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## SOCIETAL CONCERNS REGARDING SUSTAINABILITY OF PIG PRODUCTION SYSTEMS: A LITERATURE REVIEW

### ABSTRACT

Environmental and climate issues, together with animal welfare, are drawing significant media attention, challenging livestock producers to make their operations more sustainable. Highly industrialised systems, commonly associated with intensive farming, enable the efficient rearing of large animal population and contribute to food security through stable supplies and lower prices. However, while intensification has improved productivity, it raises animal welfare and ethical concerns.

This article presents a comprehensive literature review on societal concerns regarding sustainability of pig production systems. Therefore, for the purpose of this research, 26 peer-reviewed articles (both quantitative and qualitative studies) were selected, focused strictly on consumers/citizens' attitudes towards different aspects of sustainability related to pig production.

This review has shown that despite an increase in societal concerns regarding different aspects of sustainability, the wider public has little knowledge about different systems of pig production but strong negative perceptions towards modern farming practices. Thus, reconciling the need for efficient food production with ecological and welfare considerations remains a major challenge.

**Key words:** animal welfare, pig production, sustainability, consumer perception.

JEL Classification: D11, Q18, Q56.

### I. INTRODUCTION

Sustainability, including that of animal production, is the subject of growing debate. Increasing societal concern about meat production has led some consumers toward vegetarian or vegan diets (EAT-Lancet, 2019). Environmental and climate issues, together with animal welfare, are drawing significant media attention, challenging livestock producers to make their operations more sustainable. Since the Brundtland Report (1987:41) defined sustainable development as the “development that meets the needs of the present without compromising the ability of future generations to meet their own needs,” the concept has expanded across disciplines. It encompasses three interrelated pillars: social, economic, and environmental, whose balance requires integrated approaches and acceptance of trade-offs.

Livestock production exemplifies this complexity. It contributes substantially to agriculture's environmental footprint (Leip *et al.*, 2010; Kastner *et al.*, 2012;

Garnett, 2013) through resource use, emissions, and waste (Tilman *et al.*, 2002; Steinfeld, 2004). Feed crop demand also pressures land and water resources (Bruinsma, 2003). Highly industrialised systems, commonly associated with intensive farming, enable the efficient rearing of large animal population and contribute to food security through stable supplies and lower prices. Although extensive or traditional systems are often perceived as more “natural,” they also face environmental and welfare issues (FAWC, 2016). However, while intensification has improved productivity, it raises animal welfare and ethical concerns (Austin *et al.*, 2005; World Bank, 2011). Thus, reconciling the need for efficient food production with ecological and welfare considerations remains a major challenge.

## 2. STATE OF KNOWLEDGE

Sustainable agriculture has traditionally emphasised food production, ecosystem services, and social goods, but consumption patterns must also be addressed (FAWC, 2016). Most consumers are disconnected from modern farming, leading to misconceptions and anthropomorphic views of livestock (Hubbard *et al.*, 2018). They often misunderstand or mistrust welfare and sustainability claims on food labels (AWI, 2014). Understanding stakeholder and public perceptions is therefore essential, particularly when animal production practices are perceived to impose ethical costs (FAWC, 2016).

Dietary patterns vary globally due to cultural factors (de Boer *et al.*, 2006), yet overall demand for animal products has risen sharply over the past two decades (Kearney, 2010). Emerging economies such as India, China, and Brazil have seen significant increases in meat consumption driven by higher incomes, population growth, urbanisation, and changing preferences (Tilman *et al.*, 2002; Wathes, 2013). As these regions are projected to experience the greatest population growth (UN, 2015), shifts in consumption will have major implications for global food systems and trade, with traditional production unable to meet future demand.

Limited land availability restricts the expansion of extensive systems (Steinfeld, 2004), prompting a shift from ruminants toward monogastric species such as pigs and poultry because of their high feed conversion efficiency and rapid growth (Steinfeld & Gerber, 2010; HLPE, 2016). Production of pig meat, for example, reached 125 million tonnes in 2023, making pork the world’s most consumed meat (Ritchie *et al.*, 2023). As livestock production and consumption continue to rise, the ethical and societal dimensions of animal use in food systems are becoming central to sustainable agriculture (Garnett, 2013; Vinnari & Vinnari, 2014; Allievi *et al.*, 2015).

Against this background, and within the societal sustainability pillar of the ERA-NET funded SusPigSys project, a literature review was conducted to identify public concerns surrounding pig production systems focusing on animal welfare, environmental impacts, intensification, and food quality and safety.

### 3. MATERIAL AND METHOD

The complexity and multi-dimensional nature of sustainability, combined with the lack of data regarding societal concerns on the sustainability of pig production systems per se, have not allowed for the undertaking of a quantitative meta-analysis<sup>1</sup>. Instead, a more traditional literature review with some elements of a qualitative meta-analysis, drawing on primary studies that focus on several aspects of sustainability, was employed<sup>2</sup> (Timulak, 2009).

An initial search for relevant articles was carried out in several databases such as Scopus, ISI Web of Knowledge and Google Scholar, using as a start date 1999 the following search terms: “consumer\*” OR “citizen\*” OR “public\*” combined with “concern”, OR “attitude\*” OR “percept\*” and “pig” OR “pig production” OR “pig farm\*” “environ\*” OR “sustain\*” (employing the Boolean search operators ‘OR’ and ‘AND’). The asterisk (\*) refers to the word-trunks. The number of studies found were 236, 97 and 50, respectively. The focus was on the title, abstract and keywords. However, many of these studies were irrelevant. Additionally, keywords such as, “farm intensi\*”, “local community” were also used individually in combination with “pig” OR “pig production” OR “pig farm\*”. No relevant studies regarding farm intensification or local community were identified, except one. A broader search in Google Scholar using the terms “consumer” or “citizen” or “public” combined with “pig” OR “pig production” OR “pig farm\*” resulted in 17,100 articles. Following these searches a screening process took place, and given the larger number of papers a new search took place in Google Scholar using a more recent cutting date, 2009, and the terms “consumer” or “citizen\*” OR “public\*” combined with “attitude\*” AND “pig production” AND “sustainability\*”, which resulted in over 500 articles being found. However, many of these studies were not relevant to pig production systems but other species.

The search across these different databases highlighted a large number of studies that focus on animal welfare in general or specific animal welfare issues, such as gestation crates and castration without anaesthesia, with very few focusing on other aspects of sustainability or the trade-offs between different pillars of sustainability. Therefore, for the purpose of this research, following screening, 26 peer-reviewed articles were selected, published in English, which focused strictly on consumers/citizens’ attitudes towards different aspects of sustainability and included in the title or the abstract the word “pig” or “pork” or any other term related to pig production. These included both quantitative and qualitative studies.

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<sup>1</sup> A qualitative meta-analysis investigates the same general topic (usually one clear question), with the purpose to contribute to knowledge, *i.e.* theory building, theory explanation and theory development (Schreiber *et al.*, 1997). Specifically, it is characterised by “the aggregating of a group of studies for the purposes of discovering the essential elements and translating the results into an end product that transform the original results into a new conceptualisation” (ibid: 314).

<sup>2</sup> Appendix 1 provides the list of articles used and discussed in this literature review.

In addition to these articles, where appropriate, the study also refers to two literature reviews. Clark *et al.*, (2017) performed a systematic literature review, including a meta-analysis, on consumers' willingness-to-pay (WTP) on high(er) animal welfare production diseases, extending the work of Lagerkvist and Hess (2011). Thorslund *et al.*, (2017) conducted a traditional literature review which included 53 studies, published between 2000 and 2015, on the role and responsibility of European consumers in market-driven animal welfare, with a focus on pig production. Additionally, the paper also makes use of the work published by Hubbard, Clark and Foster (2018) on consumers' perception and farm animal welfare, and where necessary, it refers to other papers which may not focus on societal concerns but which, nevertheless, relate to the sustainability of pig production systems (*e.g.*, McGlone, 2013). This literature review aims to add to previous work, particularly Thorslund *et al.*, (2017) by addressing the following questions. What are the main societal<sup>3</sup> concerns and attitudes towards different pig production systems? What are the potential trade-offs between different pillars of sustainability of pig production systems? Is there a gap between consumers and citizens' attitudes towards sustainability of different pig production systems?

## 4. RESULTS AND DISCUSSIONS

### 4.1. SOCIETAL UNDERSTANDING OF PIG PRODUCTION SYSTEMS

Most of the studies acknowledge the level of livestock intensification that took place since the end of the WWII that characterises the Western agricultural production systems. This is particularly the case of pig production, which has become a topical issue in public debate (Sonntag *et al.*, 2019). Pig production is a key component of the agricultural industry worldwide, with almost 760 million pigs raised in 2024 (Statista, 2025). China is the global leader (427 million pigs), followed by the European Union (EU) (132 million) and the United States of America (USA) (763 million) (Sonntag *et al.*, 2019). It is argued that, particularly in high-income countries, most animals are reared in intensive production systems (Maes *et al.*, 2019).

Although all selected articles include references to animal production or husbandry systems, none provided a clear definition of what an intensive production system means. Instead, words such as "intensive" "commercial", "conventional", "modern", "contemporary", "industrialised", "indoor", as opposed to "organic", "outdoor", "extensive" and "low-input farming" were used to describe pig production systems (*e.g.*, Bergstra *et al.*, 2017; Weible *et al.*, 2016; Bergstra *et al.*, 2015; Krystallis *et al.*, 2012; Boogard *et al.*, 2011; Sorensen, 2012; Tawse, 2010; Krystallis *et al.*, 2012). Some studies (*e.g.*, Vanhonaker *et al.*, 2009; Verbeke *et al.*,

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<sup>3</sup> Hereafter, societal concerns will refer mainly to the attitudes/views/perceptions of consumers or citizens.

2010, Sørensen *et al.*, 2012) focused on certain characteristics of production such as stocking density, (expressed as number of animals/farm or herd size), housing and floor type, outdoor access, or animals' freedom of movement.

Weible *et al.* (2016) highlighted that research regarding consumers' or citizens' attitudes and expectations towards animal husbandry have mainly focused on animal welfare or food quality, with hardly any studies on people's opinions regarding specific animal husbandry. Hence, employing both qualitative (focus groups) and quantitative (online survey) techniques they explored German citizens' perceptions, expectations and attitudes towards modern pig production. However, modern pig production was not defined but instead participants in the (nine) focus groups were asked to describe it themselves. Additionally, the surveyed respondents had to consider the extent to which they agreed with various statements on pig husbandry, such as for example "the use of antibiotics in modern pig husbandry is a danger to human health"; "animals in intensive livestock farming are more susceptible to disease than those in smaller farms; animals do not have enough space to move in modern husbandry; "pigs feel comfortable in modern stables because they do not have other experience" of anything else.

In general, studies that employ qualitative techniques (*e.g.*, Benard and de Cock Buning, 2013) asked participants to define, describe or sketch how they think animals are reared in a contemporary pig production system. Other studies, (*e.g.*, Sonntag *et al.*, 2019; Yunes *et al.*, 2018) provided their participants with images, photos or videos of production systems, including information or texts regarding the advantages and disadvantages of these systems. In contrast, most quantitative studies that investigate perceptions, attitudes, views or opinions, employed survey techniques that measure the extent to which respondents agree or disagree with different statements (based on a five or seven-point Likert scale) that describe the production systems formulated by the researchers in accordance with the aim and objectives of their studies. These statements are usually based on results from previous studies or following discussion with pig production experts or/and other industry specialists (Sørensen *et al.*, 2012).

Most studies also focused on participants who are not associated with the pig industry or do not have a professional background regarding animal husbandry. There were, however, other studies (*e.g.*, Yunes *et al.*, 2018; Tawse *et al.*, Uzea *et al.*, 2011) that include in their sample professionals from the livestock industry (*e.g.*, vets, academics, students, farmers) or animal welfare activists, allowing for some comparison between those associated with pig production and those who are not.

Overall, results show that most participants (*e.g.*, those not associated with the pig farming industry) have little awareness and lack knowledge regarding production systems per se, no matter the country where the study was conducted. As Sørensen *et al.*, (2012:886) pointed out "Western societies are urbanised to such a degree that only few citizens ever encounter the conditions in livestock farming or in primary processing, let alone encounter them in enough detail to be able to

really distinguish the characteristics of different production systems from each other". In general, citizens/consumers have a rather negative image of production systems (e.g., Bergstra *et al.*, 2017; Weible *et al.*, 2016; Boogard *et al.*, 2011; Krystallis *et al.*, 2012). They associate modern pig farming with "agrarian factories", being "industrialised" or using "intensive livestock farming", and use terms such as "large and "mass/crowded" to describe it (Weible *et al.*, 2016). Bergstra *et al.*, (2017) noted that these negative attitudes may be the result of conflicting attitudes between stakeholders. The provision of information, text and videos (depending on the context) or farm visits could add to or diminish these negative perceptions. In contrast, small-scale, traditional farms are regarded positively.

It is also perceived that the larger the farm the weaker the farmer-animal interaction (Weible *et al.*, 2016), as farmers have less time to dedicate to individual animals. Hence, farm size (e.g., number of animals) matters significantly when evaluating pig production systems, and large-scale is regarded as "bad" whereas small-scale is "good" (Sørensen *et al.*, 2010). However, the literature generally does not provide sufficient justification or an accurate definition of "size". The most common explanation provided is linked to previous studies that identified farm/herd size as an important component which "seems to influence consumer's choices" (Caracciolo *et al.*, 2016). For example, in their experimental design, Caracciolo *et al.*, (2016) used three levels of farm size: less than 100 sows; about 400 sows, and up to or more than 800 sows. Thus, they replicated to some extent the work of Sørensen *et al.*, (2010), which may have based their research on Krystallis *et al.*, (2012). Pozo *et al.*, (2012) defined a small-scale farm, rather vaguely, as a farm smaller than 75% of the farms in industry.

Natural living conditions, sufficient space allowance, outdoor access, free movement and litter bedding, are also associated with positive images of pig production systems (e.g., Ryan *et al.*, 2015, Krystallis *et al.*, 2012; Vanhonacker *et al.*, 2009). 'Housing and floor type' (e.g., slatted floor *versus* litter bedding), 'efforts to protect the environment, including soil, air and water' on the farm, and provision of 'outdoor access' were identified as having the strongest influence on citizens' assessment of pig production systems (e.g., Verbeke *et al.*, 2010 and Sørensen *et al.*, 2012). Although consumers and citizens' concerns regarding animal welfare and the environment have increased in recent years, consumers are very price sensitive, demand high food safety and high quality (Sonntag *et al.*, 2019; Caracciolo *et al.*, 2016 and Sørensen *et al.*, 2012).

Mørbank *et al.*, (2010) noted that attributes such as product quality, fat content, food safety, and country of origin, are also important when considering production systems, although when assessing swine production systems, these attributes seem less significant than social and environmental attributes, such as provision to outdoor access and high efforts to reduce environmental impact. They investigated the importance of food safety relative to other quality characteristics in pork such as the type of production, country of origin and fat content using an

on-line survey with 1,322 Danish consumers, concluding that food safety was not ranked as important, and was even ranked lower than fat content and country of origin. As the authors argued, this may be because previous studies that apply the same technique, *i.e.* willingness to pay (WTP), focused on food safety on its own or together with only one other food quality characteristic. Nevertheless, Mørbank *et al.*, (2010) did acknowledge consumers' WTP premium for food safety. Verain *et al.*, (2016:99) also argued that "consumer food choices are crucial in shifting diets towards more healthy and sustainable consumption patterns". To understand consumers' food choices, however, it is important to identify what influences these choices and the motives and the relative importance that consumers attach to product attributes.

Sørensen *et al.*, (2012) also argued that to understand citizens' attitudes towards agricultural production systems, these must be examined in conjunction with personal values<sup>4</sup> (*e.g.*, power, tradition, achievement, benevolence, hedonism and security), hence within a wider, integrated system of attitudes. Using a cross-national survey with consumers randomly selected across four EU countries of Belgium, Germany, Denmark and Poland, the study concluded *inter alia* that there is a strong link between consumers' preferences and individual values.

Some studies also acknowledged the gap between citizens' attitudes towards food production systems, expressed WTP and their actual behaviour as consumers, which is already well documented (Harvey and Hubbard, 2013; Clark *et al.*, 2016 and 2017; Hubbard, Clark and Foster, 2018). Often participants admitted that "their attitudes towards production systems had only a little or no impact on their behaviour as consumers, although they regarded sustainable pork production as desirable" (Sørensen *et al.*, 2012). The common reasons provided by participants in these studies for the difference between consumer's attitude and behaviour are high prices at the point of purchasing food products or the lack of product availability. Moreover, from a methodological point of view, WTP studies (Cicia and Colantuoni, 2010; Lagerkvist and Hess, 2011; Clark *et al.* (2016, 2017) have their own limitations, as they do not reflect actual consumer purchasing behaviour. Although Weible *et al.*, (2016) point out that "modern animal husbandry frequently does not meet consumers' or societal expectations", with many people expressing concerns about modern animal husbandry, their results show that there are significant differences in attitudes across different groups of people, such as "opponents" or "animal welfare conscious" people, "tolerants" or "in-between" people, and "moderates" *versus* "price conscious" consumers.

Thus, people better informed or with knowledge of the agricultural industry were often found in the "opponents" group and accounted for 22% (of a total sample of 1,519), whereas "tolerants" and "moderates (indifferent)" represented

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<sup>4</sup> These were based on Schwartz (1992) who identified five meta-values, *i.e.* openness to change (self-direction, and stimulation); self-transcendence (benevolence and universalism/social justice); conservation (security, conformity and tradition); self-enhancement (power and security) and hedonism (pleasure/satisfaction).

35% and 43%, respectively. According to Weible *et al.* (2016), enhancing knowledge, for example about the production system or methods of animal husbandry employed, may have different effects on people's acceptance of modern farming systems. Their findings were in line with the earlier work of Verbeke *et al.*, (2010) who identified four clusters of EU citizens, namely those who are "environmentally conscious" (15% of a total sample of 2,437), "weak attitude" citizens (54% of total sample), "animal welfare conscious" (11% of the sample) and "small farm supporting" citizens (11% of total sample). However, the citizen-consumer dilemma remains arguable in both studies.

It can be concluded that despite growing societal concerns, especially in relation to animal welfare and environmental impacts, understanding and knowledge of consumers regarding modern production systems remains poor. Moreover, when a market segmentation takes place, there is still a large number of people who are more "tolerant" or have "weaker" or "moderate" attitudes towards modern farming practices. This could be due to the lack of or limited knowledge regarding production systems (Clark *et al.*, 2017), with media often cited as the main source of information that influences consumers' purchasing behaviour (Hubbard *et al.*, 2018; Sørensen *et al.*, 2012). Weible *et al.*, (2016) showed that there is also a strong but negative link between agricultural knowledge and the probability of belonging to the "tolerant" group. These clusters may also reinforce the citizen-consumer gap. Although as citizens, some people (the moderate group) may criticise production systems, as consumers (the way they act at the point of purchasing) are prepared to accept them, whereas others have no criticism towards modern farming and hence show a high level of acceptance (tolerant group). The latter group may resonate with what Harvey and Hubbard (2013) labelled as the "free-rider deficit". That is "the shortfall between people's willingness to pay on their own account, and the amounts they will pay if they were convinced that their spending was also matched by others". This is based on the perception that their action alone will not make a difference to the overall situation (Harvey and Hubbard, 2013). However, more research is needed to understand these clusters.

#### 4.2. SOCIETAL VIEWS REGARDING SUSTAINABILITY AND POTENTIAL TRADE-OFFS IN PIG PRODUCTION

As already pointed out sustainability is a complex, multidimensional and transdisciplinary concept that can be defined in many ways (Caracciolo *et al.*, 2016). A sustainable pig production system (industrialised or otherwise) should simultaneously benefit the animals, the environment and people (McGlone, 2013). Hence, to ensure that a production system is sustainable, any potential trade-offs between these pillars need to be considered.

Krystallis *et al.* (2012) gave a good account of the different studies regarding environmental and societal (*e.g.*, animal welfare) concerns as the driving forces for

sustainable agricultural practices. Although most studies refer to sustainability, either by examining different aspects of sustainability in isolation (*e.g.*, animal welfare or environmental concerns) or in conjunction with other product attributes (*e.g.*, animal welfare, health, food safety, price, quality product, fat content) the literature regarding potential trade-offs, particularly between the economic, social and environmental pillars, is scarce (*e.g.*, Sonntag *et al.*, 2019; Caracciolo *et al.*, 2016; Sørensen *et al.*, 2012 and Tonsor *et al.*, 2009). Grunert *et al.*, (2018) also note that there are few studies that segmented consumers “based on their preferences for a broader range of production-related attributes (*e.g.*, animal welfare, environmental impact, health and food safety and more traditional product characteristics (*e.g.*, meat colour, fat content, country of origin and price).

Sonntag *et al.* (2019) argued that it is “widely unknown how people react and deal with intra-sustainable trade-offs in conventional pig farming systems”<sup>5</sup>, hence their study was the first to address this issue. By employing both focus groups and a random survey with German citizens, they investigated people’s opinions towards farrowing crates (usually perceived as negative) and outdoor access (usually perceived as positive) and their intra-sustainability trade-offs before and after the provision of relevant information regarding the pros and cons of each husbandry practice. As expected, the results between the two methods differed. For example, interviewees were very critical of agricultural practices, showing a high interest in livestock production. This contrasted with the majority of the survey’s respondents who were less or not at all interested in livestock production. As Sonntag *et al.*, (2019) pointed out there is an element of selection bias that occurs in qualitative studies, as opposed to the quantitative survey, where participants were recruited to represent the German population. Also, the male population was slightly underrepresented and there was a small overrepresentation of rural residents in the sample. Thus, these results need to be interpreted with caution. The results also show that participants were aware of some trade-offs in pig production (*e.g.*, between animal welfare and price of pork), but they had no knowledge regarding sustainability trade-offs such as those between animal welfare and the environment, between animal welfare and animal health or between higher farm costs, and extra work for farmer and animal welfare.

To investigate how consumers may differ in their decision-making regarding trade-offs, the study also identified four clusters, *i.e.* “Unsure” (36% of a total sample of 1,297), “Animal welfare supporters” (32%), “Vague-decision makers” (24%) and “Animal and environmental protectionists” (7%), and as expected there were differences between these clusters. Receiving information in the form of photographs did not, however, make farrowing crates more acceptable to consumer nor did outdoor access appear less positive than before the photos were provided.

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<sup>5</sup> Intra-sustainable trade-offs were defined as “trade-offs between different sustainability aspects, such as between animal welfare and human health/animal hygiene, environmental aspects or climate protection (Meuwissen and van der Lans, 2005 in Sonntag *et al.*, 2019).

In Sonntag *et al.* (2019)'s study, animal welfare aspects also seemed to prevail above the economic, technological or hygienic advantages of both systems, and overall, most consumers demanded high quality products at a low price. The "Animal and environmental protectionists" also found it difficult to decide between the welfare of animals (risk to disease) and an increased risk of gaseous emissions when pigs were given outdoor access. Sonntag *et al.* (2019) concluded that the majority of the survey's respondents "were unable to set a clear priority between sustainability trade-offs". Additionally, their results "contradict the so-called "information deficit hypothesis", which assumes that more public information results in more public acceptance" (Sonntag *et al.* (2019). This is indeed an interesting finding; particularly as various commentators argue for the provision of more information regarding modern farming practices as 'the silver bullet' for addressing public concerns such as animal welfare.

Weible *et al.* (2016) also suggested that "instead information campaigns, dialogues between farmers and processors on one hand and citizens and consumers on the other" regarding pros and cons of modern farming are needed for a better understanding and acceptance of these practices. Moreover, despite studies such as Ryan *et al.* (2015) and Tuytens *et al.* (2011) showing that by providing participants with textual information combined with photos or/and videos may influence citizens' attitudes towards certain farming practices (*e.g.*, immunocastration *versus* surgical castration for male pigs; alternatives *versus* gestation crates), the provision of information and knowledge may contribute to "a more critical, engaged public ... to discuss their views on specific issues" (Yunes *et al.*, 2018). Caracciolo *et al.* (2016) extended the work of Sørensen *et al.* (2012), and in combination, these are amongst the very few studies that investigate the relationship between attributes associated with "more sustainable practices of pig farming ...[such as] herd size, housing, impact on the environment, meat healthiness and quality and human values (see section 4.1) and the trade-offs between these attributes when choosing between certain typologies of pig production (Caracciolo *et al.*, 2016).

These attributes resemble the three dimensions of sustainability, *i.e.* economic (herd size and quality delivered); social (floor type and healthiness of the pork) and environment (level of efforts to reduce ecological impact on water, soil and air). A total of 15 descriptions of various pig farms, were grouped by respondents into 15 pig production profiles/typologies. The results showed that consumers in the selected countries, namely Belgium, Denmark, Germany, Greece and Poland, were aware of both the social and environmental aspects of pig production. The attributes which supported this finding are related to production systems where animals have outdoor access and systems characterised by high efforts to reduce environmental damage whilst maintaining high quality of meat standards and good levels of livestock health. Amongst the three sustainability dimensions, the social pillar was the most important to consumers, meaning "switching to outdoor access to animals and ... preference for small farm size" (Caracciolo *et al.*, 2016). However, individual

values were crucial when choosing between different production systems. For example, consumers with more pronounced “self-enhancement”, “conservation” and “hedonism” values were more likely to pay less attention to sustainability in the swine sector, which reinforce the findings of Sørensen *et al.* (2012). Additionally, it must be stressed that neither Caracciolo *et al.* (2016) nor Sørensen *et al.* (2012) investigated consumer behaviour *per se*, meaning that as citizens they may not “behave in a way that is consistent with these attitudes when they act in their role as consumers”.

An earlier study by Barcellos *et al.* (2012) examined the gap between citizens’ sustainability-related attitudes (*e.g.*, towards the environment and nature, industrial food production, local economy and local employment) and food purchasing behaviour using empirical data from Brazil. Amongst other they identified three clusters of citizens, namely “indifferent”, “environmentally conscious” and “sustainability-oriented”. Overall, Barcellos *et al.* (2012) found that, “indifference and unawareness” regarding pig production systems characterised the entire sample (475 respondents). Additionally, despite that the environment and nature had a significant influence on citizens’ attitudes towards pig farming at cluster level, the relationship between citizenship and food purchasing behaviour was weak.

Boogard *et al.* (2011) focused particularly on the socio-cultural (animal welfare within a specific culture) sustainability of animal production, conducting visits with citizen’s panels from the Netherlands and Denmark to a conventional and an organic pig farm. They argued that socio-cultural sustainability is context dependent, being defined by social perceptions and values that are time and place specific. Hence, social concerns may differ between people and countries.

Grunert *et al.* (2018) added to the literature by estimating pork consumer choices in Germany and Poland and their relationships with (a list of ten) attributes linked to environment, human health and meat safety and animal welfare. They focused on two environmental characteristics (production with zero carbon footprint and manure used as fertiliser), four attributes for human health and safety (GMO-free feed, pigs produced to be free of microbial contaminations, pork reared with complete traceability and lower use of antibiotics) and four animal welfare characteristics (animals are free to move around, castration with anaesthesia, availability of straw and transportation to the abattoir of less than 4 hours). These ten attributes were traded off against product attributes, such as fat content, meat colour and country of origin. The results showed that “free mobility for the sow” was the most important animal welfare attribute for German consumers (selected by 42% of a total sample of 1,007). The least often selected attribute (by only 3%) was ‘a production with zero-carbon footprint. Between these, other selected attributes were those related to health and food safety, “traceability” (31%), “GMO-free feed” (28%), “no microbial contamination” (26%), and “less use of antibiotics” (26%). Most Polish respondents focused on health and food safety attributes, citing “antimicrobial contamination” (49%), “GMO-free feed” (44%) and “traceability”

(41%) as important in product selection. Animal welfare attributes were less frequently selected and only one per cent of respondents considered production with a zero-carbon footprint as relatively important when choosing their pork products. Thus overall, environmental attributes were less often selected by consumers in both countries.

To get a better understanding of what matters when people buy pork, Grunert *et al.* (2018) also conducted a market segmentation. The results showed that at cluster level there were differences not only between consumers in the two countries but between groups of consumers within a country. Based on their assessment of product attributes when buying pork, respondents were classified into four groups: “production interest” (which accounted for 39% of the German sample of 1,007 and 32% of the Polish sample of 998); “price conscious” (21% and 17%, respectively); “fat and colour” (with fat content more important than colour at 42% versus 22% for Germany and 39% versus 27% for Poland, respectively and “country of origin” (23% in Germany and 22% in Poland, respectively). The German respondents in the first cluster were more environmentally conscious than those in the other groups, but this was not the case for Poland. They were also more concerned about food safety and animal welfare than the other groups. These attributes were found to be more important in the Polish “fat content and colour” cluster. Respondents in both countries in the latter group, “country of origin”, were also price sensitive (second most important) and had relatively high environmental concerns.

Overall, Grunert *et al.* (2018:128) concluded that individual benefits related to health and food safety seem to prevail and “still have more appeal to consumers than societal benefits in terms of animal welfare and/or environmental impact”. These findings rekindle the importance of the debate regarding the gap between values, moral and ethical concerns expressed by people as citizens and their actual purchasing behaviour as consumers. It also raised questions regarding the potential trade-offs that people as consumers and citizens need to take into consideration when debating the sustainability of modern production systems, but which, however, are only poorly understood by the wider public.

#### 4.3. SOCIETAL CONCERNS REGARDING SPECIFIC ISSUES OF ANIMAL WELFARE

The previous sections have covered the growing societal concerns regarding animal welfare in modern pig production, and across the articles included in this study, animal welfare has been the dominating aspect (Poza *et al.*, 2012). Indeed, there is a vast number of studies that focus on citizens or consumers’ attitudes and perceptions about farm animal welfare in general (Vanhonacker *et al.*, 2009). There are also many studies dedicated to consumers’ willingness to pay for animal welfare friendly products including two meta-analyses by Clark *et al.*, 2016, 2017.

This is also well reflected in the current review, since studies that employ choice experiments usually estimate WTP. However, despite these reviews highlighting increasing public concerns regarding animal welfare and a negative perception towards modern farming, “yet when asked spontaneously, farm animal welfare is not a [key] priority attribute for most consumers when shopping” (Hubbard *et al.*, 2018), hence reinforcing the gap between attitude and behaviour. As shown by Grunert *et al.* (2018), when animal welfare aspects are considered in conjunction with other food attributes, animal welfare (and environment) is ranked relatively low. Although the attitude-behaviour gap might have diminished (no research in this respect has been found in the current review and it can be argued that) it still persists. Research carried out over two decades ago (*e.g.*, Vanhonacker *et al.*, 2010) concluded that on average Belgium respondents considered animal welfare a less important attribute than health, trust, product quality and safety.

Thorslund *et al.* (2017) also pointed out that animal welfare is perceived as an attribute of the quality of meat, hence improved animal welfare is considered to influence taste, flavour and tenderness. They also noticed that when animal welfare is examined against other societal concerns (*e.g.*, the environment) it has also been ranked as less important. However, as already discussed, when a market segmentation analysis is carried out there is a group of people who feel strongly about animal welfare.

Given the complexity of animal welfare, there is also a body of the literature that identifies some specific practices within pig production that are of particular concern for citizens/consumers around the world, such as the use of gestation crates for housing pregnant sows and piglet castration without anaesthesia. Several studies conducted in the USA (*e.g.*, Ryan *et al.*, 2015; Pozo *et al.*, 2012; Tonsor *et al.*, 2009); Canada (Ryan *et al.*, 2015) and Brazil (Yunes *et al.*, 2018) focused on the evaluation of gestation crates. Studies that investigated societal attitudes towards surgical castration were carried out in Belgium (*e.g.*, Beirendock *et al.*, 2013, and Vanhonacker *et al.*, 2009), Germany (*e.g.*, Heid and Hamm, 2013). Kallas *et al.*, (2013) carried out a comparative study involving EU consumers in several member states, namely Germany, France, Italy, The Netherlands, Spain and the UK.

#### *The use of gestation crates for housing pregnant sows*

All papers in the first group of studies employed on-line surveys to identify citizens' attitudes towards the use of gestation crates as opposed to alternative housing systems, such as group housing, less confined systems or gestation crates for sows. It is worth noting that the use of gestation crates for sows has been prohibited in the EU, other than for a period of up to four weeks after service. The British Veterinary Association has also called for a ban on the use of farrowing crates for sows based on concerns for animal welfare (The Pig Site, 2025).

Yunes *et al.* (2018) mimicked the work of Ryan *et al.* (2015) thereby testing Brazilian participants' attitudes before and after the provision of text and video information on the systems. Both studies concluded that participants were less

willing to accept the use of gestation crates for sows after information was provided. Interestingly is that the proportion of people indicating support for the use of gestation crates was not negligible, accounting for about a third (of a 242 sample) in the study by Ryan *et al.*, 2015. This dropped to almost 18% after the provision of additional information. The figures were slightly different for Brazil, as out of 349 participants, 15% were in favour, 6% were indifferent and 79% rejected them. However, the sample in Brazil consisted of both people who were associated with the livestock systems (so more knowledgeable) and which accounted for almost half of the sample (176) and people who were not associated with pig production. The paper also did not distinguish between these two groups. Additionally, participants were given the opportunity to watch the video before the questionnaire was completed. Some 200 people accessed this information, of which the majority where from the latter group. Hence, the figure of those who initially rejected the use of gestation crates for sows could have been higher.

The other two studies carried out in the USA, and which employed choice experiments, also showed some interesting results. Tonsor *et al.* (2009) estimated, amongst others, consumers' WTP for alternative pork practice attributes, including the use of gestation crates. The paper evaluated how a ban on gestation crates may be justified on grounds of consumer's economic benefits (consumer surplus) and how these economic welfare effects were distributed across consumers. In line with most studies that used WTP, most consumers (two-thirds of 768) were prepared to pay a premium for pork voluntarily produced without use of gestation crates. However, only 20% of the sample population, a "Ban preferring" group, expressed a significantly higher WTP for banning pork produced in gestation crates. Overall, Tonsor *et al.* (2009) also estimated statistically significant welfare losses, with consumers who have been prevented from choosing between pork produced "as usual" and gestation crate-free, being the most affected. The "Ban preferring" group also experienced a consumer's welfare loss. This study is amongst the few studies that quantify the trade-off between improved animal welfare and economic benefits for consumers. Pozo *et al.* (2012) also found that consumers indicate a positive WTP for pork produced in a gestation crate-free system, however, the amount the consumers are prepared to pay was subject to the number and nature of attributes (*e.g.*, pasture access, farm size, use of antibiotics and price).

#### *Castration without anaesthesia*

The second group of papers focused on societal attitudes towards piglet castration without anaesthesia and alternatives, *e.g.* immunocastration. the use of anaesthesia and alternatives to producing intact male pigs, such as immunocastration. Although the practice of castrating piglets without anaesthesia was supposed to have stopped by now, since the European pig industry voluntarily opted to stop castration by 1 January 2018 (Higurea, 2019), the practice is still widely used in the EU. Although there are societal voices (*e.g.*, NGOs, animal activities, supermarkets and some consumers) that express concerns regarding this

practice all papers showed that in general consumers were less aware of this practice. However, once informed most consumers were in favour of alternative methods of utilising male pigs for meat production such as castration with anaesthesia and analgesia, immunocastration or simply raising male pigs entire.

All studies but one (Beirendonck *et al.*, 2013) also found out that consumers do not perceive pig castration to be relevant to animal welfare nor to have a relationship with meat quality. This was particularly the case when assessed in conjunction with other attributes such as food safety, taste and price. However, consumers' preferences regarding pig castration were heterogenous across different countries, with consumers in the UK and the Netherlands expressing that castration was of a relatively higher importance compared with other animal welfare aspects.

## 5. CONCLUSIONS

This article presents a comprehensive literature review on societal concerns regarding sustainability of pig production systems. In the main, 26 studies were included in this analysis but when necessary additional information was drawn in from other sources. In line with other studies (Clark *et al.*, 2016, 2017) this review has shown that despite an increase in societal concerns regarding different aspects of sustainability, the wider public has little knowledge about different systems of pig production but strong negative perceptions towards modern farming practices. However, across studies, modern pig production is hardly defined. The lack of public familiarity and knowledge surrounding modern animal production can result in misconceptions (Hubbard *et al.*, 2018). The provision of more information does not necessarily translate into a higher level of public acceptance, but may have unexpected effects on people's acceptance of modern farming systems.

There is consensus across these studies that pig production on small-scale farms characterised by lower stocking densities, provision of outdoor access and other natural living conditions, housing and floor type, free movement of animals, and efforts to reduce environmental impacts are perceived to be more sustainable than so-called "conventional" systems. Although consumers and citizens' concerns regarding animal welfare and the environment have increased in recent years, other attributes such as price, food safety and quality, fat content, and country of origin, are also important when considering production systems. Depending on the study, some of these attributes prevail above societal concerns regarding animal welfare and the environment. There also seems to be a strong link between consumers' preferences and individual values, and consumer's food choices should not be neglected if a shift in diets towards more healthy and sustainable consumption patterns is to be seen.

Although some authors will argue that modern farming practices do not meet societal expectations, when a market segmentation analysis is performed the results paint a very different picture, with only some segments of the population (usually

not very large) being animal welfare or/and environmentally conscious. Usually, the proponents of high animal welfare or environmental concerns have a strong interest in animal production, knowledge and a better understanding between different production systems. Other socio-economic demographic variables such as age, gender, level of education, location (urban versus rural), income and number of children / household are also important when such a market segmentation takes place. However, given the large body of literature that addresses these characteristics, they were not discussed in this article.

Given the growing public concern about animal welfare, often supported by studies estimating consumers' willingness to pay, it could be expected that an increasing proportion of the public would shift towards purchasing animal products produced under high(er) welfare standards. However, research consistently shows that citizens' positive attitudes towards farm animal welfare do not always translate into corresponding purchasing behaviours. In line with previous studies (*e.g.*, Harper and Henson, 2001; Toma *et al.*, 2011), this review acknowledges the persistent gap between citizens' attitudes towards food production systems, their stated willingness to pay (WTP), and their actual consumer behaviour. Hubbard *et al.* (2018) identify four key factors contributing to this gap: (1) global consumerism and intensification in commercial farming, (2) limited willingness to pay, (3) consumer behaviour driven by assumptions and inferences such as misinformation or cultural norms, and (4) a lack of consumer accountability. The latter is particularly significant and often overlooked. While farmers, regardless of production system, are increasingly expected to demonstrate transparency, showing consumers how their money supports good husbandry, high animal welfare, and reduced environmental impacts, consumers also bear responsibility. They must recognise the implications of their purchasing decisions and make more ethically informed choices. Notably, few of the studies reviewed here explicitly address the issue of consumer accountability in relation to the sustainability of pig production systems. Researchers have also an important role to play by providing robust, evidence-based analyses and clearer, more meaningful definitions of key terms. Until such efforts are strengthened, achieving sustainable (pig) production systems remains a challenge.

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APPENDIX 1. LIST OF ORIGINAL RESEARCH ARTICLES INCLUDED  
IN THE STUDY

	Authors	Year	Country	Focus on	Method
1	Barcellos <i>et al.</i>	2011	Brazil	The gap between citizens' sustainability attitudes and consumers' purchasing behaviour	Survey: face-to-face Sample: 475 regular meat eaters Conjoint analysis
2	Barcellos <i>et al.</i>	2013	China	Consumers' attitudes to different pig production systems	A cross-sectional survey was carried out with 472 participants in 6 Chinese cities
3	Beirendock <i>et al.</i>	2013	Belgium	Consumers' opinion on alternatives for piglet castration without anaesthesia	Face-to-face survey Sample: 1,018 people across 5 provinces in Flanders
4	Benard & de Cock Buning	2013	The Netherlands	Differences between urban-citizens and pig farmers' attitudes on animal welfare and intensive pig husbandry	Focus groups: three with citizens and two with pig farmers (mega-stables) Sample: 21 urban-citizens Role play for urban-citizens
5	Bergstra <i>et al.</i>	2015, 2017	The Netherlands	Attitudes towards sow husbandry between citizens and conventional pig farmers.	On-line survey Sample: 1,607 citizens and 181 farmers Pre-cluster framework
6	Boogard <i>et al.</i>	2011	The Netherlands Denmark	Concerns regarding socio-cultural sustainability in conventional and organic pig farms	Farm visits and <i>citizens</i> panels Sample: 26 participants
7	Caracciolo <i>et al.</i>	2016	Belgium, Denmark, Greece, Germany Poland	Preferences of European consumers on sustainability attributes for pig farming	On-line survey, TNS European Access panel Sample: 2,437 Principal Component Analysis

	Authors	Year	Country	Focus on	Method
8	Denver <i>et al.</i>	2017	Denmark	Consumers' preferences for pig welfare;	Online survey, panel data Sample: 398 consumers Choice experiment (WTP)
9	Grunert <i>et al.</i>	2018	Germany Poland	Consumers' attitudes towards animal welfare, human health & safety; environment Trade-offs between these and fat content, country of origin, colour and price/kg	On-line survey (2015) with pork eaters Sample: 1985 pork eaters (988 Polish and 1007 Germans) Choice experiment, WTP
10	Heid and Hamm	2013	Germany	Organic consumers' attitudes towards piglet castration without pain relief and three alternatives	Focus groups (9) with Vickrey auctions Sample: 89 organic pork consumers
11	Kallas <i>et al.</i>	2013	Germany, the Netherlands, France, Italy, Spain, UK	EU consumers' attitudes regarding pig castration and other animal welfare aspects	Survey using a questionnaire in a controlled environment Sample: 825 consumers
12	Krystallis <i>et al.</i>	2012	EU, Brazil, and China	Citizens' attitudes towards sustainable characteristics of pig production systems	Sample: 2,885 Conjoint experiment and Cluster analysis
13	Krystallis <i>et al.</i>	2009	Belgium, Denmark, Poland and Germany	Mapping citizens' attitudes towards pig production systems and their association with pork consumption	On-line survey Sample: 1931 consumers Conjoint and cluster analysis
14	Liljenstolpe	2011	Sweden	Consumers' preferences for attributes of pig production, food safety and animal welfare	Survey: 1,250 citizens Choice experiment, WTP
15	Morkbak <i>et al.</i>	2010	Denmark	Consumers' preferences for food safety characteristics for pork	On-line survey Sample: 1,322 Choice experiment
16	Pozo <i>et al.</i>	2012	US	Consumers' preferences for valuation of gestation crates	On-line survey: opt-in panel Sample: 800 Choice experiment (WTP)
17	Ryan <i>et al.</i>	2015	US, Canada	Public attitudes towards housing systems for pregnant sows	On-line survey Sample: 242 respondents Quantitative and qualitative analysis

	<b>Authors</b>	<b>Year</b>	<b>Country</b>	<b>Focus on</b>	<b>Method</b>
18	Sørensen <i>et al.</i>	2012	Belgium, Denmark, Germany, Poland	Citizens' evaluation of attitudes systems towards pork production	On-line survey, random selection, TNS European Access Panel Sample: 1931 Structural Equation Modelling
19	Sontannng <i>et al.</i>	2019	German	Citizens' evaluation of intra-sustainable trade-offs in pig production	Mixed methods In-depth interviews: 10 Survey: 1,298
20	Tawse	2010	UK	Consumers' attitudes towards animal welfare on pig farms and their awareness regarding pig production methods	Survey: paper-based questionnaire Sample: 173 undergraduate students WTP
21	Tonsor <i>et al.</i>	2009	US	Consumer voting and demand behaviour regarding a ban on the use of gestation crates	On-line survey Sample: opt-in panel 768 citizens Participants provided with a list of potential changes Contingent valuation and factor analysis
22	Vanhonacker <i>et al.</i>	2009	Belgium	Consumers' attitudes towards surgical castration and immunocastration of piglets	On-line survey Sample: 225 Flemish consumers
23	Verbeke <i>et al.</i>	2010	Belgium, Denmark, Germany, Greece, Poland	Citizens' attitudes towards pig production Consumer's attitudes towards and preferences for beef and pork	Q-Pork Chains project On-line survey Sample: 2,437 randomly selected
24	Uzea <i>et al.</i>	2011	Canada	General public and animal welfare activists on quality assurance for pork	On-line survey Sample: 541 panel consumers and 82 members of animal welfare organisations Choice experiment (WTP)
25	Wible <i>et al.</i>	2015	Germany	Citizens' perceptions regarding intensive pig production	Mixed methods: Focus groups On-line survey: 1,519 Factor and cluster analysis
26	Yunes <i>et al.</i>	2018	Brazil	Views regarding the use of individual gestation stall housing for sows	On-line survey Sample: 349 people, associated (and non-associated) with pig production