



Requirements of supply chain management in differentiating European pork chains



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ABSTRACT

This paper summarizes results obtained by research into pork chain management in the EU Integrated Project Q-Porkchains. Changing demands for intrinsic and extrinsic quality attributes of pork products impact the way supply chain management should be organized from the farmer down to the consumer. The paper shows the importance of Quality Management Systems for integrating supply chains and enhancing consumer confidence. The paper also presents innovations in information system integration for aligning information exchange in the supply chain and logistics concepts based on innovative measurement technologies at the slaughterhouse stage. In the final section research challenges towards sustainable pork supply chains satisfying current consumer demands are presented.

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1. Introduction

This paper summarizes insights gained from research into management of pork supply chains in Europe and beyond, through the EU funded Integrated Project Q-Porkchains.¹ The starting point of the paper is that changing consumer and societal demands for pork products not only affect the companies that are the direct suppliers of consumers, like retailers or restaurants, but also companies upstream the supply chain, including processors, slaughterhouses, traders, farmers, feed suppliers. Therefore, a chain management approach to analyse impacts of these different stages in production on end products seems to be essential. Such an approach has been recognized in the last decade, by industry, government as well as research, as vital for industry competitiveness and consumer satisfaction. The focus of chain management is explicitly on finding the most effective and efficient way of adding value with the aim of meeting consumer requirements at minimal costs.

Because of food safety concerns and concerns on how food is produced or where it originates from, attention for integrated chain quality management systems has seen a large increase in the last two decades. Information system designers increasingly try to build systems that connect various stages in the chain, not only for communicating quality and safety data but also for the sake of traceability of the food products

as well as for logistic optimization of processes. In addition, new technologies encourage companies to pay more attention to the environmental load of their businesses. New technologies also enable companies to better differentiate the products they produce, thereby enlarging their product assortment and improving market opportunities.

This paper will investigate how market demands translate to the different stages of the pork supply chain. In addition, integrated quality management systems, new forms of organisation, and quality differentiation will be discussed that can cope with these demands from a chain management perspective.

Section 2 of this paper addresses changing consumer and societal demands for pork products. Section 3 shows how these demands translate into demands for the different chain stages. In Section 4 two main coordination mechanisms are analysed: quality management systems and (related) governance mechanisms. In Section 5 three main opportunities for pork chain management are discussed: balanced supply chain contracts, integrated chain information systems and quality differentiation. Section 6 concludes the paper.

2. Changes in demands for pork production

In the last years requirements from different stakeholders to pork production have increased considerably. Due to several crises, for example the dioxin crises in various European countries (Plaggenhoef, 2007; Wognum, Bremmers, Trienekens, van der Vorst, & Bloemhof, 2011), consumers demand for more stringent regulations and control systems with regard to food safety. At the same time, because of increasing welfare in Western economies, demands towards higher and more consistent quality have increased, at affordable price levels, though. Tendencies to mass-customization lead to more differentiated products and innovative packages, while at the same time societal concerns related

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to bio-industrial and mass production ask for more attention to ethical issues such as animal welfare and energy and waste management (Verdouw, Beulens, Trienekens, & Wolfert, 2010).

The tasks of the governments in this respect focus on safety of products and public health issues through legislation and public control instruments (e.g., meat inspection at slaughterhouses), conservation of public goods like local environment, nature and soil (manure surplus), encouragement of low ecological foot prints, integrity in food product labelling (Trienekens, Wognum, Beulens, & van der Vorst, 2012) and information provision on origin of the foods and characteristics of production processes (Meulen & Velde, 2011). Industries throughout the pork supply chain have to comply with these demands by producing through efficient (low cost) processes while at the same time producing high quality and differentiated products. In line with this, economies of scale considerations lead to business concentration in all stages of the pork supply chain (Trienekens, Petersen, Wognum, & Brinkmann, 2009). Moreover, societal concerns have penetrated deep in many industries, leading to the fast evolution of traceability systems, integrated chain quality and health management systems and energy and waste management systems.

Table 1 underlines the variety and number of requirements of consumers and government towards industry. The challenges industry has to cope with are even further intensified through the specific characteristics of food supply chains and pork supply chains in particular (Vorst, 2000, Wognum et al., 2009, Trienekens et al., 2012). These are:

- Fluctuations in yields at farm level (number of piglets per sow, feed conversion rate, etc.), due to unpredictable natural influences
- Variations in quality of the animal. Even within one breed and one farm quality variation between animals can be high
- Cross-contamination of animal diseases (e.g. salmonella) because of mixture of lots in transportation and slaughtering stages. Globalisation leads to an increase in international transports and therewith in infection routes
- Diverging production chain. One pig delivers many parts, which all have to be marketed
- At the slaughtering stage, where animals are decomposed in many

Table 1
Requirements on food products from different stakeholders.

Consumer
Safe products
High quality products
Affordable prices
Differentiated products/ broad assortment
Innovative packages
Animal welfare
Low ecological food print
Government
Assurance of safe food and public health
Control of livestock diseases (outbreaks)
Conservation of public goods like local environment, nature and soil
Assurance of low ecological food prints
Provision of adequate consumer information (labelling) about authenticity of food
Provision of adequate societal information
Industry
Compliance to legislation
High added value and high margins
Low processing costs
Market segmentation and internationalization
Product and packaging innovations
Traceability and fast recalls
Low ecological food print
Good relationships with NGOs

- parts and combined with other ingredients in the processing stage again, traceability of pork is no longer possible to an individual animal or individual farm, but to day batches. Information is lost at this stage
- Perishability of (fresh) meat products (shelf-life constraints)
- Special demands to storage and transportation of live animals and pork products.

3. Pork attributes

A pork supply chain delivers products to consumers who are at the downstream end of the supply chain. These consumers have differentiated demands with respect to the attributes of the products they consume. In general we distinguish intrinsic and extrinsic product attributes. Intrinsic attributes can be measured on the product itself and are typical search and experience attributes (Grunert, 2005; Steenkamp & van Trijp, 1996; Verbeke, Van Oeckel, Warnants, Viaene, & Boucqué, 1999). Classes of intrinsic characteristics are sensory characteristics such as tenderness, health characteristics such as safety of the product and convenience characteristics such as type of packaging. Extrinsic product characteristics are linked to the production process and in general cannot be measured (by consumers) on the product itself. Typical classes of extrinsic attributes of pork products relate to animal welfare in various stages of the chain, ecological aspects like waste management and origin and authenticity of the products (Grunert, Wognum, Trienekens, Veflen Olsen, & Scholderer, 2011; Trienekens et al., 2009, 2012; Wognum et al., 2009, 2011)

Table 2 gives an overview of major intrinsic and extrinsic attributes of pork production.

3.1. Translation of intrinsic quality attributes throughout the supply chain

An interesting question is, whether all stages in the pork supply chain are directed at the achievement of the product attributes that are requested by consumers, of the market segment that the final products are sold in. A feed producer is mainly interested in selling feed mixtures with high added value. A breeder will focus more on pig genetics for achieving high growth rate and optimal feed conversion. A farrowing farmer is interested in sow performance and mother behaviour. A finishing farmer is also interested in pig characteristics like growth rate, feed conversion and specific characteristics like meat percentage and muscle structure, because these are the characteristics that he is paid for by the slaughterhouse. However, although the payment system of slaughterhouses is based on these carcass characteristics, the payment of further downstream stages in the supply chain is largely based on process qualifications like weight, size, fat layer, and

Table 2
Intrinsic and extrinsic pork product attributes.

Intrinsic		Extrinsic	
Sensory	Tenderness	Animal welfare	Farm production system
	Colour		Transportation
	Marbling		Slaughter
Health	Safety (zoonosis)	Ecological food print	Farm manure and waste management
	Food additives		Transportation
	Antibiotics		Slaughter products (high and low value)
Convenience	Residues	Origin and authenticity	Production location
	Packaging		Community impact
	Shelf life		Farm production system
	Preparation characteristics		Processing system

meat quality characteristics such as juiciness, marbling and Ph value. Alternatively, for retailers attributes like color and shelf-life are of interest, while for consumers these and other attributes like taste and tenderness are of importance. Table 3 shows major attributes as valued by various pork chain partners (Verbeke et al., 1999; Rijpkema, Rossi, & Vorst, 2011; Trienekens et al., 2009; Wognum et al., 2011).

A major reason that attributes as valued in the various stages of the supply chain are not aligned is that processes from farm until the slaughterhouse are not directed at end markets, mainly because the payment system of slaughterhouses to farmers does not well relate to final market value (Rijpkema et al., 2011). When, for example, meat percentage is high, fat content will be lower. This means again that tenderness and juiciness (WHC-Water Holding Capacity) of the best-valued carcasses is lower. Table 4 gives insight into ways in which different stages in the supply chain can pay attention to what the consumer values. The situation is somewhat different for supply chains directed at more differentiated and high-demanding consumer markets. In this type of supply chains there is a tendency to align processes in the first stages of the chain more with consumer demands. In particular in niche chains like Iberian pigs, Mallorca Black or Parma pork production a lot of attention is given to special feed and special meat processing techniques to achieve the product that the consumer values (Trienekens et al., 2009). Such supply chains can be characterised by a clear vision on the markets they want to serve and the chain-wide approach that is necessary to best serve those markets.

Better tuning of production processes throughout the chain to end-customer demands, could therefore lead to more differentiated production of pork. The following section will go into translation of extrinsic quality attributes throughout the pork chain.

3.2. Translation of extrinsic quality attributes throughout the supply chain

Table 2 mentions three classes of extrinsic attributes of pork products, namely animal welfare, ecological foot print and origin and authenticity.

3.2.1. Animal welfare

Different stages in the pork supply chain can pay attention to animal welfare. Different levels of animal welfare have been defined which specify, for example, living space for pigs on the farm (e.g., the EU demands 0.65 m² for conventional, where Germany has 0.75 m² and the Netherlands 0.8 m², and 1.1 m² for free range animals), feeding regimes through feeding systems where animals can choose themselves when to go for feed or innovative feeding systems that can recognise which pigs already received (sufficient) feed, housing for the pigs, like possibilities to stay outdoor, straw beds instead of slats, and group housing. During transportation attention can be given to ventilation and availability of water, while selection of small non-mixed groups may have a positive effect on animal welfare. At the slaughter stage

Table 3
Product and production attributes of interest at different pork chain links.

Actor	Attributes valued
Feed producer	Value added feed mixtures, conversion rate
Breeder	Growth rate, feed conversion, muscle structure, carcass characteristics
Farmer (farrowing and fattening)	Growth rate, feed conversion, slaughter weight, meat percentage, muscle structure
Slaughterhouse	Water holding capacity, intra muscular fat, pH, tenderness
Processing	Water holding capacity, intra muscular fat
Retail	Colour, shelf life, freshness, tenderness, juiciness, marbling,
Consumer	Taste, tenderness, colour, juiciness, marbling, convenience

Table 4
Impact of various chain links on intrinsic meat quality (adapted from Biermann, 2012).

Chain link	Factor	Impact
Breeding	Genotype ^a	Duroc and Berkshire deliver more tender meat, Large White less. Duroc, Large White and Berkshire deliver better Water Holding Capacity (WHC) and pH 24h. Pietrain, Large White and Landrace deliver better marbling.
	Carcass composition	Duroc delivers more Loin and Fat. Pietrain delivers better Hams but is not so good in Loin, Belly and Fat. Large White delivers better shoulder but is less in Loin and Fat. Landrace delivers better Belly and Fat, but is less in Shoulder
Feed company	Diet	High protein leads to higher Intra Muscular Fat (IMF - marbling) and lower tenderness
	Vitamins Minerals	Vitamin E leads to better colour Magnesium leads to better WHC
Pig farming	Production system	Conventional systems have relative positive impact on WHC and pH24 h (as opposed to animal welfare and organic systems)
Slaughterhouse	Fasting	Fasting has positive impact on WHC and pH 24h
	Pre-slaughter handling	Stress has negative impact on colour, WHC and pH 24h
	Stunning	CO2 stunning combined with low stress has positive impact on tenderness. Electrical stunning of high stressed pigs has negative impact on WHC and pH 24h
	Chilling	Accelerated chilling has positive effect on colour and on drip loss

^a In this table we focus on four genotypes common in North-Western Europe. In addition, the genotypes mentioned are pure breeds. In production, most of the time cross-breeds are used, which combine properties from pure breeds. In practice there are not many differences in commercial hybrids.

resting time before slaughter, non-use of electric prods and ways of stunning (electrical or CO₂) impact on animal welfare.

3.2.2. Ecological footprint

Current research indicates that pork supply chains negatively impact the environment. For example, global warming potential of pork ranges from 2.9 to 5.6 kg CO₂e/kg carcass weight, depending on differences in production systems and management (Nguyen, Hermansen, & Horsted, 2011). In pork chains, feed production has most impact on global warming potential. The largest part of the production cost of a pig is covered by the feed the animal consumes. However, conversion rate of feed is not only of economical interest to the farmer. Manure surplus is the second major contributor to the ecological load of pig farms (Nguyen, Hermansen, & Mogensen, 2012). Transport is not a major contributor to the negative impact of pork production on the environment (Hermansen & Kristensen, 2011), at least when restricted to regional transportation. Cooled international transportation does have a larger impact. At the slaughterhouse stage, the main impact is from fossil energy use and waste. To reduce costs and achieve an allocation shift slaughterhouses move to more energy neutral facilities by implementing bio-gas installations functioning on by-products and waste and thereby meeting part of the energy demands of the plants (Nguyen et al., 2011).²

3.2.3. Origin and authenticity

In the European Union authenticity and origin of food are in many cases related to systems known as Protected Designation of Origin (PDO), Protected Geographical Indication (PGI) and Traditional Specialty

² Nguyen et al. (2011) have used lifecycle assessment (LCA) to explore improvement possibilities in the pork supply chain, in particular the conventional supply chain and the organic supply chain. LCA has been used to identify where in the supply chain the most important environmental load takes place. Six impact categories have been investigated: global warming (GHG emission), acidification, eutrophication, respiratory inorganics, non-renewable energy use, and land use.

Guaranteed (TSG) (EC, 2006a, 2006b). PDOs are agrarian products or foodstuffs, which are produced, processed and prepared (almost) exclusively in a given geographical area. The product's characteristics are also the result of the geographical conditions. To obtain a PGI designation at least one of the stages of production, processing or preparation must be linked to the specified region (EC, 2006b). In contrast to PDOs and PGIs, TSGs do not need any specific connection to a geographical area. They are characterised by special attributes of ingredients or processing stages and they must have a traditional background, which means that they must have existed on the market for at least 25 years (Ellebrecht, 2012).

In this section we will give three examples of production systems and supply chains that pay attention to extrinsic production characteristics

In **Box 1** a description of a PGI brand, focussing on origin and authenticity, is presented.

Box 1

Jambon de Bayonne (Bayonne Ham)

Jambon de Bayonne is an official European PGI brand. The label was obtained in 1998 and is used by the INPAQ or Aquitaine Inter-professional Pork council and the Consortium of Jambon de Bayonne, which consists of producer cooperatives, slaughterhouses and cutters, and processors. The chain operating under the PGI label consists of feed companies, producers under a producer cooperative, slaughtering and cutting, and ham processors. Production, processing, and development take place in the South-West of France, namely the "bassin de l'Adour", which consists of 22 departments, such as Aquitaine, Midi-Pyrénées, Pointou-Charentes, and the adjacent departments. Specifications of the PGI brand are that animal feed is based on cereals, ham are rigorously selected, and manufacturing proceeds according to traditional principles. (Rakotonandraina, Sauvée, Trienekens, & Wognum, 2012)

In Iberian Cured Ham production, besides a focus on origin and authenticity, free range keeping of animals is considered to have a positive impact on animal welfare (see **Box 2**).

Box 2

Iberian cured Ham

Iberian cured ham has four denominations of origin: Dehesa de Extremadura, Guijuelo, Jamon de Huelva and Valle de los Pedroches. Most Iberian pigs come from the South-Western regions of Spain, in the "dehesa" (meadows and woods). Aside from Iberian, there are two other Spanish PDOs in cured ham, Jamon de Teruel and Trevelez. There are two breed designations: "Iberico puro" from sow and boar of pure Iberian breed with genealogic documentation, and "Iberico" from pure Iberian sows. Feeding practices in the finishing period (Iberian pigs grow up to 160 kg) are also grouped into four designations: "Bellota" (finished on a diet of acorn, grasses, etc. in the "dehesas"); Recebo (finished on partly the same diet as the "Bellota" animals but with additional concentrates); and Cebo (mostly fed with feed concentrates and sometimes additional acorn and grasses). Bellota and Recebo live large part of the year in open areas with abundant acorns or fenced meadows. The fabrication of the hams is according traditional procedures (Pena, Felipe, & Briz, 2009).

In **Box 3** we show a combined attention to animal welfare and ecological food print in organic production systems.

Box 3

organic (EKO) food production

Requirements for organic agriculture are set down in European Regulation (EC) no. 2092/91. Raw materials in pig feed must be of organic origin. Throughout the production process, antibiotics, medicinal compounds, hormones and other substances with the purpose of increasing growth or productivity are prohibited. Also, from a health care and welfare point of view, preventive action with synthetic chemical substances and antibiotics is not allowed. Tail and teeth clipping are not allowed. Locking up or caging the animals is prohibited, except for a limited period of time when it concerns the safety or well-being of the pig. The allowable number of animals is linked to the norm for maximum disposal of manure per ha. The housing of animals is also subject to a range of specific regulations. The pigs need to have dry, clean and bedding spaces of straw or other natural materials. Only a maximum 50% of the flooring may consist of grids and pigs have to be housed in groups, except for sows in the last phase of pregnancy or in the suckling period. All pigs must have access to an outdoor area, which may be no more than 75% covered. (www.Skal.nl; Nijhoff-Savvaki, Trienekens, & Omta, 2009).

4. Supply chain coordination

To satisfy demands on the intrinsic and extrinsic attributes of pork products and processes activities and information exchange need to be coordinated throughout the pork supply chain. Various mechanisms are available for achieving coordination. First of all, quality management systems (QMSs) are in place for safeguarding food safety and hygiene, while also more specific systems are used for supporting quality claims in specialty supply chains. QMSs are the subject of **Section 4.1**. Secondly, governance mechanisms, in particular contracts, serve to structure the transactions between the different actors in a supply chain. Governance mechanisms and QMSs mutually interact with each other and need to be aligned. The relationships between QMSs and governance mechanisms are the subject of **Section 4.2**.

4.1. Quality management systems

Current quality management systems (QMSs) specify production standards, while certification indicates the degree of conformance with the standards. QMSs consist of three elements (Wever, Wognum, Trienekens, & Omta, 2010): quality signals, quality standards and quality monitoring mechanisms. Quality signals are employed by firms to indicate product and process quality to their buyers, which maybe other firms or end consumers. Quality standards and quality monitoring mechanisms support quality signals. Quality standards are set by the signal owner, which can be either a chain actor, or a public actor. Standard setting and monitoring compliance with those standards need not be performed by the same actor. QMSs can be chain-wide or company-to-company, while the degree of adoption can be high or low.

In most pork supply chains a combination of QMSs is applied. In the EU, all pork supply chains need to satisfy at least EU legislation, like the General Food Law and the Hygiene regulations. On top of this legislation national governments may specify additional rules and standards. EU and national public systems are Baseline public systems (see **Fig. 1**). Private bodies, like chain actors, farmer cooperatives, or associations may specify even more stricter QMSs, which may apply to whole supply

chains or only parts of it. Moreover, they may be sector-wide or apply to only a limited number of supply chains.

As indicated in Fig. 1 pork supply chains are subject to several QMSs in parallel. These QMSs focus mostly on intrinsic pork attributes. However, extrinsic attributes, like animal welfare and environmental impact, increasingly receive attention in high level QMSs. In addition, PDO and PGI safeguard origin and authenticity, in particular. High-level QMSs are used in addition to the more basic QMSs that other, often conventional, pork supply chains adhere to.

Especially high quality and regional pork supply chains use many systems in parallel. In a recent study, Rakotonandraina et al. (2012) have found that the pork supply chain Porcilin/Saveur en 'Or uses up to six QMSs, while Fleury Michon/Bleu Blanc Coeur uses even eight QMSs. These systems appear not to conflict with each other, but support each other although they may be redundant to some degree. This variety of QMSs can be managed, since QMSs build upon each other and require similar mechanisms. However, from efficiency point of view, harmonising the various QMSs is still a challenge, as in many cases every QMS has to be certified and audited separately.

An important aspect of QMSs is health management on a pork farm. Ellebrecht (2012) has performed research in the primary production sector of pork supply chains with a special focus on inter-enterprise health and quality management. A combination of QMSs may help to optimise service processes for improving farm management, health management, and also the end product.

4.2. Organisation and governance of the supply chain

To provide for a smooth and fruitful exchange of information and effective application of QMSs, the exchange of products needs to be coordinated by means of suitable governance mechanisms. Such mechanisms range from the polar forms market to hierarchy with several hybrid forms in-between. Governance mechanisms may be specified in contracts between chain actors or between chain actors and third parties, like cooperatives and associations. Wever et al. (2010) have specified five forms of contracts: spot market contract, verbal agreement, formal contract, equity-based contract, and vertical integration, with the following explanation (Wever et al., 2010):

- *Spot-market contract.* A contract (invoice) for instant exchange of goods or services
- *Verbal agreement.* Exchanges not formalised into written, legally enforceable contracts. Performance or behavioural standards are unlikely to be specified, but if so, they have not been formalised
- *Formal contract.* Legally enforceable, written contracts to govern the

transaction. Performance and behavioural standards have been specified in the contract

- *Equity-based contract.* A supply chain actor owns stock, with the accompanying shareholder voting rights, but less than 50%, of (one of) its suppliers or buyers
- *Vertical integration.* A supply chain actor owns more than 50% of the stock, with the accompanying shareholder voting rights, of (one of) its suppliers or buyers.

The degree of coordination increases when going from spot-market contract to vertical integration.

Contracts facilitate the reduction of transaction uncertainties related to the coordination of quality (Martinez & Zering, 2004). Contracts need to be aligned with the transaction risks that supply chain actors encounter. Based on a study of (Wever et al., 2010), QMSs have been related with the associated contracts. More specifically, the execution of a QMS requires a specific coordination of supply chain transactions. Governance mechanisms should be aligned with the requirements of the QMSs in use.

Results of case studies indicate four different quality management system types supported by specific governance mechanisms. The QMS types are the most important QMS used in the supply chain and the one that is signalled within the supply chain or to consumers. The four QMS types are:

1. *Public baseline QMS.* Supply chains with this type of system do not have a chain-wide QMS covering the whole supply chain. In particular, they contain guidelines for each actor in the supply chain to which supply chains actors need to adhere to. Together the guidelines are aimed at a baseline quality of processes and products in the supply chain. EU food law represents public baseline quality requirements for the food sector. In addition to the general EU regulation 178/2002, EU hygiene regulations 825/2004, 853/2004 and 854/2004 are particularly important for the pork industry. Adherence to the rules is responsibility of the individual actors. Therefore, no integrated governance form to safeguard quality is needed. Spot market relationships are in line with this QMS.
2. *Private chain-wide QMS as industry standard.* Supply chains with this type of system have a private chain-wide QMS on top of public baseline standards. These QMSs have a chain-wide scope and have been adopted by most of the chain actors. Additionally, chain actors may set or require additional private QMSs for their immediate linkages in the supply chain, which may also be widely adopted among the respective horizontal stages of the supply chain. Examples are IKB (Netherlands) and QS (Germany). Because of the large scale application of this QMS and because control of quality and safety takes

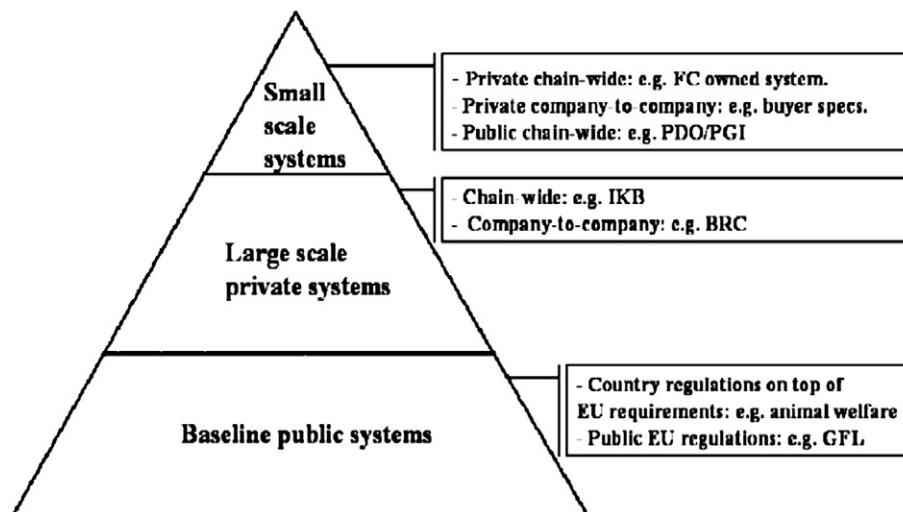


Fig. 1. Different levels of QMSs in EU pork industry (adapted from Trienekens & Zuurbier, 2008).

- place by third party certification organisations, for this type of QMS more market-like contracts can be found.
3. *Private chain-wide QMS on top of industry standard.* Supply chains with this type of system have adopted an additional private chain-wide QMS on top of an industry-wide and chain-wide private QMS. This additional QMS also has a chain-wide scope, but has been adopted only by the incorporated, limited in number, chain actors. This type of supply chains are often niche market and regional supply chains. QMSs are relative small scale and quality control and safeguarding takes place by the actors of the chain themselves. Therefore, long term relationships exist in these chains with hierarchical types of contracts.
 4. *Public chain-wide QMS (PDO/PGI).* Supply chains with this type of QMS have adopted a public chain-wide QMS on top of baseline quality standards of EU and national levels. Examples of these chain-wide QMSs are the PDO and PGI systems that tie production to a specific region. Contracts tend to be more market-like and verbal, because public actors provide (part of) the resources necessary for control and safeguarding of quality attributes of the product.

5. Challenges for pork supply chain management

In the previous section attention has been focused on safeguarding safety and quality of pork products as well as on the way supply chain actors organize themselves. In this section major challenges for the pork supply chain will be discussed.

5.1. Aligning transaction risks in the pork supply chain

A major challenge is the (further) alignment of QMSs and alignment of contracts throughout the supply chain. Supply chains actors may be exposed to multiple transaction risks, in particular upstream risks and downstream risks: demand risks, supply risks, uncertainty risks and investment risks. These risks are only partly related to product (quality) attributes and have to do with transaction relationships between actors in the supply chain. [Wever, Wognum, Trienekens, and Omta \(2012a, 2012b\)](#) have proposed an approach to bridge the gap in research, in which mainly transactions between two successive supply chain actors have been addressed until now. Various combinations of transaction risks have been identified for which suggestions for solutions are made. When upstream and downstream transaction risks are balanced in suitable contracts with both suppliers and customers, supply chain performance is expected to increase. However, research results also show that in many companies purchasing and selling are still strictly separated functions and balanced supply and demand contracts are scarce ([Wever et al., 2012a, 2012b](#)).

5.2. Pork chain information systems

To be able to align quality management systems and governance forms (contracts) in the supply chain adequate exchange of information (transparency) between the different chain stages is essential. Transparency of a chain is the extent to which all the chain's stakeholders have a shared understanding of, and access to, the product-related information that they request, without loss, noise, delay or distortion ([Hofstede, Spaans, Schepers, Trienekens, & Beulens, 2004](#)). This definition implies that data must be relevant, accurate, factual, reliable, timely and available in an appropriate quantity. Apart from well-designed information systems, trust between partners is key to achieving transparent supply chains, leading to higher levels of loyalty and better formal and informal communication.

Transparency is of utmost importance for the pork chain for a number of reasons:

1. Based on experience gained during the recent crises in the European pork sector, traceability has been shown to be a key capability for

- companies to find the origin of problems and recall hazardous products quickly.
2. Consumers require more and more information about the origin of products and the way the product is produced.
3. A reliable exchange of quality and health data throughout the chain provides actors with an instrument to better plan their production and sales processes and better match the right quality to the right market.
4. Availability of operational quality and safety data across the chain supports adequate risk management.
5. The increasing complexity of logistics flows caused by product differentiation, market segmentation and internationalisation, demands insight into production and stock data throughout the pork chain, so that companies can make better forecasts and more effectively plan logistics and distribution processes.

Two main information requirements of chain actors are on food safety and quality. In [Fig. 2](#) the generic information needs for chain actors on safety and quality are depicted, based on case studies in various EU countries ([Lehmann et al., 2011](#)).³

The arrows in the figure depict information exchange between actors in the pork supply chain. In current supply chains, however, the exchange of such information only takes place on a generic level and in most supply chains information exchange is only bilateral. Supply chain information systems which provide actors with joint access to data or where data can be combined for chain-wide analysis are still scarce. Supply chain actors tend to manage their own information needs and systems, while interaction between chain actors is not yet well supported. Moreover, information and communication technology applications show significant differences within and across European pork chains ([Lehmann, Fritz, Brinkmann, Schiefer, & Petersen, 2009](#)). Besides, in addition to technical barriers, chain actors are reluctant to share information because of the risks of improper use of information or the loss of independence.

However, the trend is towards intensifying the exchange of information in these chains. The following systems are successful examples of inter-company information exchange:

- Farmingnet (www.farmingnet.nl) is a system used by VIONFoodGroup to exchange information with supplying farmers. Farmers need to announce a delivery, while VION gives information to farmers on carcass quality. Payment is based on the quality of the pigs delivered. Currently functionality is added to the system which will enable farmers to make company performance analyses by comparing output-performance data such as carcass characteristics, organ inspection results with input data such as feeding of animals, climate in stables, space per for animal, etc.
- Wikiporc (www.wikiporc.fr) is a health management system used by Porc Armor in West-Brittany in France. The health situation on a farm is checked by veterinarians before a prescription for medicine is signed. Health information is based on disease and medication history and slaughter and laboratory information. Analysis of multiple farms and health management initiatives can be supported by the system.

These are two examples of the development towards further alignment of quality and health management systems as well as exchange of performance data, enabling more integrated management of these supply chains. Although these systems are business-to-business systems, further extension to chain-wide systems is to be expected as well as consumer access to these systems to be able to trace extrinsic as well as intrinsic attributes of the products they buy.

³ Besides for food safety and quality, [Lehmann et al. \(2011\)](#) have defined demands and services for Global Warming Potential. For this item, especially transportation distance, feed conversion, Fossil Energy use, and transportation cooling have been further specified

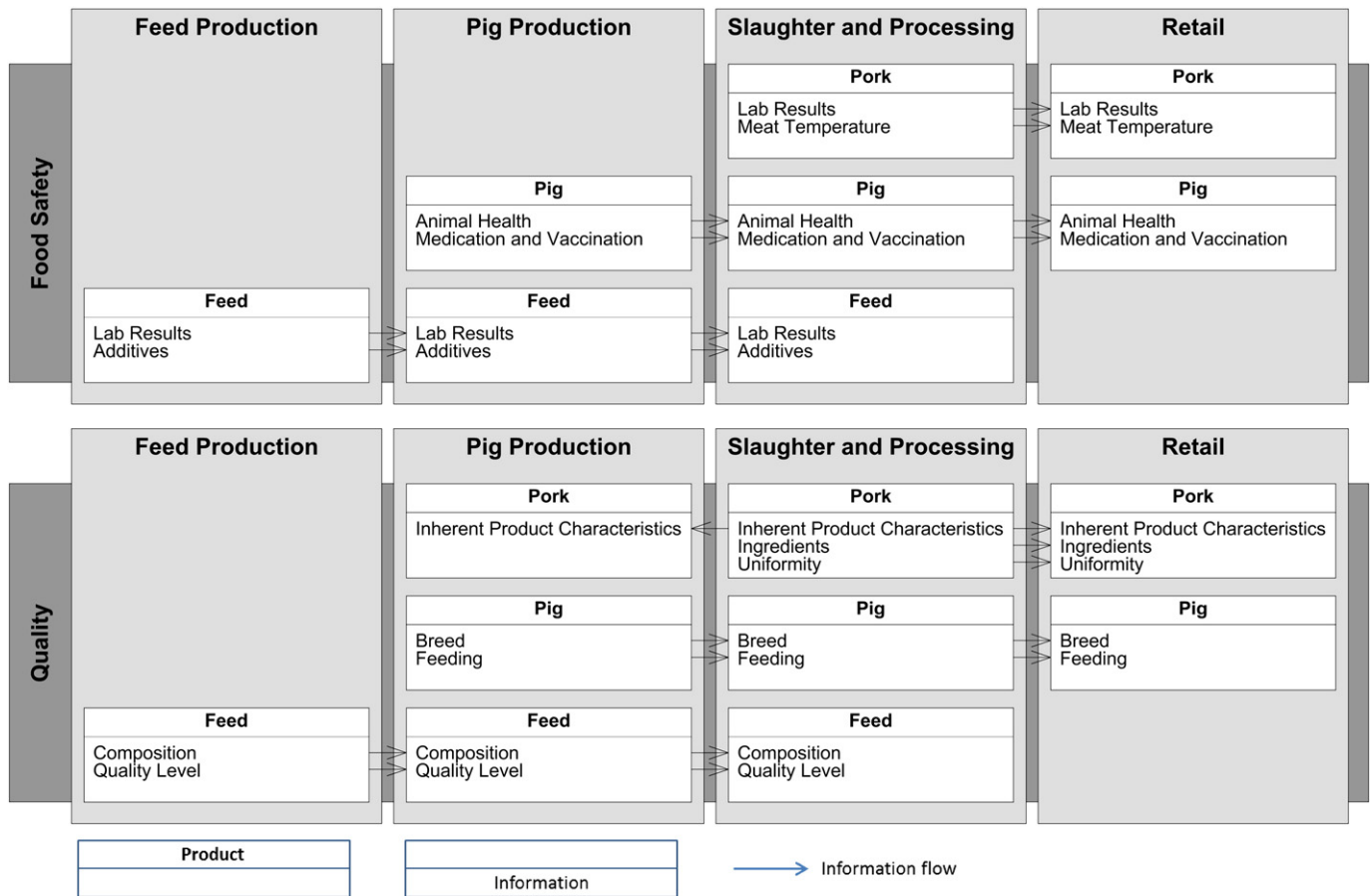


Fig. 2. Food safety and quality information demands (Lehmann et al., 2011).

5.3. Quality differentiation and advanced logistics concepts

Meat processing companies, including slaughterhouses, increasingly need to translate preferences of consumer and customer demands into clear process and production specifications for different supply chain actors (Rijkema et al., 2011). Currently, in most pork chains there is still a mismatch between delivered quality and expected quality, leading to unsatisfied customers and value losses because products are not sold against the best possible price. Grunert et al. (2005) argue that the extent of heterogeneity and dynamism in end-user markets is a determinant of the degree of market orientation in the chain. The future market for pork will be more heterogeneous and dynamic, thereby asking for more market oriented activities in this chain, at slaughterhouse, farmer and breeding stages. So far, however, in most food sectors heterogeneity of raw materials upstream in the chain is not exploited for serving market heterogeneity downstream in the chain (Grunert et al., 2005). To be market oriented and efficient at the same time, quality variation (heterogeneity) upstream the chain should be better used to match with differentiated quality demands in the market. To match input to desired output quality requires a flexible organisation of meat production and logistics processes.

Differentiation of quality of pork starts already in the breeding stage, depends on feeding and living conditions of the animals at the farmer stage and is also influenced by the way the animals are transported and slaughtered. At the breeding stage a lot of research is being done that will eventually make it possible to use DNA technology to help guide breeding programs and to better predict the quality of animals and meat. However, because pigs are living creatures with a natural variation, 100% prediction accuracy is not to be expected and slaughterhouses still will have to cope with a large variation in quality characteristics, even within batches that come from the same farmer.

As described in Section 3.1, pork quality can be defined in many different ways, like percentage of leanness, weight, visual aspects, sensory perception and suitability for further processing, and it also varies in different markets. The pork processing industry has until now mainly focused on sorting based on carcass quality: weight, lean meat ratio, fat/meat layer thickness. These are static features and relatively easy to measure. However, these features are not directly related to the quality of the meat that is produced. Here factors like microbiological quality, pH value and water holding capacity are important, which are more difficult to measure, are dynamic and are affected by multiple factors. In this regard, a successful extension to in-line quality measurements of these attributes and new processing strategies may open up opportunities for further market differentiation because quality prediction of meat products will be far more reliable. Consequently, quality can be better tuned to the specific wishes of market partners throughout the world, thereby maximising value added. The challenges at the marketing side would be to persuade buyers to pay a better price for products with consistently higher quality (consistent because it is easier to measure) and to find niche markets for special quality products. Moreover, such a development implies the design and implementation of new logistic concepts for storage and handling, as well as more fine-tuned distribution concepts for delivering the right product to the right customer at the right time.

6. Conclusion

The challenges in the previous section show the tendency to more intensive collaboration in pork supply chains through tuning of quality management systems of the different actors in the supply chain, supported by integrated information systems. They also show the development of new quality measurement approaches supported by new technology

such as advanced in-line measurement of meat quality and related logistics concepts. The examples focus on assuring, or enhancing intrinsic quality attributes of pork products. While the first example has a more economic focus, the information systems focus on food safety and company performance while the new measurement approach investigates the opportunity of organising for a wider range of quality classes.

Extrinsic attributes are in most cases covered by more or less closed pork supply chains, covered by Public Chain Wide Systems (such as PDI, PGI, EKO), or Private Chain Wide Systems, such as animal welfare branding by some of the large European slaughter companies. For example, the “one star” label developed by the Dutch Animal Protection organisation (Dierenbescherming), which has been adopted by, e.g., VION for setting up a new market concept. A clear chain-wide market vision is needed for such supply chains to be able to create value for the consumer as well as shared value for all supply chain actors. In addition, to increase sustainability of a supply chain, in terms of social, environmental, and economic value, thus also addressing more of the extrinsic demands, such a clear vision and shared approach is needed to motivate supply chain actors to invest or share investments in sustainability improvements.

However, to meet differentiating demands of consumers as well as society regarding intrinsic and extrinsic product attributes and at the same time guarantee integrity of processes, controllable by the supply chain stakeholders, important steps still have to be made.

The following on-going research challenges can be identified:

- Development of chain-wide quality management systems covering intrinsic as well as extrinsic product features, so as to on the one hand further reduce risks in the area of food safety and animal health and on the other hand inform the consumer about specific attributes of the product he buys
- Development of transparency and information exchange and supporting systems and technology for quality and logistics management
- Design of balanced supply and demand contracts throughout pork chains so as to lower transaction risks and enhance overall performance
- Use of new ways of quality measurement in the pork chain through new measurement technologies and the use of biological markers for meat quality, accompanied by the development of new logistics and distribution concepts.

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