Processors' understanding of process quality: a qualitative interview study with employees of organic dairies in Germany and Switzerland

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Abstract

Purpose – Organic food processing must include organic principles to be authentic. This qualitative study aims to understand the processors' understanding of organic food processing quality.

Design/methodology/approach – This study is based on semi-structured expert interviews with eight employees of six purely or partly organic dairies from Germany and Switzerland. Interview themes are (1) quality of organic milk processing in general, (2) assessment of specific processing techniques, (3) product quality of organic milk and (4) flow of information between producer and consumer. The interviews have been audio-recorded, transcribed verbatim and thematically analysed.

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Findings – (1) Experts prefer minimal processing; some prefer artisanal processing, whilst others stress the advantages of mechanisation. (2) High temperature short time (HTST) pasteurisation and mechanical processing techniques are accepted; ultra-high-temperature (UHT) milk processing is partly rejected. (3) Traditional taste and valuable ingredients should be present in the final product. Natural variances are judged positively. (4) Consumers' low level of food technology literacy is challenging for communication.
Research limitations/implications – The results cannot be generalised due to the qualitative study design. Further studies, e.g. qualitative case analyses and studies with a quantitative design, are necessary to deepen the results.
Practical implications – The paper shows which processing technologies experts consider suitable or unsuitable for organic milk. The paper also identifies opportunities to bridge the perceived gap between processors' and consumers' demands.
Originality/value – The study shows the challenges of processors in expressing the processors' understanding of process quality.

Keywords Organic milk processing, Quality perception, Expert interviews, Qualitative text analysis
Paper type Research paper

Introduction

The organic food market has faced constant growth and a diversification of the product range, from only slightly processed foods to highly processed convenience products (Willer *et al.*, 2021; Bickel and Rossier, 2015; Davidou *et al.*, 2022). Organic products are popular because they are associated with health and environmental benefits (Durbul *et al.*, 2021). The quality of organic products includes the product characteristics and the way of processing (Kahl *et al.*, 2012). The organic agricultural production generates raw materials that are less contaminated with pesticides and some with a higher content of nutritionally valuable components (Yu *et al.*, 2018; Średnicka-Tober *et al.*, 2016). These should be preserved during further processing (Kahl *et al.*, 2014). For processing, several principles can be identified: The basic principles lie in the organic quality of the raw material, a certified production chain and the limitation of additives (Beck *et al.*, 2004). These requirements are found within the (EC) No 2018/848 which forms the base for organic food production in the European Union (Council of the European Union, 2018). Further broadly shared and discussed principles include the production conditions for the food product (carefulness, naturalness), human health and aspects of environmental and social sustainability (Beck *et al.*, 2004). These principles are reflected in some production standards of organic farming associations (Beck *et al.*, 2004). For the assessment of organic food processing Kahl *et al.* (2014) and Gallmann (2000) propose to include not only single processing techniques but the whole production chain, including packaging, storage and transportation.

There are several paths for the further development of organic food processing, from focussing on organic raw materials to precise guidelines for processing techniques and sustainability aspects (Beck, 2004b). Kahl *et al.* (2016) have called for more research to better align food processing with the organic principles. For this it is important to know how practitioners understand processing quality of organic food. This paper aims to give more insight into this topic.

State of knowledge

Stakeholder perspectives on quality

Food quality and safety are generated at every value chain stage (Malik *et al.*, 2014). There are several definitions for food quality (Bremner, 2000; Nwadi and Okonkwo, 2021) and the actors of the food chain have their own quality understanding (Ilbery and Kneafsey, 2000). Vasileva *et al.* (2019) illustrate this in their stakeholder model which includes the consumer perspective on food quality (expected quality (EQ)) and the producers' perspective (designed quality (DQ)). EQ includes consumer perceptions regarding the physical product, the production process and the systems of control and certification. DQ includes the legal requirements and internal company standards for processing. The last component of the model is the achieved quality

(AQ) which represents the product on the market. It includes product characteristics, such as the sensory impression, physicochemical properties or microbiological status. The AQ should meet the requirements of the food producers and all relevant legal requirements. It depends on several contextual factors (van der Spiegel *et al.*, 2003), such as the quality of the raw material, the available processing technology and processing environment (e.g. sanitary conditions), transportation and storage and also the expertise and attitude of the employees (Schoenfuss and Lillemo, 2014). Furthermore, the complexity of the company and food chain are important (van der Spiegel *et al.*, 2003). Whilst processors are aware of the processing of their products, consumers only have limited access to information about processing and certain product characteristics (information asymmetry). Characteristics that cannot be assessed during purchase or consumption are credence attributes, e.g. organic quality or processing technology (Loebnitz and Bröring, 2015; Manning and Kowalska, 2021). Credence attributes are prone to food fraud. A driver for food fraud lies in the economic sphere, e.g. higher sales prices for organic food. A sophisticated system of supervision and control is necessary for prevention (Manning and Kowalska, 2021). Certification schemes and food labels are an established method to bridge information asymmetry (Latino *et al.*, 2022) and organic labels have been found to influence the perception of labelled food products, also in the case of milk (Kun and Kiss, 2021; Kresova *et al.*, 2022). Consumers often expect more from organic products than the organic food regulations provide, which can pose a risk to processors if these high expectations are not met (Meyer-Höfer *et al.*, 2015). Consequently, Vasileva *et al.* (2019) propose consumer learning for bridging the gap between consumer and producer.

The focus of this paper is on DQ. For organic products, it includes the (EC) No 2018/848 and optionally standards from organic farming associations (Vasileva *et al.*, 2019). Within these guidelines, processors can implement their own understanding of process quality. The possibilities for processors to implement their DQ and the challenges concerning organic quality are illustrated below using milk as an example product.

Quality of organic milk

Cow's milk is a popular organic food product both in Germany and Switzerland (Federal Office for Agriculture and Food, 2020, p. 106; BioSuisse, 2020, p. 17; Kaufmann *et al.*, 2021, p. 25). It is rich in proteins of high nutritional value, fat-soluble vitamins, calcium and phosphorus (Hayaloglu and Güven, 2014). Organic milk shows a more favourable fatty acid composition, higher levels of α-tocopherol and iron, but a lower iodine and selenium content (Średnicka-Tober *et al.*, 2016; Stevenson *et al.*, 2018; Walther *et al.*, 2018; Arrizabalaga *et al.*, 2015). The main aim of processing is to enhance safety and shelf-life. Raw milk can contain pathogenic microorganisms. Good dairy farming practices help reduce the contamination risk but proper heat treatment is still necessary (Alegbeleye *et al.*, 2018; van Asselt *et al.*, 2017). Thermal stress leads to losses of heat-sensitive ingredients and alterations of the protein structure (indicator: β-lactoglobulin) which influences digestibility (Kilic-Akyilmaz *et al.*, 2022; Krishna *et al.*, 2021). Some studies showed a reduction of iodine content for UHT milk (Stevenson *et al.*, 2018; Payling *et al.*, 2015), whilst others showed no effect of thermal stress on iodine (Walther *et al.*, 2018). Despite the nutrient loss, the benefits of heated milk outweigh the risks of raw milk consumption (Claeys *et al.*, 2013). Heat treatment also affects the taste, resulting in a cooking flavour for UHT milk (Krishna *et al.*, 2021). Purely mechanical methods such as high-pressure pasteurisation (HPP) are not yet used for milk (Alegbeleye *et al.*, 2018). Table 1 gives an overview of the heating techniques with effects on shelf-life and β-lactoglobulin content.

Further common processing techniques are the fat standardisation via mechanical separation and the milk fat homogenisation with pressure up to 30 MPa (Sharma *et al.*, 2022). The digestion of homogenised milk is faster, but this showed no negative effects on human health (Michalski, 2007; Michalski and Januel, 2006; Tunick *et al.*, 2016). Processed milk is

Type of drinking milk	Heat treatments	Procedure	Shelf-life	Effect on heat indicator β-lactoglobulin (mg/L)
Traditionally pasteurised milk	HTST pasteurisation	Heating at 72–75 °C for 15–30 s	Shelf-life of about 8 days for storage temperature of ≤8 °C	3'100
Pasteurised milk with extended shelf-life (ESL milk)	HHST pasteurisation	Heating at 85–127 °C for 1–4 s	Shelf-life of 10–30 days for storage temperature of ≤8 °C	1'000–1'700
	Microfiltration, deep filtration and bactofugation	Combination of HTST pasteurisation and mechanical separation of germs	Shelf-life of about 18–20 days for storage temperature of ≤8 °C	2'500–3'000
Ultra-high temperature treated milk (UHT milk)	Direct ultra-high temperature treatment	150 °C for 2 s	Shelf-life of about 6 months at room temperature	200
	Direct ultra-high temperature treatment	138 °C for 4 s	Shelf-life of about 6 months at room temperature	800

Table 1. Overview of milk processing techniques

Source(s): Own table based on Sienkiewicz and Kirst (2006, pp. 204–207), Spreer (2018, pp. 173–178) and Strahm and Eberhard (2010, pp. 15–29), Vrese (2010)

packaged into different material, e.g. glass or plastic bottles. The milk packaging should be as inert as possible and protect the milk from environmental influences (Brody, 2015). Transport and storage of milk must be geared to the perishability of the product, e.g. by refrigerated transport and refrigerated storage of fresh milk (Gözegir *et al.*, 2008). UHT milk can be transported and stored at ambient temperature but its product quality decreases with increasing temperature and storage time (Santos *et al.*, 2022; Karlsson *et al.*, 2019; Deeth and Lewis, 2017). Most food losses at the transport stage are caused by people, so it is important to use qualified personnel (Lipińska *et al.*, 2019).

The DQ of organic milk includes the stipulations of (EC) No 2018/848 that allow all processing technologies described above, but the standards of the organic farming associations are partly stricter. They reflect the different approaches of the organic farming associations, e.g. biodynamic agriculture (BLE, 2020). The association Demeter has the strictest limitations for milk processing, allowing only HTST pasteurisation and fat standardisation. The other associations accept homogenisation. The extent of thermal stress is limited by several standards using β-lactoglobulin content as an indicator. Table 2 gives an overview of regulations from organic farming associations. The table is based on freely available documents of the organic farming associations. For German-speaking consumers, comparisons of the standards are available, e.g. BLE (2020). Knowledge of the differences between the regulations seems to be low for German and Swiss consumers (Janssen and Hamm, 2012; Stolz *et al.*, 2013). Best known amongst German consumers is Demeter (Janssen and Hamm, 2011), whilst the BioSuisse label is more popular amongst consumers from Switzerland (Stolz *et al.*, 2013).

Based on the principles of organic food processing, Leskinen and Särkkä-Tirkkonen (2004) identified key issues in the processing of organic milk. Regarding naturalness

Processing techniques	Organic standards in Germany and Switzerland Bioland	Biopark	BioSuisse	Demeter	Gäa	Ecoland	Naturland
HTST pasteurisation	(+)	(+)	(+)	(+)	(+)	(+)	(+)
Techniques for production of extended shelf-life (ESL) milk	(+)	(+)		(–)	(+)	(+)	(+)
HHST pasteurisation	(+)	(+)	(–)	(–)			
Microfiltration, deep filtration and bactofugation	(+)	(+)	(*)[1,2]	(–)			
UHT treatment (sterilisation)	(*)[3]	(*)[3]	(*)[3]	(–)	(–)	(+)	(+)
Homogenisation	(+)	(+)	(+)	(–)	(+)	(+)	(+)
Fat standardisation	(+)	(+)	(*)[4]	(+)	(+)	(+)	(+)

Note(s): [1] β-lactoglobulin content must be 3'100 mg/L
[2] max. heating temperature of cream phase: 90 °C
[3] β-lactoglobulin content must be above 500 mg/L
[4] only for skimmed milk
Legend: (+) = allowed, (–) = prohibited and (*) = allowed under certain circumstances
Source(s): Own table based on Biodynamic Federation - Demeter International e.V. (2021, p. 128), Bioland e.V. (2020, p. 5), Biopark e.V. (2016, p. 37), Bio Suisse (2021, pp. 207–208), Gäa e.V. (2014, p. 47), Naturland - Verband für ökologischen Landbau e.V. (2020, p. 3) and Ecoland e.V., Verband für ökologische Land-und Ernährungswirtschaft (n.d., p. 23)

Table 2.
Organic standards for organic milk in Germany and Switzerland

separation and isolation techniques, intensity of processing (heat, pressure) and transparency towards processing methods are critical. For environmental sustainability, food miles are relevant. Further environmental topics of processing are energy consumption (Josijevic *et al.*, 2020) and packaging material (Ghenai, 2012). For social sustainability, key issues are traditional processing technologies, regionally adapted small processing plants and the concept of freshness. Leskinen and Särkkä-Tirkkonen (2004) considered novel or combination technologies, such as HTST pasteurisation, HPP or microfiltration, for the further development of organic milk processing. Some of these are seen critically by some organic farming associations (see Table 2). Demeter and BioSuisse argue, their restrictions ensure careful and gentle processing (Kahl *et al.*, 2014). Yet, the term carefulness is also used in the (EC) No 2018/848 (§7) and is defined differently by experts in the organic sector (Kretzschmar and Schmid, 2011). Care can be related to the product but also to human health and the environment (Nielsen, 2004). Whilst the principles for organic processing are set, it is unclear how to translate them into practice. Experts set their own quality standards (Seidel and Kretzschmar, 2008) but describe finding processing technologies for organic food as challenging (Kretzschmar and Schmid, 2011). Besides the surveys by Seidel and Kretzschmar (2008) and Kretzschmar and Schmid (2011), literature on this topic is scarce, because most studies focus on other food chain members (Kamrath *et al.*, 2019).

To reduce this gap, we want to answer the following questions.

RQ1. What is the DQ of organic food processors?

RQ2. Which technologies do they deem appropriate for it?

Methods

We decided on a qualitative, exploratory study design suitable for not well-researched issues (Bitsch, 2005) with explorative, semi-structured expert interviews with employees of fully or partly organic dairies (Kruse, 2015, p. 167; Gläser and Laudel, 2010, p. 111). The employees are experts in their field because of their special knowledge and possibilities of action (Bogner *et al.*, 2014, pp. 11–12).

We developed the interview guideline according to Helfferich (2009, pp. 182–189) and conducted two pre-tests in partly organic food processing companies. The interview guideline covered four topics: (1) quality of organic milk processing in general, (2) assessment of specific processing techniques for organic milk, (3) product quality of organic milk and (4) flow of information between producer and consumer. The document "Supplementary Appendix_Interview Guideline" provides the basic interview guideline, translated by the authors.

We contacted the dairies at the Biofach Organic Trade Fair 2020 in Nuremberg and via telephone and were able to include six dairies in the research. All dairies hold the public organic certification and some additionally private organic certifications: Bioland (4 dairies), Naturland (3 dairies), Demeter (2 dairies) and Biokreis (1 dairy). According to the number of employees, all companies can be classified as micro, small or medium-sized enterprises (Commission of the European Communities, 2003, p. 39). The dairies completely focus on milk processing and do not combine farming and processing.

Due to the COVID-19 pandemic it was not possible to conduct the interviews directly on site. The pre-tests were conducted as telephone interviews. The method proved to be suitable (Oltmann, 2016) and was used for the final interviews. From August to December 2020, the first author conducted the telephone interviews with six employees from the fields of quality and production management, product development and research and development (employees E1-E3 and E6-E8) and with two from the field of communication and marketing (employees E4 and E5). Interview times ranged from 26 to 64 min (median: 45 min). The interviews were audio-recorded, transcribed with simplified transcription rules according to Dresing and Pehl (2011) and directly anonymised. The interviewees did not get any remuneration for their participation. All agreed in writing to the recording and processing of their data. The interviews were conducted, transcribed and analysed in German. Quotes from the experts in this article are translated by the authors. The interviews were analysed via qualitative text analysis (Kuckartz, 2019) using a set of deductive-inductive codes. The document "Supplementary Table_Code system" shows the code system. Consensual coding of half of the interviews with a student experienced in the field of qualitative content analyses strengthened the robustness of the coding guide (Guest *et al.*, 2012). The analysis was performed using MaxQDA 2020.

Results

In the following we present the findings from the interviews.

(1) Quality of organic milk processing in general

- Deductive codes

The experts assess the terms gentle and careful processing differently: some can describe their understanding precisely, two reject the terms as too vague. They describe gentle processing with as few, less intensive processing steps as possible to preserve the authenticity of the raw material whilst guaranteeing product safety. Careful processing means exclusively organic, resource-saving processing with minimal losses and regular monitoring of compliance with the defined quality parameters during processing.

With organic milk processing, the experts associate sustainable agriculture, more animal welfare, local production in good cooperation with the farmers and reduced packaging material, as well as artisanal and minimal processing with modern, energy-efficient technology.

The experts say organic processing should guarantee exclusively organic quality. Processing should add value to the product without the use of chemical substances and the addition or extraction of ingredients. On the one hand, the experts reject the imitation of

conventional products in organic quality and selling organic products in the non-organic food market. On the other hand, they explain that the entry of organic products into the mainstream market has positive effects because this supports environmentally friendly organic agriculture. They state that processing should be transparent to consumers, including traceability to the farmers. In general, organic food processing should not be assessed by single procedures but by the whole production system:

> [. . .] not so much always singly on one process or processing stage, but rather the whole thing as a whole, that is what I would like to see. (E7, p. 14)

- Inductive codes

The experts prefer production without food losses and with as few, less intensive processing steps as possible. They rate thermal stress as particularly critical and partly reject the complete disassembly of raw milk for standardisation. Instead work should be done by hand. The experts raised the topic of mechanisation during the interviews, which they assess heterogeneously. For the expert E2, manual processing leads to an own type of quality more suitable for organic. Following the guidelines of the organic farming associations:

> [. . .] is much more difficult than producing a standardised process in a conventional cheese dairy. But we work by hand [. . .] That's the big difference and also the attraction of making it. I am closer to the product. (E2, p. 10)

The experts describe that industrialised processes are more hygienic and lead to standardised products. Some experts accept a high extent of mechanisation for organic milk, whilst others associate organic quality with small-scale and manual processing:

> I personally think that a high process quality can only be achieved on a small scale. And that works in an alpine dairy, in a small production facility, [. . .], where someone does something artisanal. (E1, p. 9)

The experts raised the topic of local production which they find an important aspect of organic processing. They stress that local production supports the local economy, preserves regional foods and is more authentic.

(2) Assessment of concrete processing techniques for organic milk processing

- Deductive codes

Heat treatment

The experts assess HTST pasteurisation as necessary. They prefer extended shelf-life (ESL) milk because it combines the traditional taste of HTST pasteurised milk with longer shelf-life. They prefer a combination of microfiltration and pasteurisation because it leads to a longer shelf-life than bactofugation. One expert (E1) prefers HTST pasteurisation because it is only one processing step compared to pasteurisation plus microfiltration or bactofugation. This expert notes that the taste of HTST pasteurised milk is closer to that of raw milk than HTST pasteurised milk. Whilst HTST pasteurisation combined with mechanical methods is in line with organic processing for the experts, the case of UHT milk is more complex. Some experts (E1 and E8) reject it for organic food because of the negative impact on sensory aspects and nutritional value. Its long shelf-life contradicts the organic demand for freshness. Besides thermal stress, they criticise the packaging of UHT milk because it contains aluminium which is challenging in waste disposal. However, some experts (E2, E3, E5 and E6) point out the advantages of organic UHT milk: The long shelf-life ensures that UHT milk can be used as a reserve and might reduce food losses. It helps consumers change to an organic diet. Organic

raw milk production supports sustainable agriculture and animal welfare which outweighs the disadvantages. The specifications of BioSuisse and Bioland regarding β-lactoglobulin content are seen as an incentive to use careful processing methods but are difficult to implement in practice because the typical indirect heating technique leads to higher losses (see Table 2).

Fat treatment

Whilst the experts reject the complete disassembly of milk, the separation of fat and skimmed milk fits into their concept of organic milk processing quality, for it is purely mechanical. The experts accept the fat standardisation because semi-skimmed milk products generate fat for butter and cream and satisfy demands for low-fat products. The experts note they often use a slightly higher fat content for organic milk to better differentiate these from their non-organic milk (e.g. 1.5% fat for non-organic skimmed milk and 1.8% fat for organic skimmed milk). In Switzerland fat standardisation is prohibited for organic whole milk (see Table 2). One expert (E8) appreciates the natural fluctuations in fat content but says this is economically viable only for organic milk due to the higher sales prices.

The experts broadly accept homogenisation but some find non-homogenised milk more natural and special (E1, E2, E4 and E6). They see consumer expectations as limiting; especially consumers who shop in non-organic food stores would interpret creaming as spoilage.

- Inductive codes

Packaging material

Three experts mentioned packaging material (E1, E2 and E5), especially regarding consumer claims. Organic products should be in eco-friendly packaging but prevent food waste and ensure the desired shelf-life. Glass as a sensory-inert packaging material fits well with organic but is expensive to install and requires high amounts of water for cleaning.

Further technologies

Besides the processing of drinking milk, some experts (E1, E2 and E8) also reported on cheese and yoghurt production. Both are influenced by the natural seasonal variances of raw milk. These can be handled via adjustments of the incubation time or with a dry matter increase. They describe balancing the natural variances of cheese as craftsmanship, especially with the limited use of additives available for organic cheese-making.

(3) Product quality of organic milk

The experts describe raw milk quality based on fat and protein content, low germ and cell count, correct freezing point, pH and freedom from inhibitors. The nutritionally valuable ingredients should be preserved during processing. Some welcome natural variances within the product. One expert describes the beauty of differently composed milk throughout the year and proposes to

> take advantage of the fact that it's not always the same [. . .] and you don't have to try to always do it the same way. It's nice that there are differences (E1, p. 9)

This expert complains about the trend towards standardised products.

The experts mentioned the influence of processing, fodder and geographical origin on milk taste. It should be free from off-flavours and give a good mouth feel. One expert (E4)

states that organic milk has a fresher and more natural taste than non-organic milk. They reject the taste of UHT milk and prefer the taste of HTST pasteurised and ESL milk.

(4) Flow of information between producer and consumer

The experts report that only a few consumers ask questions about processing techniques. Consumers would be more interested in the nutrient content, special dietary needs and packaging material, animal welfare and hay milk. The experts report that organic farming associations become more relevant to consumers. Questions about processing usually come from organic customers because these are more interested in nutrition. Experts from dairies that offer guided tours report that during these, consumers show high interest in processing techniques.

Many experts explain that consumers reject HTST pasteurised milk because they want to buy groceries just once a week. Simultaneously they report a rising demand for natural products. Consumers have become accustomed to ESL milk and hardly ever ask questions about it. One expert (E2) suspects that most consumers are not aware of the difference. The experts report low consumer food technology literacy and that they interpret natural milk characteristics such as thickening as an indication of poor processing (E1, E2 and E8).

The experts see the rejection of modern technology in food production as problematic. One expert (E8) states that people accept modern technology and automatisation in other fields but reject it for food production. Consumers think that traditional, handmade production leads to better quality, whilst modern technology and automatisation often help reduce product damage from mechanical or thermal stress. Therefore,

> the only thing I admit to gentle processing is a sophisticated, well-engineered production line. (E8, p. 16)

Yet the expert would not use this description towards the consumer because these think

> [. . .], no, gentle processing is when you stir by hand in your cheese kettle. (E8, p. 16)

The expert sees a reason for this in the advertising, which does not show modern processing. Another expert (E3) would welcome less ideology and negative prejudices towards milk processing. The experts want consumers to appreciate the high value of the milk processing chain but to be critical of the production conditions.

They report that the decision on which information is used for advertising is influenced by the perceived consumer needs and competitor products. The package is the most important tool for consumer communication. It must contain the unique selling propositions of the product and the dairy.

(5) Further topics raised by the experts

Guidelines for organic food processing

The experts describe the (EC) No 889/2008 as simple to implement. They report that the guidelines of the organic farming associations and IFS Food (International Featured Standard Food) have greater impact on the processes in the dairies. Strict regulations can be challenging. Combining guidelines so that all products fulfil all relevant specifications gives more flexibility in the production process. The expert E1 describes finding the right level of rigour as challenging: Too much rigour ensures that no one can meet the standard; a too lax set of rules robs the standard of its meaning. However, production by stall husbandry only should be rejected by any organic regulation. One expert (E7) would like to see the approval of individual technologies that help to improve the eco-balance (e.g. reverse osmosis) but in general accepts the rigour of the guidelines. The expert states that the organic sector sees high-pressure technologies critically.

Food traders' requirements

One expert (E1) stresses the influence of the food traders' requirements on milk processing. Food traders expect fresh milk with a longer shelf-life and require skimmed milk in addition to whole milk.

Discussion

Regarding research question 1, the experts described their DQ in detail. They supplemented the topics of the interview guide with further aspects that play an important role in their understanding of quality. In line with Kahl *et al.* (2014), the experts' understanding of process quality includes not only single processing techniques but also the whole food production chain. They brought up several original aspects, including the extent of mechanisation, short transportation distances and packaging material (see inductive codes). Food miles and local production are key issues for organic milk production (Leskinen and Särkkä-Tirkkonen, 2004). Improving transport efficiency and the package are relevant to reduce the environmental impact of milk (Berlin *et al.*, 2008; Ghenai, 2012). Short food miles also reduce the risk of damage during transport (Lipińska *et al.*, 2019).

The experts include carefulness as defined by Nielsen (2004) and the humanisation of processing (Abouab and Gomez, 2015) in their DQ. Their quality approaches go beyond basic principles of organic food processing and include aspects of the broadly shared and discussed principles (Beck *et al.*, 2004). In contrast, their statements regarding product quality are mostly in line with the raw milk regulation (Federal Ministry of Food and Agriculture, 2021).

For high process quality, the experts advocate few, low-intensity processing steps to preserve the valuable ingredients, which can be described as minimal processing (Alzamora *et al.*, 2015). Food processing at an industrial scale is often easier to control and more efficient compared to the household scale (van Boekel *et al.*, 2010). Some experts see a high automation degree critically and stress the benefits of manual processing (E1, E2 and E5), whilst others state that machine control enables work gentler to the product (E8).

Regarding research question 2, the experts commented in detail on processing technologies that deem the appropriate. The experts prefer a combination of mechanical and thermal treatment for heat reduction. They accept HTST pasteurisation, but most assess it as outdated and not in line with consumer requirements. A longer shelf-life is a positive food characteristic for consumers (Schroeter *et al.*, 2016) but not in the case of milk, where UHT milk has a negative image amongst consumers (Kresova *et al.*, 2022). The experts assess UHT treatment critically because of the lower product quality. UHT treatment reduces the amount of heat-sensitive compounds (Krishna *et al.*, 2021); some studies found a lower level of iodine in UHT milk (Payling *et al.*, 2015; Stevenson *et al.*, 2018), whilst others found no effect (Walther *et al.*, 2018). This is serious because milk is a main source of iodine and its level is already lower in organic milk (Średnicka-Tober *et al.*, 2016; Payling *et al.*, 2015; Stevenson *et al.*, 2018; Walther *et al.*, 2018). Therefore, we recommend further studies to better assess the effect of UHT treatment on the iodine content of milk. Besides these negative effects, some experts find that UHT milk supports sustainable agriculture and animal welfare. In this case, the stage of raw production is of greater importance than further processing. Organic milk tends to have a higher somatic cell count (Schroeter *et al.*, 2016; Brodziak *et al.*, 2021) and is more prone to spoilage, so UHT treatment is a strategy to reduce food waste (Schroeter *et al.*, 2016). This is beneficial, especially against the background of the high greenhouse gas emissions in the dairy sector (Al-Obadi, 2021; Conrad and Blackstone, 2021). Moreover, UHT milk is transported and stored at ambient temperature which could lead to saving energy (Malliaroudaki *et al.*, 2022). However, we see herein a potential conflict between naturalness and environmental sustainability. The experts see mechanical stress and separation techniques as less critical

than thermal stress. They did not mention technologies for the reduction of grade and pressure for homogenisation (Beck, 2004a). Techniques that replace thermal with mechanical stress might be a fruitful field of research. HPP has already proven to be a possible alternative for non-bovine milk (Deshwal *et al.*, 2021). However, reservations about high-pressure procedures in the organic sector must be considered.

The experts raised the topic of transparency during the interviews which is also described as an important aspect of organic food in the literature (Leskinen and Särkkä-Tirkkonen, 2004; Jose and Shanmugam, 2020). Processing is a credence attribute (Loebnitz and Bröring, 2015; Manning and Kowalska, 2021) and mistrust in food processors is high amongst consumers (Wu *et al.*, 2021). The experts reported difficulties in communication with consumers because of their low food technology literacy. This even influences how milk is processed (e.g. use of homogenisation because consumers misinterpret creaming as spoilage). Consumer education can increase the acceptance of differently processed milk. It is also a measure to prevent food fraud (Manning and Kowalska, 2021). Only a few consumers ask about processing technologies, but the experts from dairies that offer guided tours state that consumers become very interested in processing techniques when allowed to observe them. Factory tours are a good way to explain food processing to interested consumers. However, they are not always feasible. Educational videos are another way to increase food technology literacy (Bornkessel *et al.*, 2021; Daun and Gambardella, 2018). In previous research, we found only fragmental information about processing on dairy websites from Germany and Switzerland (Borghoff *et al.*, 2021, pp. 54–56). Pictures of idyllic production are widely used in the German-speaking dairy market (Hirth and Keller, 2017) which the expert E8 also complains about. Videos about processing should inform as neutrally and transparently as possible about the production process.

Only one expert (E1) raised the topic of the food traders' influence on processing. Supermarkets have market power, as they are the most important sales market for organic milk in Germany (Orsini *et al.*, 2020). As power imbalances can influence product quality (Nurhayati *et al.*, 2021), this should be critically examined.

Based on the interviews, the processors' understanding of process quality includes humanised minimal and careful processing. This means preserving the valuable ingredients of the raw material in an eco-friendly way, craftsmanship in the production process, animal welfare and socially responsible local production. Due to the qualitative approach and interviewees only from Germany and Switzerland the results cannot be generalised to the whole organic milk sector. Further research is necessary to find more details about the processors' DQ. Research should be extended to more product types, including plant-based products. Additionally, quantitative research can be conducted based on our qualitative research design. Regarding milk processing, research on the combination of careful and minimal processing with a high degree of humanisation seems to be fruitful for the organic food sector. Qualitative case analyses might be a way to get more insight. The transformation of DQ to AQ is limited by the requirements of food traders and consumers. Raising the level of food technology literacy could help widen the possibilities for processors. The consumers' understanding of process quality should be examined to find out the differences and similarities between processors and consumers.

Conclusion

This research examined the DQ of organic milk processors and the technologies they deem appropriate using qualitative expert interviews with employees from organic dairies in Germany and Switzerland. It gives insight into the practitioners' perspective on organic food processing which has only been investigated in a few studies so far.

The experts integrate the entire food value chain into their understanding of quality. The impact of production on the environment is particularly important to them. They understand high quality processing of organic food in the sense of careful processing as defined by Nielsen (2004). The term careful processing is often used in the organic food sector, e.g. in the (EC) No 2018/848, but lacks a common definition. For the further development of the organic food processing sector, finding a common interpretation would give clarity. The definition by Nielsen (2004) seems worth discussing, as it is already used implicitly in practice by the participants of this study. Further research should investigate whether this is also the case for other organic processors. A precise explanation of what is meant by careful processing should also be included in the legislation.

Following from the study's findings, the extent of automation can play an important role for organic food quality. The advantages and disadvantages of manual and mechanical processing were discussed by experts and both ways of processing fit into their quality perception. Organic processing can therefore be a field for technological development as well as for the preservation of artisanal processing techniques. Instead of weighing one way of processing against the other, practitioners could use these aspects to differentiate from competitors and to assert themselves on the market. This means that a wide range of expertise is required and that employees with different training levels are in demand in the organic sector. A wider range of differently processed products would also help consumers to find products that match their quality requirements.

Regarding specific processing techniques, disadvantages were seen above all in processes with high thermal stress and mechanical methods were preferred. From the processors' point of view, a long shelf-life is desirable to prevent food losses. Moreover, food traders and consumers demand products with extended shelf-life. In the long term, it would be desirable to find an alternative to ultra-high temperature heating, which the experts do not consider to be suitable for organic processing. To maintain a long shelf-life whilst preserving valuable ingredients, processing methods that replace thermal stress with mechanical stress should be further sought. The suitability of high-pressure processes for organic food should be determined by the organic stakeholders to make sure that the technology does not violate the organic principles. Close cooperation between research, practitioners and organic experts could help to achieve this.

In this study, transparency about processing was advocated by experts, but difficulties in implementation due to low consumer knowledge were reported. Increasing food technology literacy appears to be desirable as this would help communicate about the quality of less processed products, such as non-homogenised milk. Ways to increase consumer knowledge have been presented in this paper. Consumer education actors should take up this topic and include it in their canon. Organic producers can become active by opening their processing facilities for tours. Cooperation between education actors and processors could be fruitful to find successful methods of conveying information.

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Supplementary material

Please note that the interview guideline was open to dairy-specific or spontaneous questions (Gläser and Laudel, 2010).The sequence was structured but open to changes during the interview (Bitsch, 2005). When interviewees used unclear descriptions of processing, such as the term "natural", they were always asked to explain what they understood by these terms.

Main code	Sub code	Deductive or inductive
Product quality *Characteristics of the physical product, including price and brand, cf. Brunsø et al. (2002), Kahl et al. (2012), Brunsø et al. (2002), p. 6*	–	Deductive
Process quality *General principles for the processing of food, cf. Brunsø et al. (2002), p. 6*	Definition of careful and gentle processing	Deductive
	Food processing in general	Inductive
	Organic food processing	Deductive
	Guideline for high quality processing	Deductive
	Extent of mechanisation	Inductive
	Transportation distances	Inductive
Food processing techniques *Specific techniques for the processing of the raw material to final products, cf. Hamatschek (2016), pp. 14–15*	HTST pasteurisation	Inductive
	Techniques for production of ESL milk	Deductive
	UHT treatment	Deductive
	Homogenisation	Deductive
	Fat standardisation	Deductive
	Package material	Inductive
	Further technologies	Inductive
Consumer communication *Describes the flow of information between producer and consumer as well as what the experts want consumers to know*	Consumer requirements	Deductive
	External presentation	Deductive
	Expert request for customer knowledge	Deductive
Legal requirements *Requirements of legislators and certification bodies*	–	Inductive
Food traders' requirements	–	Inductive

Table S1.
Code system

Topic 1: process quality
Background: In this part of the interview, we want to find out about the experts' understanding of process quality, especially regarding organic milk. This includes their interpretation of the term careful/gentle processing which is used in the EU organic regulation (EC) No 2018/848 (careful) and BioSuisse (gentle), their perception of the general direction of processing and limitations of processing – especially for organic milk.

Questions

(1) What is your understanding of the term careful/gentle processing?

(2) How do you choose which processing methods to use for your milk?

(3) Can you give a guiding principle of what high quality processing should look like?

Topic 2: Specific processing techniques
Background: There are different techniques for the preservation and further processing of milk (e.g. homogenisation and fat standardisation). In this part of the interview, we want to find out about the experts' view on these processing techniques, especially with regard to the question of whether they fit in with organic quality.

Questions

(1) Which processing technologies are (not) suitable for organic processing from your perspective?

(2) Are there any limits that should be observed when breaking down milk?

Topic 3: product quality
Background: Processing affects the product characteristics. Therefore, conclusions about the necessary processing can be drawn from the desired product properties. We want to find out about the experts' understanding of product quality, especially for organic products.

Questions

(1) What are the key characteristics for high product quality?

(2) Which characteristics should be preserved during processing, especially for organic milk?

Topic 4: Flow of information between producer and consumer
Background: In this part of the interview, we want to find out more about the flow of information between producer and consumer. These questions were especially relevant for the experts from the field of marketing and communication.

Questions

(1) When you get enquiries from customers, what do they want to know about your organic milk?

(2) What do your customers want to know about the processing steps?

(3) How do you decide which information you use to advertise it, e.g. on the packaging or the homepage?

(4) What do you think your customers should know about your milk and its production in general?

Finale

Background: The interview ends with an open question about missing important aspects.

Question

(1) Are there any other aspects of processing organic milk that are important to you but you haven't told me yet?

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