices. At the same time, however, it has do be determined and clarified how thoroughly segregation practices for organic and conventional foods in parallel production facilities need to be ensured, as conventional foods are no contaminants.

Avoiding gluten and allergens

Meurens (2011) points out that the legal limitations of purification methods, e.g., for organic glucose syrup are creating problems in particular with regard to celiac disease. Avoiding gluten, however, is a central challenge in the food industry (Gallagher et al. 2004, Hirschenhuber et al. 2006, Vogelsang 2009). According to the relevant Codex Alimentarius standard from 1976, food labeled as gluten-free may not contain more than 200 ppm gluten.

New ingredients or new techniques such as genetic engineering may introduce, on purpose or inadvertently, allergenic substance into foods (Bindslev-Jensen et al. 1997). The elimination of possible allergens in organic food is limited by the technical requirements of organic legislation (Regulation (EC) No 834/2007) and may be in conflict with the general objectives of organic production. For example, ion exchange technologies may not be used to eliminate gluten residues from organic glucose syrup (interview Meurens 2011). Thus, it is necessary to identify or develop new technologies that are in accordance with organic objectives.

Research and transfer needs

Segregation issues are of great practical importance in the grain and grain product production chain. This is true both for the segregation of conventional and organic grains and for avoiding cross-contaminations that may result in residues. There is a need to take a differentiated look at which segregation strategies need to be applied at which level of segregation. “Good Organic Manufacturing Practices” need to be refined to this end.

More research and development is needed for technological options for eliminating allergens in organic grain products in accordance with the Organic Regulation. Approved techniques and strategies should be evaluated for suitability, and/or new technologies need to be developed.

3.3.4 Challenges in the processing of organic grains: Practical instructions for organic bakeries, isolated enzymes in chilled dough methods

Current state of knowledge

Practical instructions for the production of organic baked goods

Like no other industry, the baked goods industry in Europe is characterized by small and medium sized businesses. There are a number of older German language publications addressing the production of and the transition to organic baked products (Seibel 1990, Hofmann 1999, Beck 1999). These books do not contain all of the information needed today, some of them are no longer available, and they are not current in terms of the legal and technical situation. The internet portal www.oekolandbau.de provides current and relevant information in German. Based on a survey conducted via the mailing list of IFOAM’s SGOP (Sectoral group organic processing) it was determined whether current practical instructions for the production of organic baked goods are available in other languages. It was found that only few and incomplete practica l instructions for organic baked goods production are available in other official languages of the European Union (e.g. Ball 2011, Largier 2011, Blom 2011). Only Largier (2011) reported that individual information publications are available in French (Agence Bio 2011), but that there are no comprehensive instructions. However, such information is of significant importance for the safe implementation of legal requirements, in particular by artisan bakeries, and for successful market expansion.

Isolated enzymes in chilled dough methods

A special practical issue is the production of chilled organic dough pieces without addition of, e.g., isolated amylases and xylanases (Ball 2011, Hiestand 2011, Beck 2004). Many manufacturers of baked products consider isolated enzymes as problematic processing aids (Beck 1999). A whole range of EU organic associations (Demeter 2010, Bio-Suisse 2011) prohibit their use in baked products. Many authors (Hilhorst et al. 1999, Butt et al. 2007) have addressed the use of such enzymes in baked goods production, including their effects on particularly high-fiber products (Laurikainen et al. 1998) such as whole grain products that tend to have low loaf volume (Butt et al. 2007). A whole string of patents exists in this field (e.g., EP 2103220A1 2009, US 005306633A 1994, US 005589207A 1996, US 0076716A1 2004). Today, isolated enzymes are extensively used in the production of baked goods (Klinger 1995). If chilled dough pieces are produced without isolated foreign enzymes, the result will be deviations in the production process and, often, insufficient quality (Hiestand 2011, Kähler 2011).

Research and transfer needs

In order to successfully change the large number of baked goods producers to organic production, significant knowledge in the fields of production and plant management is required. This knowledge is available only in an incomplete manner for an EU wide context. It should be provided in several official EU languages.

Research and development is needed regarding the production of high quality and uniform organic rolls and pastries that are produced using chilled dough pieces. Here, the specific challenge will be in producing these without adding isolated foreign enzymes.

3.3.5 Quality standards and consumer expectations for organic bread and baked goods

Current state of knowledge

Organic baked goods quality often is assessed with test systems and standards developed for conventional baked goods. Due to differences in raw material quality, dough process and available ingredients and additives this often leads to a devaluation of the organic products. The situation for consumer expectations is similar. For example, according to a survey of experts, consumers often complain about the lower loaf volume of organic rolls compared with conventional rolls (Schomaker 2011).

Consumer expectations

A qualitative consumer survey by Stolz et al. (2009) showed that sensory properties, in particular taste and texture, are priorities in the perception and assessment of organic bread and baked products. The type of flour used, with whole grain flour being preferred over white flour, and ingredients such as grain kernels and oilseeds were also considered to be important. Leavening agents and preservatives were disapproved of (Stolz et al. 2009). One important expectation for organic baked goods is the production of whole foods or whole grain products. According to Seibel et al. (2002), however, there is a trend away from whole grain products made with the three-stage sourdough method to lighter organic baked goods and flour breads. There is a marked difference between actual buying behavior and consumer surveys, with the latter estimating the sales of whole grain products much higher than they actually are (Seibel et al. 2002). In contrast, the shape of the food is of less importance to consumers of organic foods (Bruemmer 2002). Regarding the source of the raw materials, consumers prefer direct sourcing from the producer. Furthermore, the majority does not accept any significant variability in products (Felgentreff et al. 2003). The greater effort required for producing organic baked goods leads to added value for the consumer, in particular with respect to transparency, protection of the environment, and monitoring (Seibel et al. 2002).

Quality standards

Process and product quality are decisive for the quality assessment of organic baked goods. Regulation (EC) No 834/2007 provides the basic standard for organic baked good production, regulating process-relevant criteria for production and processing. Building on this basis, there are specific standards by grower associations for the production of bread and baked goods that guarantee high quality processing. For example, Demeter strongly limits the use of additives and does not allow intense processing technologies such as hammer mills (Demeter 2010). Special characteristics of organic processing are traditional artisan methods, limitation of synthetic additives as much as possible, and the dominant use of whole grain flours (Wrona 2003).

According to DIN standard 10355, the term “whole grain” is precisely defined. It comprises the entire components of the cleaned grain kernel and, therefore, is an untreated product of varying composition. There is a controversial discussion of current international attempts to extend this definition, in particular to products that include mixtures of grain fractions of the same species but from different batches in relative amounts that are roughly those of the grown grain with the purpose of creating more uniformity. Irritation and protests from processors and consumers are expected (Lindhauer 2011, Brack et al. 2009).

The product quality of baked goods is determined by nutritional value, health value, sensory value, suitability value, and vitality (Seibel et al 2006). Regarding the nutritional value, organic baked goods, due to their high whole grain content, provide a large part of the recommended fiber intake and thus also influence the energy content (Seibel et al. 2002). According to Seibel et al. (2006), health benefits would be achieved only if consumption habits of organic consumers shifted towards wholesome baked goods. Vitality as quality factor comprises the positive effects of the baked goods’ internal structure, which is influenced by agricultural practices and by processing, on human health and well-being (Seibel et al. 2006).

For sensory quality assessment, often either the DLG bread testing scheme for conventional breads and baked goods is used, or other testing methods inspired by this scheme, such as those by Demeter or Stiftung Warentest. For organic bread, there are neither national nor international sensory bread profiles defined (Felgentreff et al. 2003). In DLG assessments, organic baked goods often are rated a little lower than comparable conventional products. This is due to their different processing technologies such as sourdough method and whole grain recipes (Brümmer 2002).

Research and transfer needs

Consumer expectations for organic products often differ greatly from expectations for conventional products. So far, there are hardly any scientific studies of consumer expectations and behavior with regard to organic baked goods. Consumer expectations are strongly reflected by consumer behavior and, thus, play an important role in product sales. Therefore, it is necessary to document these expectations, in particular for organic breads and baked goods, in comprehensive and current surveys.

In order to better communicate the special quality of organic baked goods, it is necessary to advance and establish holistic testing methods and assessment approaches for organic breads and baked goods that take into consideration the particular processing conditions of organic products.

3.3.6 Formation of acrylamide in wholesome organic baked goods

Current state of knowledge

Wholesome recipes that are used in particular in the production of organic breads and baked goods often result in higher acrylamide levels. This is because wholesome products contain more of the amino acid asparagine than white flour baked goods, and asparagine is one of the precursors responsible for acrylamide formation. Strategies for minimizing this formation with protective additives are in conflict with the overall objective of organic agriculture of avoiding additives as much as possible. Therefore, different approaches for production and processing processes are required.

One option is to reduce the amount of the precursors responsible for acrylamide formation in the grains. Testing of organic wheat samples at the Hohenheim University showed that the asparagine content depends on variety, type, fertilization intensity (N fertilization), growing site, and climate (Stockmann et al. 2009). In another trial it was shown that adding N fertilizer during wheat growing leads to a higher level of free amino acids and raw protein in the grain (Claus et al. 2006a). Studies by Weber (Weber et al. 2007) showed that the reducing sugar content of different wheat, spelt, and rye varieties has little, the free asparagine content has a strong influence on acrylamide formation. Among the different grains, wheat showed a lower asparagine content on average than rye. Within the same grain species, there were significant differences from one variety to the next, for both for wheat and rye. In rye inbreeding lines with a high protein content the percentage of asparagine was increased fivefold (Weber 2007). As mentioned above, the acrylamide content increases with the extraction rate because asparagine content and protease activity are higher in the outer layers of the grain. Therefore, products made from whole grain flour with its higher fiber and ash content tend to have a higher acrylamide content which is in contrast with the positive nutritional vale of whole grain products (Claus et al. 2008a). Fermenting dough with yeast for up to an hour before baking will reduce the asparagine content because the yeast metabolizes a major portion of the asparagine (Claus et al. 2008a). Heating duration, temperature, moisture, and heat transfer of the oven (top heat, circulating air) influence acrylamide formation significantly. Thus, the acrylamide content of the finished product can be minimized by properly setting these parameters (Claus et al. 2008a). Another option is the substitution of ingredients and additives, for example, of ammonium hydrogen carbonate, which additionally enhances the reaction, by sodium salts or phosphate-containing baking powder, or of the reducing sugars glucose and fructose, which honey contains in high concentrations, by sucrose (Amrein et al. 2005a). Adding additional substances to the recipes is yet another option. Possible additives are organic acids such as citric acids or ascorbic acid. By lowering the pH, these significantly impair the reaction conditions for acrylamide (Amrein et al. 2005a). Other options are fibers, natural antioxidants, or polyphenols (Claus et al. 2008a). However, many possible additives such as enzymes (asparaginase), amino acids, and cations are either not suitable or not allowed for use in organic food production.

Research and transfer needs

A number of approaches for reducing the acrylamide content have either not been tested under practical conditions (Claus et al. 2008a) or are not suited for organic processing. Many methods can be implemented only in a limited manner because they would possibly impair taste, aroma, texture, color and nutritional value of the finished product (Amrein et al. 2004). Therefore, there is a need for researching and testing approaches for reducing acrylamide specifically in organic wholesome baked goods. Furthermore, due to the higher potential for acrylamide formation of whole grain flours or of wholesome recipes that is in contrast with their nutritional value, weighing these two factors from a health perspective is essential, in particular for the production of organic baked goods.

Minimizing the asparagine content in grain by targeted selection of varieties, fertilization, and breeding may constitute a useful approach. There is a need for further research in this field, in particular regarding the factors influencing asparagine formation, as there might be advantages for organic farming. However, breeding grain varieties with the sole aim of lowering their asparagine content would contradict an organic holistic approach.

3.4 Milk and dairy products

Ursula Kretzschmar, Tabea Meischner, Franziska Espig

3.4.1 The effect of a limited use of additives in organic milk processing on the shelf life and quality of organic dairy products

Current state of knowledge

Milk

According to the experts, the quality and length of shelf life for fresh and processed organic milk does not present a problem (quality of milk, see 2.3.1). The most serious obstacle mentioned was the constant supply. Technological restrictions in terms of approved processing methods will not only lead to carefully processed food but also to a limited product range (e.g. some associations prohibit sterile products) and a reduction in the shelf life of milk products (e.g. prohibition of long time pasteurization and microfiltration of milk, so-called ESL milk). (see detailed description in chapter 3.4.2)

Acidified milk products

Acidified milk products are made with the help of lactic acid bacteria and other microorganisms. Some private organic guidelines stipulate that the cultures used in the production of organic acidified milk products must have been produced in organic milk. According to the experts, the supply and quality of organic cultures is not a problem. As with conventional products, natural acidification ensures proper shelf life. Added to that, preservatives including benzoic acid, sodium, potassium and calcium benzoates can be used in conventional products. These substances are not approved for organic processing (VHM 2006). There is no knowledge deficit regarding the use of preservatives in acidified milk products because the production of such products poses no problems.

There are several fermentation methods available for yoghurt (e.g. long-term and short-term incubation). The method chosen influences the overall production process. Aimed at improving the production processes, the Swiss Research Institute ALP has investigated an over-night long-term incubation method (ALP 2009a). The research results are interesting in particular for small and medium-sized enterprises where the milk is processed at and sold directly from the farm. This is a common concept for organic companies.

Sensory quality differences between organic and traditional acidified milk products can be observed for products with added fruit or other ingredients, for example, fruit yoghurt. Since colors and flavors are not, or only to a limited extent, approved for organic processing, the quality of the bases and semi-finished products is decisive. According to experts, deviations in sensory quality that cannot be balanced by flavors are one of the largest problems in terms of taste and appearance of a final product. Added to that, texture is another important parameter. Some organic associations prohibit the use of non-milk stabilizers (e.g. gelatine). This limitation affects texture and shelf life, e.g. due to the high risk of syneresis. However, there are no specific studies available on this issue. There is ongoing research at the Swiss Research Institute ALP on how to improve the texture of yoghurt with the use of exopolysaccharide-producing lactic acid bacteria.

Health is an important factor for consumers; it governs their purchasing decisions, in particular for organic foods. In order to cater for these needs, and also in regard to fruit yoghurt, the sugar content needs to be reduced as much as possible. A consumer survey has been conducted in Switzerland aimed at investigating how much of a sugar reduction consumers would accept in strawberry and mocha yoghurt. It was shown that yoghurt with a 10% sugar content was equally preferred to yoghurt with only 7% sugar (ALP 2010a). The results of such studies are important for the development of organic food and should be made available to the processors through the transfer of knowledge. Added to that, the combined effects of reduced sugar content and other taste-determining factors such as acid characteristics (cultures) need to be investigated.

Cream products

Stabilizers, e.g. carrageenan, are often used in the production of traditional cream products to prevent further creaming. Carrageenan is suspected of being detrimental to human health. This is the reason why some organic standards do not allow the use of carrageenan while it is approved for organic cream according to the EC Organic Regulation. To prevent creaming of organic cream that does not contain carrageenan, alternative products or are needed or the consumers must be informed about that phenomenon. However, there is no scientific literature available on this subject. This means that there is a knowledge deficit in the sector of organic milk processing.

Blancmange/flan products

As the shelf life of blancmange/flan products is not supported by natural acidification, conventional products of this kind contain acid regulators such as potassium phosphate. The addition of such acidifiers is not permitted in organic processing. Added to that, conventional blancmange/flan products often contain added modified starches for improved texture and emulsifiers (e.g. mono- and diglycerides of fatty acids). These additives are not allowed in the production of organic blancmange/flan products. Instead, organic products often contain corn starch and guar gum as stabilizers. In general, it can be stated that the shelf life of blancmange/flan products of organic quality is a serious challenge for all producers. This aspect was mentioned several times in the expert interviews. There are no scientific studies available on this issue.

Butter products

The quality and shelf life of butter products is highly dependent on the fatty acid composition. Because of the special dairy cattle feeding, organic milk contains a higher amount of nutritionally desired unsaturated fatty acids such as conjugated linoleic acid (Butler et al. 2011, Butler et al. 2011a, Slots et al. 2009, Prandini et al. 2009). The increased level of poly-unsaturated fatty acids also carries a high risk of oxidation which may cause the formation of off-flavors in the butter (Gonzalez et al. 2003).

In conventional butter production, sometimes the so-called NIZO method is applied where lactic acid concentrates and flavor concentrates are added to the sweet butter. This process has the advantage of utilizing by-products from milk processing (Wechsler 2011). However, this method does not comply with the principles of careful and gentle processing of organic products. Therefore, this method has not been approved by private associations, although it is permitted in the EC Organic Regulation. Resulting from the limited processing methods allowed by the organic association, the question arises on how the by-products from butter making can be further utilized for the optimization of the value chain.

Cheese products

The quality of the raw milk as well as the cultures used in cheese production have a large impact on the quality of the cheese. A large amount of unsaturated fatty acids may cause fat oxidation which impairs the sensory properties of the cheese (Jakob et al. 2009).

According to Regulation (EC) No 889/2008 on organic production, the use of lysozyme, nisin, nitrates (potassium and sodium nitrate) and natamycin is not permitted in cheese production. Lysozyme and nitrate are used to prevent late blowing and other defects that may occur during cheese ripening (Fox et al. 1993), while natamycin is used to suppress mould growth on the surface of the cheese. Nisin is applied as a peptide with an antibiotic effect for preservation purposes (Pintado et al. 2010, Sobrino-López et al. 2008, Oliveira et al. 2007). More information on how processors of organic cheese products can ensure product safety and quality despite these restrictions is available at the information portal www.oekolandbau.de (in the German language). Even though this issue is of high relevance for consumer protection, there are no studies available on this subject. Currently, the Swiss Research Institute ALP is searching for new strategies for organic preservatives to be used as alternatives. In this context, the effectiveness of microorganisms with antimicrobial effect is predominantly being investigated (ALP 2009, ALP 2010).

For the production of processed cheese, emulsifying salts, e.g. phosphates and citrates, are employed. They have a distinct effect on the texture of processed cheese and are also important shelf life parameters (Strahm 2006). Added to that, polyphosphates are used to prevent late blowing in processed cheese (VHM 2006). Phosphates are not approved for use in organic cheese products, but citrates are (except potassium citrate). Citrates and phosphates produce similar textures in processed cheese (Cunha et al. 2010), which means that this restriction has no detrimental effect on the sensory properties of the final product.

For the production of whey cheese, different acids are used for protein precipitation. The dairy industry applies acetic acid and citric acid for this purpose; according to the EC Organic Regulation, both acids are not approved in the processing of food of animal origin. According to the German Association for Artisan Dairy Processing in Organic Agriculture (VHM), these acids shall be included in the positive list of the Organic Regulation, in particular, for allowing the traditional production of Ziger (whey cheese) (VHM 2006).

Preservatives used in traditional cheese products are sorbates, including sodium and calcium sorbates, which prevent the growth of yeasts and moulds. These preservatives must not be used for organic cheeses. This restriction can be compensated for in organic processing by pH reduction and a higher sugar or salt content.

Powdered milk

Traditionally made milk powders contain added free-flowing agents, mainly calcium phosphate, to prevent the powders from lumping. Calcium phosphate is not allowed in organic processing. Therefore, organic powdered milk does not contain free-flowing agents; this has a detrimental effect on the metering processes but not on the shelf life.

Research and transfer needs

The effects of a restricted use of additives in organic milk processing on the shelf life and quality of organic dairy products

The greatest challenges in milk processing are the procurement of raw materials, the quality of the basic materials and the shelf life of semi-finished products, according to the expert interviews. The most relevant factors regarding the shelf life and quality of dairy products in this context are the restricted use of stabilizers, flavors and colors. Processors of organic dairy products have found in-house solutions on how to handle these limitations while ensuring product quality and safety. There are no studies available on these issues specifically for organic products. This means that a research need has been identified for the following dairy products:

- Cream products: The non-approval of carrageenan for organic cream products by some private organic associations has resulted in problems with regard to creaming. There is a gap in knowledge as to which alternative substances would be suitable to replace carrageenan and which would yield the same effects and could be approved for organic processing.
- Blancmange/flan products: Some research is needed regarding the question on how to ensure the shelf life of organic blancmange/flan products that are made without acidifiers and emulsifiers.
- Butter products: In order to increase the value of organic butter production, alternatives for the further processing and utilization of by-products will be needed.

Added to that, there is also a transfer need to communicate study results to processors and marketers of organic dairy products. The results from consumer surveys and technological aspects for improving the production flow and/or product quality are decisive here. In particular, methods for the transfer of knowledge should also be identified to reach SMEs, which, due to their size, do not have their own research and development departments.

3.4.2 Processing technologies for organic dairy products: Challenges and product-preserving alternatives

Current state of knowledge

Regulation (EC) No 834/2007 stipulates the product-preserving processing of food. However, apart from the prohibition of using genetic engineering and ionizing radiation, no other processing technology or requirements for gentle processing has been evaluated (EC 834/2007). Basic processes such as homogenization, pasteurization and sterilization are permitted without any limitation which results in different practices throughout Europe (Schmid et al. 2004). Many organic associations do not allow treatment with microwaves or microbicidal gases for sterilization or the application of nanotechnology methods.

Technical challenges due to lack of processing aids

Contrary to conventional milk processing, the use of additives and processing aids in organic processing is limited to a minimum, or to natural substances only. This often requires an adaptation of individual processing steps. As discussions with practitioners showed, for proper product stability, it is necessary to adapt the temperature processes in the production of organic yoghurt such as the filling temperature because of the restrictions regarding the use of approved thickeners. In organic powdered milk production, the non-use of free-flowing agents must be compensated for via technological adjustments. Practical tests for the development of organic-compatible alternatives are most often done in-house or commissioned to external consulting or research institutes. The results are proprietary to the company and not for public use. No scientific literature was found on this topic.

Processing technologies for organic dairy products and product-preserving alternative methods

In food technology, innovations are often developed based on the requirements of conventional production and then adapted for organic processing, for example, microfiltration for the production of ESL milk. Product-preserving alternative methods for organic processing are hard to define retroactively. There is a lack of established evaluation criteria for the assessment of already existing and new organic cultivation principles which may be used as a starting point for future research. Nevertheless, the consideration of the entire process and the assessment of its effects on the final product quality would be necessary.

Every organic association has different rules for the processing of individual dairy products which are listed below categorized by product groups.

Milk

Bioland and Bio Suisse allow UHT treatment only when accompanied by a ß-lactoglobulin analysis with a value above 500 mg/l because otherwise the quality may be impaired (e.g. cooked flavor). ß-lactoglobulin is an indicator for protein denaturation during heat treatment. As the value has been defined as being above 500 mg/l, only the direct UHT process is allusively approved because the required value can be achieved with today's technology (Bio Suisse 2001). Furthermore, Bioland, Naturland and Bio Suisse do not approve sterilization for preservation. High temperature and multiple pasteurization processes are preservation methods that are not accepted by Bio Suisse. This association allows ultrafiltration and homogenization with information about the maximal applicable pressure. Demeter allows pasteurization methods but no sterilization, UHT-treatment and all processes used to make ESL milk. Added to that, no technical homogenization methods are permitted in milk processing operations.

The restrictions imposed by the associations raise different issues that need to be discussed. On the one hand, the restrictions shall serve the principle of careful processing whereas on the other hand, many consumers demand milk products with a prolonged shelf life, which can be achieved, for example, with ESL methods. Microfiltration used in this process can yield an improved inactivation of microorganisms at lower processing temperatures (Walking-Ribeiro et al. 2011). Furthermore, direct UHT treatment is much gentler on the product but requires definitively more energy (Eberhard 2011). The associations have to consider and ponder these aspects when developing their guidelines. The different preservation methods should be researched, analyzed and evaluated based on organic specifications and independently from any association. In his study, Strahm et al. (2009) explains the pros and cons of different preservation methods. He names off-flavors and reduced thermal protein stability as drawbacks of homogenization. Furthermore, he describes the indirect heating process for ESL milk as being not very careful on the product leading to higher denaturation of whey proteins and cooked flavor in the product. The direct UHT method is described as being much more careful because of the lower thermal stress (Strahm et al. 2009). He does not present a concluding evaluation of the processes. In her study on milk samples, Balzer-Graf et al. (2000) used picture forming analysis of different pressure treatments to prove that with increasing pressure and exposure time, the vital quality of the sample deteriorates parallel to the denaturation of the compounds. This shows that treatments such as high pressure and homogenization affect the quality and - considering the principle of minimal processing - should be critically examined. Alternatively, homogenization also has its advantages because it prevents creaming (Strahm et al. 2009), which can hardly be prevented in unhomogenized products.

Cream products

Bioland only approves the sterilization of coffee cream. Demeter does not allow the homogenization of whipping cream. Naturland prohibits sterilization and ultrafiltration when it is applied for reducing the volume by more than 50 per cent Bio Suisse allows direct and indirect UHT treatment for coffee cream and pasteurization at a temperature above 90 °C is permitted for the production of cream products in justified cases only. The production of UHT whipping cream is not permitted. The associations' requirements also affect the stability and sensory properties. In Switzerland, for example, UHT cream products are only available from the conventional range (Moos-Nuessli 2002). To meet the consumer demand for UHT coffee cream, it seems reasonable that the associations approve the use of direct and indirect UHT methods for the production of some cream products. Nevertheless, more research is required into alternative methods to UHT processes which comply with the principles of careful processing.

Acidified milk products, butter products, cheeses, blancmange/flan products and desserts, and powdered milk

The associations sometimes have very specific processing requirements for these products, e.g. for cheeses. As with milk, the restrictions partly affect the stability and sensory properties of the products. In particular, the cheese flavor is decisively influenced by the technology applied. The most important factors are the adjustment of the fat content as a flavor carrier, different ripening parameters (e.g. humidity, temperature, time) and the salt pick-up during brining (Jakob et al. 2009).

In the expert interviews, no challenges connected with technological restrictions posed by the associations or desirable evaluation criteria for the processes applied have been named. Scientific publications on issues specific to organic processing in terms of technological aspects or technology assessments were not found. It seems that the restrictions do not have a detrimental effect on the product quality so that there is no need for further research into these fields.

In summary, it can be seen that the different technological restrictions of the various associations not only yield carefully processed dairy products but also limit the product range and reduce the shelf life. However, there are almost no studies on technological restrictions that could be used for an evaluation. The scientific literature also hardly contains any indication of assessments of careful processing methods. Within the Core Organic/QACCP project, Saerkkae-Tirkkonen et al. (2010) assessed different preservation methods. Many processes such as ionizing radiation or microwave treatment do not solve the problem because they either affect the products too much, or are prohibited by the EC Regulation or other guidelines for organic food processing, or are simply not suitable for milk products. For some methods, further research is needed. These methods, including resistance heating, pulsed electrical fields or high pressure treatment of acidified milk products, promise only minimal structural changes and improved maintenance of nutrients and vitamins compared to traditional sterilization methods.

Other processes that should be evaluated in this context are high temperature pasteurization and microfiltration (Schmid et al. 2004).

Research and transfer needs

Investigation of the influence of technological processes on product quality and shelf life and compilation of evaluation criteria for processing technologies under consideration of their suitability for organic milk processing

The associations assess current common technologies very differently which results in different approvals. There are hardly any evaluations on careful processing technologies available in scientific studies. Criteria specific to organic processing need to be developed for the evaluation of existing and new technologies so that they can be used for assessing their compatibility with the principle of careful processing. The development and evaluation of alternative methods should be taken up by the research institutes. In conclusion, the following research topics can be identified:

- Development of uniform evaluation criteria for assessing the suitability of technologies for organic milk with regard to minimal processing and end product quality
- Development of technologies as alternatives to processes that do not comply with the principle of careful processing in order to ensure product quality and safety

Transfer needs: Establishing consultation services of the organic associations for dairy processors regarding technological adaptations to a limited range of processing aids

The technology adjustments are often made in-house depending on the respective machines and products. Therefore, individual advice for the processor provided by the associations is recommended as a transfer service.

3.5 Meat and meat products

Annette Weber, Kathrin Seidel

3.5.1 Transport of organically raised animals for slaughter

Current state of knowledge

The transport of livestock is divided into the following steps: depopulation, loading onto vehicles, transport to the slaughterhouse, unloading, lairaging (Praendl et al. 1988). According to Art. 17 of the German Animal Welfare Act, no animal should suffer pain or distress (BMELV 2011). Council Regulation (EC) No 1/2005 stipulates the protection of animals during transport within the EC. There are hardly any requirements concerning the transport of organic animals:

According to Council Regulation (EC) No 834/2007, the duration of transport of livestock shall be minimized (Article 14). Loading and unloading of animals shall be carried out without the use of any type of electrical stimulation to coerce the animals. The use of allopathic medicinal products prior and during transport is not permitted (Regulation (EC) No 889/2008, Art. 18). In addition to this, there are some guidelines provided by organic associations that demand that the transport times and distances do not exceed 4 hours or 200 km (BLE 2006).

Stunning and slaughtering of the animals near the farm will not only reduce transport costs and environmental impacts but also enhance animal welfare and meat quality. On the other hand, very short transport distances may have a detrimental effect on the meat quality as the animals have no time to calm down after loading before unloading starts (Wenzlawowicz et. al. 2008). Moreover, the regional sourcing of organic meat and the knowledge of its origin, as provided, for example, in direct marketing, are important quality signals (Fink-Kessler 2007). European regulations on slaughtering (Regulation (EC) No 853/2004 and German Regulation on Meat Hygiene of 2007) resulted in a structural diminishment of regional slaughterhouses and artisan meat processing. This is because it is only meat slaughtered in companies that have been approved by the EC that is allowed to be traded within the EC. The BÖL (Federal Program for Organic Agriculture) project "Artisan organic meat processors" assisted small and cooperative slaughterhouses in the EC approval process providing guidelines and documents for self-control and founded the "Association of artisan meat processing farmers (focus on organic production)" (Fink-Kessler et al. 2010).

Research and transfer needs

In order to meet the animal welfare expectations that consumers have of organic products, organic animal husbandry and meat processing need clear and transparent rules for transportation (distances) and slaughtering. The transport of living organic animals shall be strongly reduced in favor of the transport and trade of carcasses. Furthermore, regional slaughterhouses create value in the region and maintain artisan expertise. More training and consultation is needed to support this development although former structures such as small or cooperative slaughterhouses should be revived as well. It is only competent and experienced staff in the slaughterhouse that can ensure animal welfare and high meat quality.

There are still knowledge gaps in hygiene risk evaluation in artisan slaughtering processes. It would be required to define contamination risks and respective measures.

3.5.2 Stunning and slaughtering

Current state of knowledge

One objective of Regulation (EC) No 834/2007 is to respect high animal welfare standards and to meet the species-specific behavioral needs of the animals (Art. 3). In practice, the stunning and slaughtering of organic animals is not different from conventional slaughtering processes. As requested for transportation, the handling of the animals in the slaughterhouse should be done in such a way so as to reduce fear and stress and to comply with animal welfare regulations. In this way, fewer stress hormones such as cortisol will be produced which otherwise result in meat being of inferior quality, having a reduced shelf life and impaired processing properties. Improper handling and stunning produce pain, stress and fear during the slaughtering process (Wenzlawowicz et. al. 2008, Holleben et. al. 1996). Animals from extensive husbandry are much wilder by nature, show more respect for humans and will therefore experience higher levels of stress during slaughtering (Wagner et. al. 2006). Animals in organic farming that are also not used to humans can alternatively be stunned in the field by a gunshot. However, this method requires a huge amount of knowledge which is not always available. If this is the case, this method may not comply with animal welfare standards. Organic animals may also have a thicker hair coat or a thicker, drier skull than conventional animals. Therefore, appropriate guns and parameters need to be used in order to ensure stunning in accordance with animal welfare standards (electrode contact, power of impact of the bolts) (Holleben 2011). Improper stunning must be avoided.

Research and transfer needs

Organic animals, and in particular those from extensive farming, are not used to humans. This aspect should be taken into consideration when handling such animals in the slaughtering process. Added to that, improper stunning should be avoided by selecting the correct stunning method (e.g. no CO_2 for pigs and special bolt stunners for cattle). Procedures for good organic stunning and slaughtering shall be compiled, defined and transferred to the slaughterhouse staff via training and knowledge transfer.

3.5.3 Organic characteristics specific for slaughtering and the quality of carcasses and meat

Current state of knowledge

The quality of the carcasses is determined and graded in the slaughterhouse. The parameters are beefiness and fat cover. The grades are not the only parameters that determine the quality of the carcasses; other factors include damages to the carcasses, for example, bruises. The quality of the carcasses has a direct influence on the price. This is the reason why most farmers aim at producing well pronounced carcasses with sufficient fat cover (LVVG 2010). The quality of the carcasses is – similar to the meat quality – to a large extent governed by the breed (genetic factors), the production system and the handling during slaughtering.

The internal quality determines the sensory and nutritional meat quality and includes characteristics such as tenderness (shear force), color of the meat and fat, marbling (intramuscular fat), loss of water during broiling and roasting, and certain meat components such as fatty acids (e.g. omega 3 fatty acids) (Velik 2010).

Pork

The quality of pork can be assessed based on the fat content and, most of all, on the fat composition. Polyene acids influence the consistency and stability of the meat; they cause a softer consistency. This means that the selection of the breed and a feedstuff low in polyene acids are decisive for the meat quality (Wagner et. al. 2006). Studies on breed selection for organic pork production have shown that conventionally bred animals deliver better and economically important fattening performance even in organic farming when compared with ancient domestic breeds (Brandt et al. 2007, Weißmann 2003). Organically raised pigs show less fattening, a poorer feed conversion rate and a different carcass quality, independent of the breed. On the other hand, the meat quality from organic farming is higher because of the higher content in intramuscular fat (Weißmann et al. 2010). Other studies on the effects of organic feeding and organic husbandry systems on pork quality conclude that the influence of these parameters is assessed as being rather low compared to conventional rearing and feeding (Hansen et al. 2006, Millet et al. 2005). Considering the current market situation, organic carcasses with increased fattening (in particular due to the animal being older and heavier when slaughtered) cannot be marketed optimally; the improved meat quality due to intramuscular fat does not play a role under added value aspects (Weißmann et al. 2010). Starting in 2012, organic pigs must be fed with 100% organic feedstuff; the use of conventional potato protein is no longer permitted. These feeding regulations will affect the quality of the carcasses and with it the price (Studer et al. 2011).

Beef

The tenderness of beef is one of the most important quality criteria (Dufey 2005). It can be decisively influenced by the age of the animals at the time of slaughter, post-mortem ripening and chilling after slaughtering (Stachetzki2011, Dufey 2005). Another criterion, in particular from the consumer's point of view, is the meat color. A comparison between calves kept individually (as prescribed by the organic regulations from the second week of life) and calves kept in groups did not show any differences in meat color (Velik 2010). Defects in meat that result in a lower consumer acceptance are e.g. hemorrhages in the carcass (Alexandrescu 2010).

Stress reactions during loading and in the slaughterhouse also impair the meat quality (Ferguson et al. 2008). The unfamiliar presence of humans, in particular, increases the animals' stress reactions. Spengler Neff (2009) conducted a study on handling methods aimed at improving the confidence between man and animal in order to reduce the stress prior to slaughtering. The handling resulted in the cattle being less stressed the day before the slaughtering which in turn was positive for the meat quality (see also 1.1.2).

Research and transfer needs

The raw material quality of meat has been comprehensively investigated in terms of different keeping systems and feeding. The procedures during slaughtering and the effects on the meat quality have also been considered. However, there is very little literature and practical experience available in the slaughterhouses regarding the quality of organic carcasses and their appropriate price.

The grading of organic carcasses from pigs will not only be detrimentally influenced by different fattening performances and the often higher age of the animals at time of slaughtering but also in the future by the stipulation to feed 100% organic feedstuff. The prices paid to the farmers will go down accordingly. On the other hand, the enhanced sensory and nutritional quality of organic pork (higher intramuscular fat content, improved tenderness and taste, etc.) will not be rewarded properly. This drawback could be compensated for by a carcass evaluation system for organic meat or an individual quality concept for organic pork (Branscheid 2003, Werner et al. 2007). More research into carcass qualities specific to organic meat, the collection of respective data in the slaughtering houses and an adequate monetary renumeration is needed. At the same time, the expertise of the staff in the slaughtering house must be improved by training.

3.5.4 Nitrite curing salt in organic meat products

Current state of knowledge

According to Annex VIII of Regulation (EC) No 889/2008, sodium nitrite and sodium nitrate may be used in meat products provided that "… it has been demonstrated to the satisfaction of the competent authority that no technological alternative, giving the same guarantees and/or allowing to maintain the specific features of the product, is available." (VO(EG)Nr.889/2008). It is not only requested by legislation that the production of organic food is free from additives to the greatest possible extent but also that the consumers expect that the producers of organic foods refrain from using them, wherever possible (Beck 2004).

In meat and processed meat products, nitrite is used for color development as it provides flavor and has oxidative and microbiological effects (Beck et al. 2006a). Currently, there is no other substance available that will produce the same effects in meat and processed meat products as nitrite (Beck et al. 2006a).

Nevertheless, it is possible to produce slowly ripened raw sausages (dry sausages) and raw ham with a long ripening time without nitrite (Kabisch et al 2008).

Positive results in terms of flavor, cured meat color and protection against oxidation can be achieved by reducing the amount of curing agents. However, this amount does not display any antimicrobial effects any more. Often this dilemma can be solved by adjusting the recipe and by controlling the production process accordingly (Friedrich 2005, Beck et al. 2006).

From the food hygiene aspect there are some products that cannot be produced without nitrite. These include all spreadable raw sausages with quick ripening times including onion mettwurst (fermentation temperature above 18-20 °C, ready for sale after 3 weeks or even earlier) and canned meat (cooked sausage) that are not subjected to a so called botulinum cook (F121 = minimum 3.0) (Kabisch et al. 2008, Lücke 2011).

Furthermore, cooked ham and "Kassler" cannot be made without nitrite due to their product characteristics (DLK 2011).

Cooked sausages made without nitrite have a grey color; the consumer may presume lack of freshness or even a spoilt product. Another drawback to introducing nitrite-free or nitrite-reduced products in self-service counters is their reduced shelf life compared to nitrite-containing products. A shorter best-before-date results in higher depreciation and does not comply with customer expectations (Beck et al. 2006, Friedrich 2005).

The knowledge needed for the production of nitrite-free or nitrite-reduced sausages and processed meat is available, but is known to only a few butchers because they learn their trade with nitrite in their apprenticeship and training. Given the lack of consumer acceptance for nitrite-free or nitrite-reduced products in terms of color and marketability, alternatives for replacing this chemical-synthetic additive are unavailable (Beck et al. 2006).

In practice, some producers are using vegetable powder as a source of nitrate. However, there are still some unsolved scientific and legal questions in this field (Stegeman et al. 2008, Kopp 2006).

Research and transfer needs

It is known how to produce sausages and processed meat products without or with lesser amounts of nitrite curing salt. Gaps have been identified in the area of knowledge transfer. In general, the effect of nitrite on product safety has been well investigated. There is some need for research on how to ensure food quality and shelf life and how to compensate for the flavor and color changes resulting from the non-use of nitrite. Furthermore, the use of vegetable powder, its effects and evaluation need to be researched more intensely.

3.5.5 Reducing the amount of binders and stabilizers by taking advantage of the “warm meat effect”

Current state of knowledge

Consumers expect from organic food that it has been made with no or as low amounts of additives as possible (Beck et al. 2004). The legislator also requests that hardly any additives shall be used in the production of organic food. Regulation (EC) No 834/2007 states in Article 4(c): “the strict limitation of the use of chemically synthesized inputs…” and in Article 6(b): “the restriction of the use of food additives, of non organic ingredients with mainly technological and sensory functions and of micronutrients and processing aids, so that they are used to a minimum extent and only in case of essential technological need or for particular nutritional purposes” (VO(EG)Nr.834/2007).

The water binding capacity of meat is one of the most important properties when producing heat-treated processed meat products. The water binding capacity is higher so long as the muscle contains adenosine triphosphate (ATP). The ATP content is at its highest level prior to rigor mortis. After ATP has been degraded and glycogen broken down, which cannot be regenerated because of lack of aerobic respiration, rigor mortis occurs and the “warm meat effect” is lost. Binders and stabilizers (condensed phosphates, often di-phosphates, or citrates) must be added to ensure that there is sufficient water binding capacity needed for the production of homogeneous sausage meat (Ungethüm et al. 1988, BLE 2003).

The processing of meat prior to rigor mortis (warm meat processing) is suitable for the production of cooked sausages. Time is another decisive factor in this type of processing. Beef must be processed within three hours, pork within one hour. If the meat is processed within this period, then no binders and stabilizers are needed for the production of high quality products (Schweisfurth et al. 1996). If for some reason the sausage meat cannot be processed on the day of slaughter, the favorable processing properties of warm meat can be preserved by so-called “warm mincing” (“warmschroten”) and shock freezing (oekolandbau.de 2009).

The advantages of processing warm meat and the respective processing methods are known (Prändl et al. 1988, Schweisfurth et al. 1996, oekolandbau.de 2009). Nevertheless, it is predominantly empirical values that are available and there is hardly any documented knowledge (Schweisfurth 2011). In practice, the method of warm meat processing is hardly used because slaughtering within a company is not very attractive from both the ecological and organizational points of view. Furthermore, there are only a few large slaughtering houses available and the long distances that have to be traveled to reach them may be prohibitive for warm meat processing. Veterinary controls are another obstacle in warm meat processing. They delay the production so that the optimum time span for warm meat processing may be exceeded (Beck 2011, Dylla 2011, Euen 2011).

Research and transfer needs

The process of warm meat processing complies with the objectives of organic processing. The theory of warm meat processing is well-known and described. However, there is hardly any documented experience. There is a need for knowledge transfer. Qualification measures for butchers are lacking. This subject is also not included in their education and training. Added to that, the framework conditions for warm meat processing should be improved because the special requirements for warm meat processing are not taken into consideration in the schedule and organization of slaughtering houses including veterinary controls.

3.6 Fruit, vegetables and products made thereof

Yvonne Henkel, Ann-Sofie Henryson, Kerstin Spory

3.6.1 Sprout inhibition in onions (Allium cepa)

Current state of knowledge

Right after harvesting, onion bulbs are in a dormant state. Depending on the variety, the bulbs start sprouting days or even weeks later which causes a loss in weight and quality (Bufler, 2009a).

The climatic conditions during the growth phase of the onions also govern their storability. Onions that grow under favorable weather conditions (average day and night temperatures between 17 and 18 °C from June through August and uniform distribution of rain) have a better storability (chilled storage) and there is less of a tendency to sprout early compared to onions grown in warm and dry weather which ripen prematurely due to these conditions (Adamicki 2005, 2006).

Since 2009, a sprout inhibitor may be used in conventional agriculture prior to harvest which prevents cell division in the meristem tissues thus inhibiting sprouting and root growth in stored onions for some weeks (Bufler, 2009a, Kühwetter, 2009).

As the sprouting tendency of onions is dependent on the variety, the storage period can be influenced by selecting the most suitable varieties (Lattauschke 2009, Laun 2011). Varieties with a good storability can be kept in machine-chilled storage at 1 °C for 6-8 months, in CA storage (controlled atmosphere) or ULO storage (ultra low oxygen) for as long as one or two more months. At a temperature of 4-5 °C, storage is possible until December (Koller et. al., 2007).

Apart from using proper storage technologies, the sprouting of onions can also be inhibited by ethylene. Since August 2008, ethylene – included in the list of substances and preparations for the production of pesticides as a “substance for the in-house preparation and production of plant protection agents” – may be used in the company according to Sec. 6a (4), sentence 3 of the German Act on the Protection of Plants in Organic Agriculture as a sprout inhibitor for onions and potatoes (Jacobsen 2008, Bufler 2009a). A treatment with ethylene can be performed with cylinder gas or with the so-called restrain process (generator that turns ethanol into ethylene and water) is possible.

Studies conducted by Bufler showed that the elongation growth in onions held in continuous ethylene (between 5 and 15 ppm) was inhibited at 3 °C as well as at 18 °C. If the exposure to ethylene is interrupted, the elongation growth starts again. One undesired side effect is that ethylene to various extents stimulates respiration, probably depending on the temperature (Bufler 2009a).

The sprout inhibition in onion bulbs can be influenced by variety selection, and chilled storage with respective technology can delay this until March/April. For prolonged storage, the use of ethylene and/or storage in controlled atmosphere (CA, ULO) is possible, but this will require expensive technology. For small and medium sized organic companies which do not have the latest chilled storage technologies (CA, ULO), the treatment of the onions with ethylene may be interesting in order to be able to supply the domestic market with onions for as long as possible.

Research and transfer needs

Transfer needs regarding the influence of ethylene on sprout inhibition

Approval of ethylene

Since ethylene is often used for suppressing sprouting in conventional onion agriculture, the experiences from this sector are hardly known in organic agricultural companies. A knowledge transfer is necessary to make the experiences from conventional production available to organic production.

According to Sec. 6a of the German Act on the Protection of Plants, ethylene may be applied as a “substance for the in-house preparation and production of plant protection agents” and can be used in organic agriculture for sprout inhibition in onions and potatoes.

The German Plant Protection Act is currently being revised. It is not known today whether this will have any consequences on the possible use of ethylene.

3.6.2 Storability of carrots (Daucus carota subsp. sativa)

Current state of knowledge

In general, for long-term storage carrots are kept in chilled storage. In regions with favorable climates (not too heavy a frost), it is also possible to store smaller amounts in so-called clamps or pits on the field (Wonneberger et al. 2004).

According to Vogel (1996), the optimal storage temperature is between 0 and 1 °C; higher temperatures support spoilage of the carrots. The relative humidity shall be at least 95% to prevent water loss as carrots have a tendency for strong transpiration. These conditions allow carrots to be stored for six to seven months provided they have not been damaged too much during harvesting.

According to recent studies, carrots shall be stored at below 10 °C within 24 hours after harvest, followed by a temperature below 5 °C after three days. After four weeks they shall be chilled at 0-1 °C until removal from storage. Humidity shall not fall below 98%. Furthermore, tests showed that the lining of large crates with plastic film can increase the storage yield because it prevents transpiration of the carrots. This is also the reason why water losses in larger storage areas are less when compared to smaller storage houses. Added to that, ethylene shall not be introduced into the storage area via fresh air because it promotes the formation of isocumarin which can result in bitter tasting carrots (Kägi et. al. 2008).

During storage, *Chalara* mould may cause quality deteriorations because the fungus discolors the surface of the carrots which first turn yellow and later cover the entire carrot with a grayish-black color. To minimize the infection risk, the carrots shall be harvested gently and at cool temperatures, if at all possible. In so-called shelf life tests, the carrots were first washed traditionally with circulating water. For the final flushing step, fresh water was applied with high pressure. This resulted in clearly fewer and smaller black *Chalara* spots on the carrots compared to carrots that had been subjected to the traditional washing process only (Kägi et al. 2008).

In the past, different institutes have worked on developing models to predict the storability of carrots (Ewaldz 1997, Alpers 2004). The presence of different storage diseases is used to predict the storability of a sample stored at 10 °C and high humidity for several weeks (forced storage) via an estimation framework. According to Alpers (2011), the approaches have not yet proved to be successful. Experts from the practical field also said in the interview that it would be interesting to have a prediction model on the storability of carrots on hand.

Research and transfer needs

Quality assurance for carrots

In terms of quality assurance, the washing process takes a central role in the carrot production chain, in particular, for the prevention of *Chalara* mould. Efficient improvements can be implemented quickly with the washing process. The additional final rinse with fresh water under high pressure results in clear improvements compared to the washing process commonly applied. This does not seem to be known among the practitioners; additional training and education will be necessary in this field.

Model for predicting the storability of carrots

The long term storability of carrots is often impaired by the onset of so-called storage diseases. A model that can be used to predict the possible storability of carrots and which is based on previously developed models will be of interest for the practice.

3.6.3 Storage of squash

Current state of knowledge

In organic and conventional agriculture, squash has developed from being a niche product into an attractive vegetable whose significance is on the rise. Squash sales have increased by almost 60% since 2003. The cultivation area in Germany has grown by almost one third within five years making up almost 1,800 hectares in 2010 (AMI 2011).

There is a large range of different squash varieties available. Predominantly, the red Hokkaido squash is interesting for agricultural production because of its attractive color, its handy size and its good processing possibilities. The green Hokkaido squash is also of some importance; it is said to have better storage properties (Hirthe et. al. 2007, 2008).

The right time of harvest is very important for the storability of squash. The stem must be well lignified; color intensity and the hollow sound also indicate the degree of ripening of the squash (Buchter-Weisbrot 2001). Depending on the variety, squash can be stored for four to six months between +10 °C and 15 °C (some varieties even longer). Squash intended for storage shall be undamaged, still have its stem and must be ripe (Pfisterer 2001, Wonneberger et.al. 2004).

Hirthe and Heinze (2007, 2008) conducted storage tests on squash (red and green Hokkaido) in two subsequent years. The storage temperature was between 10 and 15 °C. The storability of the squash deviated strongly from one year to the next thus indicating that the weather conditions prior to the harvest play a key role here. The storage trials also showed the slightly enhanced storability of the green Hokkaido squash. However, no storage recommendations could be derived.

Up to now there is hardly any literature available on the optimal storage conditions for squash. Practitioners in the interviews mentioned squash storage as being an important research topic.

Research and transfer needs

Investigation of optimal storage conditions of squash

While the cultivation of squash is becoming increasingly important, very little is known about its storage technology. This is a knowledge gap: Research is needed on the optimal storage conditions of squash including handling during harvest, subsequent drying as an important factor for the ripening of the skin, optimal storage temperature and humidity as well as other parameters that prevent the squash from bruising.

3.6.4 Influencing the quality of organic apples by storage technology

Current state of knowledge

Advanced storage technologies for organic apples use temperature reduction combined with controlled oxygen and CO_2 in the storage sections. The metabolic activity of the stored fruits can be reduced to a minimum with minor amounts of oxygen and increased levels of CO_2. This will enormously improve the storability of the apples depending on the variety. Such apple storage technologies are needed in order to be able to offer organic apples from domestic production throughout the year.

In "Dynamic Controlled Atmosphere" (DCA) or "Dynamic Controlled System" (DCS) storage, a minimal oxygen content atmosphere in the storage room is dynamically adjusted to the current physiological state of the apples. This is a further development of former technologies such as the "Ultra Low Oxygen" (ULA) or "Controlled Atmosphere" (CA) storage where the oxygen content in the atmosphere had been adjusted statically based on empirical values. With DCA storage, a reduction in the firmness of the fruit flesh and deteriorating fermentation processes can be prevented (Hennecke et al. 2008; Lafer 2009). During DCA storage, the fluorescence changes in apples are constantly monitored. The atmosphere in the storage will be dynamically adapted to the physiological activity of the apples and reduced to an oxygen level that is slightly higher than the one needed by the apples for survival (anaerobic compensation point). This optimized low oxygen storage is of interest for organic apple producers because a chemical post-harvest treatment with 1-MCP is not permitted for prolonging the storability (VO(EG) Nr.834/2007, Lafer 2008).

This high and specific quality of organic raw materials and food has already been discussed in the chapter on "Quality". Added to that, the high quality of organic apples – firmness of the fruit flesh, increased level of valuable substances including polyphenols or better taste – have been proven in a study. The difference between organic and conventional apple samples could clearly be assessed with holistic methods (picture forming methods, degradation tests) (Weibel et al. 2004).

The quality development during storage is defined by external parameters and individual components (Roth et al. 2007, Soska et al. 2006). Firmness and compounds in the apples change during storage. The ratio of soluble solids to organic acids, for example, increases with the storage time. If the values diverge too much during storage, the apples are perceived as being too sweet. In organic apple cultivation, the successful "Topas" variety shows a favorable ratio. Apart from storage time and modalities, the variety significantly influences the quality parameters of the apple (Soska et al. 2006).

Studies on the quality of organic food, more or less, focus on individual compounds or their concentration. A holistic quality concept for organic cultivation (Busscher et al. 2004) is able to prove the special quality of organic apples.

Research and transfer needs

Quality development of products stored under low oxygen conditions according to holistic test methods

The research needs on quality development of products stored under low oxygen conditions has to be assigned to the area of researching the holistic quality of organic products.

How does this quality develop according to holistic examination methods during CA storage compared to the commonly used analysis of components and other parameters such as firmness?

3.6.5 Gloeosporium fruit rot during the storage of organic apples

Current state of knowledge

An infection with Gloeosporium (bitter rot) during the long time storage of apples can result in up to 50% losses. Humid weather and late harvest have been identified as parameters supportive to infection. In post harvest, the infection can be significantly reduced by hot water treatment (BfE 2003, Maxin et al. 2005).

For optimum results, temperature and dipping time shall be adjusted depending on the variety. Hot water treatment may cause changes in the skin of some varieties; in this case, the temperature shall be reduced which in turn affects the reduction in bitter rot infection (Maxin et al. 2005). Maxin et al. (2006) recommend hot water treatment only for that part of the crop that is strongly threatened by the occurrence of Gloeosporium fruit rot. This includes, in particular, the varieties Topaz, Pinova and Ingrid Marie. This study did not recommend hot water treatment for Jonagold/Jonagored, Gloster, Boskoop and Holsteiner Cox.

Within the scope of research and development projects, hot water dipping plants have been designed which are economically feasible to be used in practice (Maxin et al. 2008). Standard hot water dipping plants are readily available as well as standard equipment at some organic fruit storage companies. It is possible to treat large crates with up to 300 kg apples in these plants (Kulling et al. 2011).

Gloeosporium is a mould species. Therefore, the search for naturally occurring antagonists suggests itself. Preliminary trials with an application on the tree and a subsequent post-harvest treatment have already been conducted with a yeast-like fungus (Aureobasidium pullulans) and lactic acid bacteria. The results show a large range of fluctuation. Tests with a product based on calcium bicarbonate yielded a more reliable inhibition of Gloeosporium (Rühmer 2010). Furthermore, tests with copper in the pre-harvest area also turned out to be successful. However, copper should be avoided as much as possible so this application is not a satisfying solution. Moreover, a significant reduction in infections in the pre-harvest area was observed with aluminum sulphate (sulphuric clay minerals, “Myco-Sin”) (Zingg 2004).

Research and transfer needs

Knowledge transfer in the field of hot water dipping plants

Over the past decade, some successful research has been completed in the field of hot water dipping plants used for preventing bitter rot during storage. This process reduces the occurrence of bitter rot in large companies. The implementation of the recommended measures is also relevant for small and medium-sized companies that also store apples. Appropriate knowledge transfer measures could help here.

Further research into antagonists or active agents to stop Gloeosporium

Up to now, the use of antagonists in the field of Gloeosporium control has yielded only moderate or deviating results. Research into other active agents has already been successful. Further need for research in this field has been identified in order to control bitter rot in the pre- and post-harvest area with specific microorganisms and possibly with other substances approved for organic cultivation. Contrary to a pre-harvest treatment, no post-harvest treatment is allowed in many countries, regardless of the type of substance applied. Therefore, it must be checked whether experimental scale results can be implemented into an approved practical application.

3.6.6 Preservation of pH-sensitive juices

Current state of knowledge

Juices, in particular, vegetable juices, are often pH sensitive. When the processing takes place at pH 4.5 and higher, the presence of pathogens cannot always be reliably excluded (Brosch 2009). Apart from the juice production itself (destruction of spores by heating to 120 °C), it is mainly the filling into glass bottles that is the critical point because during this process cross-contamination can occur (AoeL-Mitglied 2011). The microorganisms can be air-borne or present in the bottles, at the lids and in the machines (filling valves, etc). Large producers often have sterile rooms for aseptic filling processes. For economical reasons, smaller producers do not have these types of filling equipment (Braitinger 2008). They are confronted with the problem as to ensure the sterility of the juice during and after filling by other means. Low acid juices shall either be acidified or subjected to lactic acid fermentation (Schobinger 1987. Similar to the heating process, such processes may also impair the taste. Consumer requests, e.g. for mild carrot juice that does not have a sour taste, can currently not be met without risks.

Research and transfer needs

Basically, the aseptic filling into glass bottles is the right approach. However, it is associated with high costs for SMEs. Organic juices are predominantly sold in glass bottles, because they are ecologically reasonable and also an inert material; however, more research is needed in this field. The heating to higher temperatures for ensuring product safety for products in glass bottles also seems to be questionable because vitamins and other compounds shall be maintained as much as possible. The protection of the product (microbiological safety) and the organic requirements (glass bottle, preservation of compounds during heating) are conflicting issues. Alternative solutions for aseptic filling are available, but their application in practice is not satisfying (Schobinger 1987). One solution is sterilisation at 120°C. Thus the vegetative form is being destructed and spores are being inactivated.

Another solution is the mechanism of Tyndallisation where the vegetative form is being destructed through pasteurisation (about 90°C) and germination of the spores is being activated (about 20-35°C). This whole process can be repeated for several times (Interview juice producer, 2011). Questionable is in this context for example for how long the heating should last in terms of securing product quality as well as microbiological safety. Another question is if the additional energy consumption is ecologically compatible and which spores will be present in the air, the bottle etc.? The main emphasis is laid, amongst others, on carrot and beetroot juices.

In order to develop functional/economical, safe, ecological and energetically reasonable applications for SMEs/small plants, more research is needed in the further development of existing methods and the design of new, adapted technologies.

3.6.7 Alternative products to replace conventional antioxidants in processed potato products

Current state of knowledge

In potato processing, enzymatic browning reactions will occur triggered by endogenous enzymes in the potatoes (i.e. peeled potatoes, dumpling batter) (Heimann 1976). Conventional products are often chemically protected against oxidation with sulphur (sulfites – sodium metabisulfite or sodium bisulfite) (Heimann 1976). According to Annex VIIIa of Regulation (EC) No 889/2008 on Organic Production, sulphur is approved as an additive in fruit wines only. Therefore, there is no effective protection against oxidation that is not associated with impaired taste or discolorations. Some organic associations, e.g. Demeter, are even more restrictive when it comes to the use of antioxidants. They also disapprove of the use of citric acid (inhibition of the enzyme through lower pH) (Demeter 2010), a method that could be applied as an alternative to sulphur in preventing browning reactions (Heimann 1976). The use of lemon juice, a generally permitted alternative, may quickly lead to an acidic taste in the product.

Research and transfer needs

According to Regulation (EC) No 889/2008 on Organic Production, sulphurization is not allowed, and because Demeter bans the use of citric acid in its processing guidelines, research is urgently needed to identify approved and effective alternatives to conventional antioxidants. Consistency and with that the handling during cooking as well as the color of the final product are important criteria that are decisive for the consumer. Organic products that contain processed potatoes cannot always meet these criteria (see also Stiftung Warentest – test on organic dumplings). Compared to conventional products, organic products may yield presumably worse test results if these organic product properties are not taken into consideration.

3.7 Packaging

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The legal framework for the production of organic products, Regulations (EC) No 834/2007 and 889/2008, do not contain any stipulations regarding the packaging of organic products. It is only the organic associations that have defined requirements for the packaging of organic products (Seidel 2009).

3.7.1 Packaging made from renewable or recycled materials – ecosystem services

Current state of knowledge

Packaging made from renewable raw materials or recyclable, reusable, and biodegradable packaging materials is of high interest for the organic sector from the ecological point of view. Consumers of organic food expect that the packaging used will have no detrimental impact on the environment.

The life cycle assessments compiled so far do not provide clear results in terms of the ecosystem services of packaging made from renewable and biodegradable materials or do not cover individual parameters.

The German Federal Environment Agency assumes that, “it can be expected that biodegradable plastic materials are superior to common plastic materials from the ecological point of view, provided the raw materials come from sustainable agricultural production that works according to ecological criteria…” (UBA 2009).

The most decisive factors are the type of cultivation of the renewable raw materials and the associated environmental impacts such as monoculture, use of genetically engineered plants, use of synthetic fertilizers and pesticides.

This range of topics mainly affects agricultural research and will therefore not be discussed here.

The cultivation of renewable raw materials is expected to compete in the near future with the cultivation of food and the cultivation of crops as the total sum of arable land is limited. This will aggravate the competitive situation. In order to avert this competition among the cultivation of food/energy crops, “residual materials from the agriculture and food production must increasingly be used.” (UBA 2009). T To do this, it is necessary to investigate these residual materials or side products for further utilization or to develop ways for cascading utilization. Currently there is a joint project running in Germany on biorefining of lignocellulosis (“Lignocellulose-Bioraffinerie - Aufschluss lignocellulosehaltiger Rohstoffe und vollständige stoffliche Nutzung der Komponenten (Phase 2), Teilvorhaben 1: Projektkoordination und Projektdokumentation” (Nachwachsende-Rohstoffe.de 2011). More research is needed to review methods for the utilization of residual materials such as sugar or starch. Research carried out so far on different substances has been merely technology research that did not include life cycle assessments (Weiland-Wascher 2011).

A 2010 study of the nova institute on “The development of instruments to support the material use or renewable raw materials in Germany” showed the most important concrete changes to regulatory and support instruments (Carus et. al. 2010).

In the short term and due to the low quantities, a thermal utilization is more reasonable from the economical and ecological point of view. In the long run, however, the recycling and/or compostability of packaging made from renewable materials has to be considered individually from an ecological point of view. To date, packaging made from renewable materials, e.g. Danone Activa yoghurt cups. or calcium carbonate cups of the Lobetaler Molkerei (Gerber et al. 2011), are not subjected to material use but rather to energy recovery. Here again, the German Federal Environmental Agency defines requirements, namely that "a high quality material or energy use takes place at the end of the life cycle" (Beier 2009).

Possibilities and obstacles of material use have to be analyzed. For example, film layers made from whey proteins have been developed within the scope of the "Wheylayer" project. They ensure that the individual film layers can be separated for further recycling. The individual layers are additionally coated with whey proteins. The project has not yet been implemented and tested in practice (WheyLayer 2011). Implementation and transfer are needed here.

Research and transfer needs

Research and transfer in the field of packaging made from renewable materials is, in particular, needed for organic agriculture in terms of analyzing the environmental impacts within the value chain.

Added to that, the life cycle assessments for renewable materials have to be completed in terms of environmental impacts during cultivation, utilization and recycling.

The development of packaging materials made from organic residues from agriculture and food production must be pushed in order to prevent competition for agricultural cultivation areas. Furthermore, a possible cascading utilization should be taken into consideration. Research in this field shall focus, in particular, on the unused/hardly used residual materials/side products from the agriculture and food industries. Available residual materials are, amongst others, whey from cheese production (WheyLayer 2011), offal from slaughtering, pomace from juice production, etc.

Research is needed to identify the reusability challenges with the goal of being able to recycle packaging made from organic plastics or from plastics not produced from mineral oil derivatives (e.g. yoghurt cups made from calcium carbonate). Further research is needed into how to overcome these difficulties and/or which alternative recycling methods would be available.

3.7.2 Migration of substances from the packaging – a risk for organic quality?

Current state of knowledge

Organic products are characterized by a very careful and labor-intense agricultural production that prevents the use of and the contamination with synthetic pesticides. According to experts, the migration of compounds from the packaging material has a much higher impact on organic food than pesticides (Grob 2010). The objective must be to exclude these risks as far as possible and to offer safe organic food.

An increasing number of studies show that compounds migrating from packaging into the food may have a detrimental health effect. High risk materials include plasticizers from twist-off lids or printing ink compounds (mineral oils) from recovered paper packaging (primary or secondary packaging) (Muncke 2009).

Phthalates are mainly used for the production of products made from plasticized PVC such as toys, cosmetic and household products, but they are also contained in lid seals or PVC films. These substances are not chemically bound to PVC. They can easily be released by contact with liquids or fats. Phthalates are suspected of affecting the hormone system, causing cancer or impairing fertility. Animal studies showed that phthalates impair male fertility and may cause developmental disorders among their offspring. The use of phthalates as a plasticizer in PVC films intended to come into contact with food is generally forbidden (SR 817.023.21), but not in lid seals. The EFSA has reevaluated different phthalates and defined specific TDI values, for example, 0.05 mg per kg body weight for DEHP.

IXT and benzophenone are used as UV-cured photoinitiators; they support the drying of printing ink on paper board or plastic materials. ITX migrates into the food by contact while the volatile benzophenone is transferred into the food if no functional barrier is present. There was insufficient data available to EFSA for a concluding evaluation so that both substances were not considered as having a mutagenic or genotoxic potential.

In terms of mineral oil residues in packaging from recycled paper two hydrocarbons have been distinguished: open-chain, branched, “mineral oil saturated hydrocarbons” (MOSH) and “mineral oil aromatic hydrocarbons” (MOAH) (PTS:PTS914). The body easily absorbs and accumulates MOSH up to C35. As shown in animal studies, these can damage the liver, cardiac valves and lymph nodes. However, up to now, no clinical, toxicological significance could be found for these deposits (ANS 2009). Therefore, the precautionary principle shall apply. According to the German Federal Institute for Risk Assessment (BfR), it cannot be excluded that MOAH contain carcinogenic compounds. Current risk assessments by BfR consider a temporary ADI value of 0.01 mg per kg body weight for mineral oils with a mean molecular weight (C16 – C35) as proposed by the JECFA (Joint FAO/WHO Expert Committee on Food Additives). Based on usual assumptions, the safe maximum concentration in food would be 0.6 mg per kg body weight for MOSH and 0.15 mg per kg body weight for MOAH.

Research and transfer needs

Neither the EC Organic Regulation nor the associations are looking into the migration risks posed by packaging materials. Nevertheless, consumers request that organic products are free from residues. This cannot be guaranteed. Migration takes place uncontrolled and by accident, making it impossible to ensure the complete absence of residues. Nevertheless, the organic sector should take a view on this subject and create awareness on low migration packaging within the industry. Added to that, potential toxicological health risks caused by migration residues must be more deeply investigated and analyzed including binding risk evaluation statements. As long as this does not happen and as long as too many uncertainties impede an objective risk assessment, the precautionary principle applies to protect the interests of the consumers.

3.7.3 Packaging technologies put to test: ionizing radiation

Current state of knowledge

According to Regulation (EC) No 834/2007, the treatment of food with ionizing radiation is prohibited; however, this restriction does not apply to the packaging sector (Gerber et. al. 2011). Irradiation not only destroys the microorganisms’ DNA, it also affects the packaging: new polymer links will develop and existing chains split (Guillard et al. 2010). This changes the mechanical properties of the packaging materials (e.g. the stability increases or decreases, etc.). The production of volatile substances (radiolytic products) is also possible which may then migrate into the food and change the sensory properties (Welle 2005). The type and extent of the changes is not only dependent on the irradiation dose (in kGy) and the irradiation type but also on the presence of oxygen. Apart from that, the type of packaging materials and the amount and type of additives have a strong influence on the formation of radiolytic products. The production of bioplastics materials even takes advantage of the linking effect of the rays (Guillard et al. 2010). Studies showed that the migration behavior of PET and polystyrene is hardly changed as a result of the irradiation (5 – 25 kGy), but polyolefins (PE, PP), polyamide and PVC seem to become more susceptible to change (Welle 2002).

Research and transfer needs

There are hardly any findings available on the toxicological risks of irradiation of packaging and consequently of food. It is only known that there are changes. It has not yet been clarified if the precautionary principle of the IFOAM shall be applied in this case resulting in a ban of irradiation of packaging used for organic food. Further research into the risks posed by different packaging materials and, in particular, the bag-in-box system is recommended.

3.7.4 Packaging technologies put to test: nanotechnology

Current state of knowledge

Applying nanotechnology can improve the properties of packaging materials thus resulting in an improved shelf life of the food. In general, there are different nanotechnology applications that can be used in packaging:

- Nanocomposites improve the material properties of packaging materials, for example, the mechanical properties (stability, processability through the use of nanoclay, nano-titanium nitride, nano-aluminum oxide fibers for plastics), improved barrier properties of plastics or bioplastics materials against gases (nanoclay) and UV rays (nano-titaniumnitride); protection of cardboard against mould or for the reduction of material weight (Fiedler 2008, Lagaron et al. 2005).
- Nanocomposites are active agents in active packaging and will migrate into the food in order to prolong the shelf life, e.g. antimicrobial coatings (nanosilver), O_2 scavengers (nanoclay in combination with metal oxides, e.g. ferric oxide), enzymes (Azeredo 2009, Duncan 2011). The nanoparticles are bound to surface coatings and can be released slowly.
- Nanocomposites in intelligent packaging (nanoclay with metal oxides) are used as biosensors; they monitor the condition of the food and display the degree of ripening (Hatzigrigoriou et al. 2011).
- In general, the organic sector has a critical attitude towards the application of nanotechnology. For IFOAM, the use of anthropogenic nanotechnology is not compatible with the precautionary principle. Therefore, the contamination of organic food with such substances, e.g. via packaging, shall be avoided as much as possible (IFOAM 2011). As long as toxicological risks for man (e.g. caused by migration) and for the environment (e.g. via disposal) cannot be excluded, no nanotechnology should be used in organic product packaging (Gerber et. al. 2011). However, a general ban shall be reassessed and detailed approvals drawn up in order to use the opportunities that nanotechnology offers, e.g. resource savings by reduced

material consumption. For that, a number of general and organic-specific knowledge gaps must be filled.

Research and transfer needs

Nanoparticles can be incorporated e.g. between two layers, they can be bound to surfaces (coating) or are present as free nanoparticles (as subsequent surface treatment). Further research is needed to find out what quantities of nanoparticles will pass into the food (e.g. by migration, wear, diffusion through packaging layers) and/or how mobile the type of nanoparticle is.

There is also a lack of knowledge regarding the toxicity of orally ingested nanoparticles and their behavior in disposal and recycling streams.

Active packaging releases substances into the packed food or the environment in a targeted fashion with the goal of prolonging the shelf life. For the most part, such substances have an antimicrobial effect and inhibit the growth of microorganisms or destroy them. Apart from nanosilver, alternative antimicrobial substances in nanosize or larger can be used. Possible alternatives include plant extracts (e.g. rosemary oil), lysozyme, sorbic or benzoic acid. Research and development is needed to determine efficient active agent-food combinations and to achieve a similarly high efficiency without the use of nanoparticles. Moreover, the organic sector should present its view on the functioning principle of an active packaging (BÖLW statement (in the German language only) “Nanotechnology statement regarding its use in food processing”).

Today, the competitive use of bioplastics would be unthinkable without the use of nanoparticles. Bioplastics can only compete with their mineral oil based counterparts when they have barriers or their processing properties (machineability or stability) have been enhanced by nanotechnology (Sanchez-Garcia et al. 2010, Lagaron et al. 2011). For that, cellulose or other bioplastics basic materials are nanotechnologically modified apart from using synthetic nanosilicates. However, the stability of these nanoapplications within processing, their toxicological potential and their behavior during composting it is almost unknown.

3.8 Sustainability

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3.8.1 Legal basis for sustainable processing

Current state of knowledge

In order to limit the topic of sustainability/sustainability approaches and the focus to organic processing, in a first step we analyze whether and, if so, which legal requirements of Regulation (EC) No 834/2007 obligate the processing enterprise to address the issue of holistic sustainability based on the three pillar model.

From the matrix below (Tab. 1) it becomes clear that Regulation (EC) No 834/2007 hardly contains any direct requirements or instructions for actions regarding the issue of sustainability. From the general requirements of Regulation (EC) No 834/2007, primarily indirect instructions for actions regarding the individual indicators of sustainability can be derived. The development and operational implementation of a typical, specifically organic, strategy of sustainability with measurable and, therefore, comparable indicators can neither be inferred nor demanded based on the Regulation. Thus, at the legal level, there are no or only very minor systematic differences between organic and conventional processing procedures where aspects of sustainability are concerned.

However, often conflicts of objectives are observed between high product quality and possible objectives of sustainability (Kammermann 2010). Therefore, it is necessary to take into account sustainability aspects when refining the rules of organic processing. It is, however, still unclear how certain regulations affect indicators of sustainability. This is true in particular for the exclusion of technologies, such as the prohibition of the use of genetically modified organisms (GMO) or of synthetic chemical additives. It remains unclear how excluding these technologies may lead to altered CO_2 emissions or differences in resource consumption.

A survey of experts conducted as part of the QLIF project also showed that aspects of sustainability such as environmentally acceptable processing, packaging, regionality or even social justice, ought to be better regulated in the field of processing. However, the survey did not yield any unambiguous results regarding the question whether this should be regulated by legislation or at the level of private associations (Kretzschmar et al. 2011).

Research and transfer needs

Sustainability analysis of the exclusion of technologies and additives is necessary, for example by means of life-cycle analysis

(Knowledge) transfer to the regulator regarding requirements of ecological, economic, and social dimensions of sustainability in organic processing are necessary

Regulation (EC) No. 834/2007		Biodiversity	Water consumption/contamination	Carbon balance / energy consumption	Consumption/ contamination of natural resources soil, air, raw materials	Economic efficiency	Investment behavior	Efficiency of ingredients/amounts of waste	Stakeholder involvement / fair trade relationships	Qualifications / continued education	Corporate social responsibility / social commitment
Objectives, Article 3	Producing a wide variety of foods and other agricultural products that respond to consumers' demand for goods produced by the use of processes that do not harm the environment, human health, plant health or animal health and welfare.	direct influence: site equipment indirect influence: purchasing behavior / terms of delivery	variety requires a lot of water, but produced by means that are not detrimental to the environment	variety requires a lo of energy, but produced by means that are not detrimental to the environment	produced by means that are not detrimental to the environment	causes costs	more investments necessary in order to create variety	increased amount of defective products due to variety (cessation of production etc.)	no influence	demand for higher-level artisan knowledge	produced by means that are not detrimental to human health responsible action that is not detrimental to human and animal health
General principles, Article 4	To exclude the use of GMOs and products produced from or by GMOs with the exception of veterinary medicinal products	promotes biodiversity; prevents monocultures	no influence	no influence	prevents soil contamination	causes costs	no influence	limited selection	no influence	no influence	indirectly: social commitment
	To conduct risk assessment, and use of precautionary and preventive measures, when appropriate	protection of biodiversity through	protection of water through precautions	protection of the climate through precautions	protection of resources through precautions	increased cost of risk assessments	no influence; precautionary principle	no influence; precautionary principle	no influence	qualifications required	precautionary principle for health protection
Specific principles for the processing of organic foods, Article 6	The production of organic food from organic agricultural ingredients, except where an ingredient is not available on the market in organic form	direct influence: site equipment indirect influence: purchasing behavior / terms of delivery	water consumption / contamination	carbon balance/energy consumption	consumption/ contamination of natural resources soil, air, raw materials	economic efficiency	investment behavior	ingredient efficiency / amounts of waste	stakeholder involvement/fair trade relationships	no influence	requests for sustainable raw materials
	The restriction of the use of food additives, of non organic ingredients with mainly technological and sensory functions and of micronutrients and processing aids, so that they are used to a minimum extent and only in case of essential technological	no influence	unknown	increased energy consumption due to prolonged processing procedures	different consumption of resources depending on the production process	causes costs	increased expenditure	increased amount of ingredients necessary; limited selection	no influence	demand for higher-level artisan knowledge	consumer protection
	The exclusion of substances and processing methods that might be misleading regarding the true nature of the product	no influence	no influence	no influence	no influence	causes costs	increased expenditure	no influence; limited selection	no influence	demand for higher-level artisan knowledge	no influence
	The processing of food with care, preferably with the use of biological, mechanical and physical methods	influence of the production process (space	increased water consumption for more careful production methods	increased energy consumption for "more careful" production methods	no influence	causes costs	increased expenditure required for careful processing	no influence; limited selection	no influence	demand for higher level artisan knowledge	no influence
Prohibition of ionizing radiation, Article 10	The use of ionizing radiation for the treatment of organic food or feed, or of raw materials used in organic food or feed is prohibited.	no influence	no influence	energy needs for alternative pest control	radioactive wastes are avoided	no influence	increased expenditure	no influence; limited selection	no influence	qualifications required	worker's protection
General requirements for the production of processed foods.	The preparation of processed organic food shall be kept separate in time or space from non-organic food	no influence	increased water consumption for higher cleaning effort	increased energy consumption higher cleaning effort	increased usage of resources higher cleaning effort	increased cost for physical separation	expenditure for larger storage areas and cleaning	no influence; limited selection	no influence	knowledge of segregation of flow of goods	no influence
	Substances and techniques that reconstitute properties that are lost in the processing and storage of organic food, that correct the results of negligence in the processing of these products or that otherwise may be misleading as to the true nature of these products shall not be used.	no influence	influence of the production process	influence of the production process	increased consumption of resources, higher costs	increased costs	increased expenditure	increased amount of ingredients necessary; limited selection	no influence	demand for higher-level artisan knowledge; qualifications required	consumer protection

Table 4 **Requirements or instructions for actions laid down in Regulation (EC) No 834/2007 with respect to sustainability**

3.8.2 Process-oriented quality approaches to measuring sustainability

Current state of knowledge

Sustainability is one aspect of process-oriented quality of organic products. So far, there is no uniform, standardized set of indicators of sustainability that could be used for measuring the performance of enterprises. The existing approaches are either a) not based on performance but on management (e.g. GRI G3 Guidelines), b) concern only partial aspects of sustainability (carbon footprint according to PAS2050 or GHG Protocol, life cycle assessment according to ISO 14040 and 14044 with various methods for impact analysis, ecological footprints, etc.), or, c), they encompass only individual parts of the value chain (KSNL, RISE).

Therefore, individual assessments of sustainability cannot be compared beyond an individual enterprise. Based on the Rio sustainability conference (Rio+20/Earth Summit, 2012) and on behalf of the FAO, the Bern University of Applied Sciences - School of Agricultural, Forest, and Food Sciences, HAFL and FiBL are developing guidelines for a uniform assessment of sustainability in the food sector. These guidelines will be performance-oriented, and processors will be able to apply them as well. However, they will need to be broken down by sector.

Research and transfer needs

Research for refining performance-oriented indicators of sustainability

Scientific research is needed in order to develop concrete, performance-oriented indicators of sustainability and to remove the currently existing vagueness and uncertainty regarding system limits, data bases, and calculation methods. Because of this lack of clarity, there also are no suitable implementations and best practice examples in the food business.

Research approach: Practice-oriented implementation of FAO guidelines for small and medium size organic processing enterprises and development of best practice examples.

3.8.3 Business management approaches to sustainability: Focus on business management systems

Current state of knowledge

As stated under 1.3.2, Regulation (EC) No 834/2007 does not directly require measures for the installation of an environmental or sustainability management system in organic processing businesses. From the IFOAM regulations and the association statutes, only an indirect request for organic food producers to establish their own, specific sustainability management systems can be inferred (Kammermann 2010).

Introducing complex environmental management systems that encompass the entire enterprise is difficult, in particular in small and medium size businesses. Often, it is more than artisan businesses can handle. According to a BMU study (BMU 2005) only very few enterprises employ complex systems such as EMAS. In 2009, only 20 agricultural businesses were EMAS certified, one of them being an organic business. The same is true for food processing. Of the 48 certified businesses, 8 are organic processing businesses (EMAS membership directory 2009). While there are about 15 additional environmental management approaches derived from the EMAS standard or from ISO standard 14001 that can be certified, they only take into consideration partial aspects of sustainability and the three pillar model. The tool most frequently used is “ÖKOPROFIT/ECOPROFIT” with a focus on lowering operational costs while sparing natural resources (BMU 2005).

The EFQM 2010 management system is of increasing importance. Since its revision, it specifically addresses the issue of sustainability with its three pillars. However, it is not yet a model of sustainability that offers certification.

In addition, there are different standards and guidelines that have been developed worldwide with the intention of bringing about standardization and comparability of sustainability analyses. Of those, the ISEAL Code of Good Practice (an international reference document for the development of credible social and environmental standards), ISO standard 2600 (CSR guideline) and the GRI G3 guidelines (basic principles for a uniform reporting practice) are to be highlighted. A successful example for the implementation of the GRI G3 guideline is the 2010 sustainability report by the bread manufacturer “Märkisches Landbrot".

Other standards address partial aspects of the sustainability model. These are, for example, PAS 2050 (basis for the standardization of life-cycle assessments in the area of greenhouse gas emissions; PAS 2050 builds on the existing climate impact methods ISO14040 and 14044) and the Greenhouse Gas Protocol Scope 3 (an international binding set of rules regarding the determination of a greenhouse gas balance along corporate value chains).

All of these standardization approaches and guidelines may be used as individual building blocks in the development of management systems that encompass the entire enterprise. Thus, they form an important part of integrated management approaches. However, even taken in total they are not equivalent to classic enterprise management systems that consist of identifying goals, setting benchmarks, describing and implementing processes, and continuous improvements (e.g., plan - do - check - act cycles).

No specific holistic and binding sustainability approach dedicated to organic processing enterprises and the entire organic value chain could be distilled from the evaluated literature.

Research and transfer needs

Knowledge transfer from existing sustainability management systems to a practical implementation for the entire organic field

Existing all-enterprise sustainability management systems (e.g., EMAS, EFQM) and partial aspects of environmental management systems (e.g., GRI G3 etc.) should be reviewed and evaluated regarding their applicability to organic processing, in particular for small and medium sized processing businesses. Based on this review, systems considered suitable should be adapted to the special requirements of organic businesses. Interested organic processors also should be supported by knowledge transfer events, guidelines, and checklists when they introduce and implement sustainability management systems.

Research approach: Development of a practice-oriented sustainability management system tailored for artisan businesses, based on EMAS and EFQM requirements.

3.8.4 Business management approaches to sustainability: - Focus on social / ecological accounting

Current state of knowledge

Individual indicators for the documentation of sustainability in processing enterprises in the "economy pillar" are well known and can be measured in monetary terms. These include the rate of profitability, cash flow, net investments etc. In addition, approaches such as EFQM 2010 and the Balanced Scorecared derived from it serve to provide sustainability strategies with business management benchmarks, to make them quantifiable, and, thus, to develop a regulatory mechanism or a basis for comparisons. Therefore, initial approaches for the monetary quantification of environmental or sustainable performance within management systems exist, but they have not yet been translated into accounting systems.

In the scientific literature, two options (Fischbach 1997) have been described for monetary quantification of sustainability indicators within a business' accounting procedures: a) By integrating ecological data into the existing uniform accounting systems or, b), by extending the accounting systems by different types of tools.

However, neither of these approaches has been followed up upon in depth (Fischbach 1997). Stagnation can be observed regarding integration of these aspects into existing uniform accounting systems. The development of sustainability reports constituted a positive extension of accounting systems by other tools (Isenmann et. al. 2008). While different indicators for measuring sustainability criteria are developed, a comprehensive approach for the entire value chain of a particular food is still missing (see 1.3.2). For the purposes of social and ecological accounting, all indicators have to be monetarily assessed; in as far as this is possible and meaningful. There are different methods for this assessment available (willingness to pay, benefit transfer, hedonic pricing) (Hampicke 2003; Pruckner 2001). However, no practice-based model procedure has been developed so far. It will be necessary that such a model can be used both for the entire value chain and for individual food manufacturers.

Research and transfer needs

Knowledge gap and knowledge transfer regarding the issue of social ecological accounting and its practice-oriented application

Also see the call for R&D tenders of the German Federal Program of Organic Agriculture and Other Sustainable Forms of Agriculture (Bundesprogramm Ökologischer Landbau und andere Formen nachhaltiger Landwirtschaft) in the area of "Socioeconomics" of August 1, 2011. This included various socioeconomic aspects of the sustainability issue. It remains to be seen which project plans will be submitted in this area and whether and to which extent they will address the issue of social economical accounting.

Research approach: Development of a social ecological accounting system based on selected practical examples from the ecological/organic processing field.

3.8.5 Business management approaches to sustainability: criteria of social sustainability specific to organic businesses

Current state of knowledge

Several management approaches focusing on “social” aspects, such as industrial safety/occupational safety, employee training etc. are documented in the business management literature. From the various management approaches, indicators of sustainability such as workplaces offered, age structure, gender balance, fluctuation etc. are derived for the practice.

In addition, various guidelines have been developed at the European or international level. These include social standards by Naturland, GRASP - GLOBALGAP Risk Assessment on Social Practice (an optional module on social responsibility by GLOBALGAP and partners, GIZ and German and Swiss food trade businesses) and the BSCI Code of Conduct (Business Social Compliance Initiative by European trade businesses). The BSCI Code of Conduct is intended to facilitate (adequate) working conditions and socially responsible behavior by its participants in a globalized economy. Its basis are the applicable national requirements, and its practical implementation by certification is regulated on the international level by guideline "SA8000 - Social Accountability". These guidelines are considered partial aspects of social accountability assessments of a company's global activity. For small and medium sized organic processing businesses in Germany, most of these criteria are regulated by legal requirements.

In addition to these basic social guidelines/laws, there are further indicators for a social sustainability assessment of food businesses such as the involvement of stakeholders (see Agenda 21) or the issue of fairness among the individual participants along the value chain.

Involving stakeholders in decision making processes in food and agricultural business has been sufficiently described in the literature (Gerlach 2006). However, there are no specific approaches and practical implementations for organic processing businesses.

Fairness along the value chain is a characteristic social aspect in the organic industry and, therefore, has been studied extensively (Schäfer et al. 2010, Schekahn et al. 2008, 2010). These studies describe, e.g., the factors contributing to successfully establishing and offering fairness along value chains. They also describe the issue of fair price setting, both for fair trade and regional initiatives and for the various organic growers’ associations.

However, topics such as regional social commitment and alternative economic systems (e.g., community supported agriculture [CSA] models) and their effects on employee quality of life and the environment are rarely found in the indicator sets of social sustainability. Here, adaptation is necessary, both of the indicators and of the implementation within sustainable business management systems.

Research and transfer needs

Knowledge transfer for the practice-oriented implementation of indicators of social sustainability specific for organic businesses into management systems

Research need regarding the development of indicators of social sustainability specific for organic businesses

Answers to concrete questions are required, including:

- The assessment of social actions within regional economic cycles
- The social importance of CSA projects, in particular in urban areas
- The assessment of quality of life.

3.8.6 Research regarding the sustainability pillar of ecology: Biodiversity management

Current state of knowledge

Because of the significant complexity of biodiversity assessments there is currently no suitable approach for evaluating the biodiversity effects of various foods along the value chain in a product-based manner. Carbon balancing offers a number of different approaches, but the entire value chain cannot yet be described (Schader et al. 2010). Thus, current biodiversity management systems are only partially related to effects.

Management systems for biodiversity are described as individual systems based on the PDCA cycle management method. Direct effects of a company's behavior on biodiversity (e.g., Schaltegger et al 2010) are compared in matrices to the relevant internal functions via general factors such as site/building, supply chain, production processes, transport and human resources. This management approach can be transformed by different methods such as audits (EMAS) or guidelines (BMU 2010) into holistic enterprise management systems. However, there is no mandatory integration of biodiversity management systems into the practical implementation of organic guidelines for processing businesses (e.g., Regulation (EC) No. 834/2007 or association guidelines).

Research and transfer needs

There is no applicable method for the product-related assessment of (impacts on) biodiversity along the value chain

Research approach: Practical implementation of biodiversity goals in enterprise management systems of organic processing businesses.

Knowledge transfer in the field of biodiversity management

So far, there are no manuals, guidelines, or checklists for establishing a specific organic management system for biodiversity along the entire organic value chain. Thus, it would be important to develop practical biodiversity management models and matching implementation aids.

3.8.7 Research regarding the sustainability pillar of ecology: Water processing and waste water treatment in organic businesses

Current state of knowledge

Generally, the use of drinking water quality water as defined by Directive 98/83/EC as processing aid for organic products is approved according to Regulation (EC) No 889/2008. In addition, only a limited selection of (washing) water additives or detergents and disinfectants are approved for organic products (Regulation (EC) No. 889/2008 Appendix VIII Section B and Appendix VII).

However, there are no additional requirements, neither at the legal level nor at the association level, regarding the ecological, environmentally friendly handling of water in organic processing businesses. Water consumption and waste water production vary depending on the processing step (such as washing, rinsing, blanching, cooking, pasteurizing, cooling, steam production, general plant cleaning) and product (e.g., 30 m³ waste water generated per 1 ton of frozen carrots or 4.15 m³ for 1 ton of beer; Casani et al. 2005).

Environmental management systems contain approaches for the ecologic use of water. The most effective elements are options for conserving water, the conscious use of water of different qualities, the degree of water contamination, and water processing procedures.

Examples of possibilities for conserving water include the reuse of water, e.g. in corn starch production, or in optimized combinations of cleaning baths and rotary-drum washers and a coordinated control of pressure, time, and movement in fruit and vegetable cleaning (Mosig 2004). In addition to drinking water, process water can be used in many instances (Mavrov et al. 2001); or water consumption may be reduced by 20% to 50% by treatment (Oelmez et al. 2009). One suitable balancing tool for water consumption is the water footprint (Sonnenberg et al. 2009; Hoekstra et al. 2003, 2009, Hörtenhuber et al. 2011).

Two important parameters of the environmental impact of waste water are the physico-chemical quality of added additives such as disinfectants and detergents and the amount of contaminated waste water (Oelmez et al. 2009). Quality is assessed based on the water's chemical oxygen demand (Mosig 2004). Methods used for the treatment of waste water, depending on its quality, are enzymatic techniques, application of oxygen or chlorine, membrane-based separation methods such as reverse osmosis, nano, ultra, or micro filtration, and UV irradiation (Casani et al. 2005). Some of these water treatment methods are not approved for direct contact with foods in organic food production, e.g., ozone and chlorine. For many other treatment methods, detailed information on environmental and health impacts is not available, and the organic industry has not provided an opinion by now (e.g. for nano filters)

Research and transfer needs

Knowledge transfer regarding water management measures, e.g. the development of guidelines/checklists regarding water conservation potentials in organic processing

The water protective nature of organic agriculture and the agricultural practices supporting this nature have been documented in a guideline (Haas 2010). However, there is no or only very limited information on water management in organic processing businesses. Knowledge transfer measures such as checklists for potential measures of water conservation and for waste water management might make businesses aware of the issue and might result not only in ecological but also in economic advantages.

3.8.8 Pest-control in organic businesses / Organic pest management

Current state of knowledge

Pests of stored goods or stored product insects are a problem known to every business processing, storing, or transporting foods. Typical stored goods include grains, fatty seeds (nuts, raw cacao, oilseeds), pulses, tea, spices, dried fruit, raw coffee, and tobacco (Adler 2010). In conventional storage facilities, affected foods are treated with synthetic chemicals (Wyss et al. 2007). Biological pest control is similar to integrated pest management and is a holistic concept. Association guidelines as well as the EU Organic Regulation limit the choice of protection methods for stored goods and prefer methods that prevent pest infestations, such as cleaning and construction measures, over post-infestation control measures (Schoeller et al. 2005). The use of traps for invasion monitoring and pest monitoring is essential for biological pest control, as is the non-use, as far as possible, of synthetic chemicals and the recommendation of natural substances (Schoeller et al. 2005). Alternative pest control measures such as the introduction of beneficial animals (biological measure), pressure treatments, thermal treatments, saturated steam processes, impact treatment (physical procedures) or the use of diatomaceous earth and chemical measures are available as adjunct techniques (Marschall et al. 2007). The computer software VOEL 1.0, developed specifically for use in organic agriculture, supports businesses in the decision making processing when it comes to determining which control measure will be particularly effective at what point in time (Schoeller et al. 2007).

Research and transfer needs

Ecological refinement of physical and thermal measures

High (about 55°C) and cold (-20°C) temperatures are considered effective pest control measures. However, the heating or cooling of large rooms for extended periods is associated with high energy costs. In most cases, thermal applications are based on general assumptions. The detailed determination of treatment time and temperature required to eliminate individual pest species is still in its infancy, as is the development of energy conserving thermal ovens.

Need for applied research in the field of beneficial animal use

One of the most ecological pest control measures is the release of beneficial animals to prevent a pest invasion or to control minor to intermediate infestations. Both the scientific basis of matching beneficial animals with pests and some commercially bred beneficial animals are available. However, not all useful beneficial animals can be bred at industrial scales (e.g., Holepyris sylvandis for the control of the red flour beetle [Tribolium castaneum]) and their use in special storage facilities such as silos has not been tested. Successful releases of beneficial animals depend not only on the time of release, the distribution and quality of the beneficial animals, but also on the adapted management of the business.

Knowledge transfer and training measures for disseminators and organic farmers regarding construction planning of insect proof storage rooms

The main risk of infestation with storage pests is not encountered in silos or storage facilities of mills and other processing businesses, but during storage on the farm itself. Any damage of harvested goods always constitutes an economic damage for the grower, but farmers know very little about preventive post-harvest protection measures and pest monitoring. A particularly effective measure for the prevention of pest invasions is the adequate construction of storage facilities. Therefore, farmers and disseminators of information should be provided with sufficient information for the planning and implementation of insect-proof storage facilities.

Abbreviations

Abbreviation	Long form
1-MCP	1-Methylcyclopropene
ADI	Acceptable daily intake
ALA	Alpha-linolenic acid
ALP	Agroscope Liebefeld-Posieux
AMI	Agrarmarkt Informations-Gesellschaft mbH
AoeL	Assoziation ökologischer Lebensmittel Hersteller e.V.
ATP	Aenosine triphosphate
ATR	Vertikale Kugelmühle (Ball mill)
BFEL	Bundesforschungsinstitut für Ernährung und Lebensmittel, now Max Rubner-Institut (MRI)
BfR	Bundesinstitut für Risikobewertung
BLE	Bundesanstalt für Landwirtschaft und Ernährung
BMELV	Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz
BMU	Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherheit
BNN	Bundesverband Naturkost Naturwaren
BÖL	Bundesprogramm Ökologischer Landbau now BÖLN (Bundesprogramm Ökologischer Landbau und andere Formen nachhaltiger Landwirtschaft)
BÖLW	Bund Ökologische Lebensmittelwirtschaft e.V.
BSCI	Business Social Compliance Initiative
CA	Controlled atmosphere
CI	Confidence interval
CORE	Coordination of European transnational research
CSA	Community Supported Agriculture
CSB	Chemischer Sauerstoffbedarf (chemical oxygen demand)
CSR	Corporate Social Responsibility
CSV	Comma-Separated Values
d++	cumulative effect size
DCA	Dynamic Controlled Atmosphere
DCS	Dynamic Controlled System
DECHEMA	DECHEMA Gesellschaft für Chemische Technik und Biotechnologie e.V.
DEHP	Diethylhexylphthalate
DHA	Docosahexaenoic acid
DLG	Deutsche Landwirtschafts-Gesellschaft e.V.
DNA	Deoxyribonucleic acid
DPA	Docosapentaenoic acid
ECNH	Federal Ethics Committee on Non-Human Biotechnology
EDIFACT	Electronic Data Interchange For Administration, Commerce and Transport
EFQM	European Foundation for Quality Management
EFSA	European Food Safety Authoroty
EMAS	Eco Management and Audit Scheme
EPA	Eicosapentaenoic acid

Abbreviation	Long form
ESL	Extended shelf life
FAO	Food and Agriculture Organization of the United Nations
FAWC	Farm Animal Welfare Council
FiBL	Forschungsinstitut für biologischen Landbau
FKZ	Förderkennzeichen (support code)
FNR	Fachagentur Nachwachsende Rohstoffe e.V
FS	Fettsäuren (fatty acids)
GHG Protocol	Greenhouse Gas Protocol
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GMO	Genetically modified organism
GRASP - GLOBALGAP	GLOBALGAP Risk Assessment on Social Practice
GRI	Global Reporting Initiative
GVO	Gentechnisch veränderter Organismus (Genetically modified organism)
HAFL	Hochschule für Agrar-, Forst- und Lebensmittelwissenschaften
HIT	Herkunftssicherungs- und Informationssystem für Tiere
ICC	International Association for Cereal Science and Technology
IFOAM	International Foundation for Organic Agriculture
ISI	Institute for Scientific Information
ISO	International Organization for Standardization
ITX	Isopropyl thioxanthone
JECFA	Joint FAO/WHO Expert Committee on Food Additives
JSFA	Journal of the Science of Food and Agriculture
KAT	Kontrollierte alternative Tierhaltungsformen
KMU	Kleine und mittlere Unternehmen (Small and Medium-sized Enterprises)
KSNL	Kriteriensystem nachhaltige Landwirtschaft der Thüringer Landesanstalt für Landwirtschaft
KTBL	Kuratorium für Technik und Bauwesen in der Landwirtschaft e.V.
LM	Lebensmittel (food)
MHD	Mindesthaltbarkeitsdatum (best before date)
MOAH	Mineral oil aromatic hydrocarbons
MOSH	Mineral oil saturated hydrocarbons
MUFA	MonoUnsaturated Fatty Acid
N-Dünger	Nitrogenous fertilizer
OGS	Organic Guarantee System
ORBI	Organisch Biologisch - Fördergemeinschaft für gesundes Bauerntum
PAS 2050	Public Available Specification 2050 „pecification for assessment of the life cycle greenhouse gas emissions of goods and services“
PDCA	plan–do–check–act
PDV	Productschap Diervoeder
PE	Polyethylene
PET	Polyethylene terephthalate
PflSchG	Pflanzenschutzgesetz (Plant Protection Act)
PP	Polypropylene
PUFA	Polyunsaturated fatty acid

Abbreviation	Long form
PVC	Polyvinyl chloride
QACCP	Quality analysis of critical control points within the whole food chain and their impact on food quality, safety and health
QLIF	Quality Low Input Food
R&D	Research and development
RISE	Response-Inducing Sustainability Evaluation
SA	Social Accountability
SGOP	Sectoral Group Organic Processing
SHL	Schweizerische Hochschule für Landwirtschaft
SME	Small and Medium-sized Enterprises
TDI	Tolerable Daily Intake
UBA	Umweltbundesamt
UHT	Ultra-High Temperature
ULO	ultra low oxygen
VHM	Verband für handwerkliche Milchverarbeitung im ökologischen Landbau e.V.
WHO	World Health Organization

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