JAST (Journal of Animal Science and Technology) TITLE PAGE

Upload this completed form to website with submission

ARTICLE INFORMATION	Fill in information in each box below
Article Type	Review article
Article Title (within 20 words without abbreviations)	Exploring the Multifaceted Factors Affecting Pork Meat Quality
Running Title (within 10 words)	Factors Influencing Pork Meat Quality
Author	Sriniwas Pandey1#, Sheena Kim1#, Eun Sol Kim1, Gi Beom Keum1, Hyunok Doo1, Jinok Kwak1, Sumin Ryu1, Yejin Choi1, Juyoun Kang1, Haram Kim1, Yeongjae Chae1, Kuk-Hwan Seol2, Sun Moon Kang2, Yunseok Kim3, Pil Nam Seong3, In-Seon Bae3, Soo-Hyun Cho3, Samooel Jung4*, Hyeun Bum Kim1*
Affiliation	1 Department of Animal Biotechnology, Dankook University, Cheonan, 31116, Korea 2 Planning & Coordination Division, National Institute of Animal Science, Rural Development Administration, Wanju, 55365, Korea 3 Animal Products Utilization division, National Institute of Animal Science, Rural Development Administration, Wanju, 55365, Korea 4 Division of Animal and Dairy Science, Chungnam National University, Daejeon 34134, Korea
ORCID (for more information, please visit https://orcid.org)	Sriniwas Pandey (https://orcid.org/0000-0002-6947-3469)1 Sheena Kim (https://orcid.org/0000-0002-5410-1347)1 Eun Sol Kim (https://orcid.org/0000-0001-8801-421X) Gi Beom Keum (https://orcid.org/0000-0001-6006-9577) Hyunok Doo (https://orcid.org/0000-0003-4329-4128) Jinok Kwak (https://orcid.org/0000-0003-1217-3569) Sumin Ryu (https://orcid.org/0000-0002-1569-3394) Yejin Choi (https://orcid.org/0000-0002-7434-299X) Juyoun Kang (https://orcid.org/0000-0002-3974-2832) Haram Kim (https://orcid.org/0009-0002-7504-5249) Yeongjae Chae (https://orcid.org/0009-0004-5573-1465) Kuk-Hwan Seol (https://orcid.org/0000-0002-0907-882X) Sun Moon Kang (https://orcid.org/0000-0003-3947-4337) Yunseok Kim (https://orcid.org/0000-0003-4186-7877) In-Seon Bae (https://orcid.org/0000-0003-3543-8785) Pil Nam Seong (https://orcid.org/0000-0003-2915-1059) Soohyun Cho (https://orcid.org/0000-0002-8073-8771) Samooel Jung (https://orcid.org/0000-0002-8116-188X)* Hyeun Bum Kim (https://orcid.org/0000-0003-1366-6090)*
Competing interests	No potential conflict of interest relevant to this article was reported.
Funding sources State funding sources (grants, funding sources, equipment, and supplies). Include name and number of grant if available.	This work was carried out with the support of "Cooperative Research Program for Agriculture Science and Technology Development (Project No. PJ0162112024)" Rural Development Administration, Republic of Korea
Acknowledgements	Not applicable.
Availability of data and material	Upon reasonable request, the datasets of this study can be available from the corresponding author.
Authors' contributions Please specify the authors' role using this form.	Conceptualization: Pandey S, Kim S, Jung S, Kim HB. Data curation: Kim ES, Keum GB, Doo H, Kwak J, Seol KH, Kang SM, Kim Y. Investigation: Ryu S, Choi Y, Kang J, Kim H, Chae Y, Seong PN, Bae IS, Cho SH. Writing - original draft: Pandey S, Kim S. Writing - review & editing: Pandey S, Kim S, Kim ES, Keum GB, Doo H, Kwak J, Ryu S, Choi Y, Kang J, Kim H, Chae Y, Seol KH, Kang SM, Kim Y, Seong PN, Bae IS, Cho SH, Jung S, Kim HB.

Ethics approval and consent to participate	This article does not require IRB/IACUC approval because there are no human and animal participants.

CORRESPONDING AUTHOR CONTACT INFORMATION

For the corresponding author (responsible for correspondence, proofreading, and reprints)	**Fill in information in each box below**
First name, middle initial, last name	Samooel Jung
Email address – this is where your proofs will be sent	samooel@cnu.ac.kr
Secondary Email address	
Address	Division of Animal and Dairy Science, Chungnam National University, Daejeon 34134, Korea
Cell phone number	+82-10-9380-1136
Office phone number	+82+42-821-5774
Fax number	

CORRESPONDING AUTHOR CONTACT INFORMATION

For the corresponding author (responsible for correspondence, proofreading, and reprints)	**Fill in information in each box below**
First name, middle initial, last name	Hyeun Bum Kim
Email address – this is where your proofs will be sent	hbkim@dankook.ac.kr
Secondary Email address	
Address	Department of Animal Resources Science, Dankook University, Cheonan 31116, Korea
Cell phone number	+82-10-3724-3416
Office phone number	+82-41-550-3653
Fax number	+82-41-565-2949

Exploring the Multifaceted Factors Affecting Pork Meat Quality

Sriniwas Pandey[1#], Sheena Kim[1#], Eun Sol Kim[1], Gi Beom Keum[1], Hyunok Doo[1], Jinok Kwak[1], Sumin Ryu[1], Yejin Choi[1], Juyoun Kang[1], Haram Kim[1], Yeongjae Chae[1], Kuk-Hwan Seol[2], Sun Moon Kang[2], Yunseok Kim[3], Pil Nam Seong[3], In-Seon Bae[3], Soo-Hyun Cho[3], Samooel Jung[4*], Hyeun Bum Kim[1*]

[1]Department of Animal Biotechnology, Dankook University, Cheonan, 31116, Korea

[2]Planning & Coordination Division, National Institute of Animal Science, Rural Development Administration, Wanju, 55365, Korea

[3]Animal Products and Utilization division, National Institute of Animal Science, Rural Development Administration, Wanju, 55365, Korea

[4]Division of Animal and Dairy Science, Chungnam National University, Daejeon 34134, Korea

[#] **Equal contributors**

These authors contributed equally to this study

* **Corresponding authors**

Samooel Jung

Division of Animal and Dairy Science, Chungnam National University, Daejeon 34134, Korea

Tel: +82-42-821-5774

Email: samooel@cnu.ac.kr

Hyeun Bum Kim

Department of Animal Resources Science, Dankook University, Cheonan 31116, Korea

Tel: +82-41-550-3653

Email: hbkim@dankook.ac.k

Abstract (up to 350 words)

The significance of pork meat quality extends far beyond mere consumer satisfaction, encompassing crucial aspects such as health and nutrition, economic impact, reputation and branding, food safety, and sustainability within the global food system. Influenced by a multitude of factors, each playing a pivotal role in shaping its sensory attributes and consumer appeal, pork meat quality stands as a cornerstone of the meat industry. Thus, understanding these factors are imperative for ensuring consistent high-quality pork production, aligning with consumer preferences, and elevating overall satisfaction levels. In this review, we provide a comprehensive overview of the diverse factors affecting pork meat quality, including genetic characteristics, rearing systems, feed composition, gender differences, pre-slaughter handling, and meat aging processes.

Keywords (3 to 6): Pig, Meat quality, Pork

Introduction

Pork is one of the most widely consumed red meats worldwide, accounting for 35% of global meat consumption [1]. In consumers' diets, pork is one of the important sources of rich animal protein and other essential nutrients (essential vitamin, mineral, and fatty acids) [2–4]. As consumers' lives become enriched, interest in meat with high nutritional and functional value and excellent taste and texture is increasing, and there is a trend in placing high value on the quality of meat in consumption patterns [5–7]. In order to meet these consumer demands, meat quality is also emphasized at the production and processing stages and is becoming more economically important [3,8–10].

The concept of pork meat quality can be categorized into two main aspects: production process quality and product (meat) quality [11,12]. Production process quality include all measures used in animal production, pre-slaughter handling of animals, carcass and meat processing, and more and more consumers are considering process quality as a value in itself [13]. Product quality can be subdivided into functional (initial and final pH, water holding capacity, marbling, and fat quality), sensory (eating experience, ethical, and cultures), nutritional value, and hygienic (food safety) quality [10–12]. However, most pork meat quality is defined as the culmination of several important characteristics such as color, smell, flavor, texture, firmness, tenderness, pH, water holding capacity, drip loss, etc. [14–16]. From the processor's perspective, meat properties such as moisture holding capacity, drip loss, cooking loss, pH, collagen content, protein solubility, and fat binding capacity are objective characteristics that ensure a final product of excellent quality [17,18]. However, from the consumer's perspective, an important factor that influences the final evaluation of meat quality and repeat purchase decisions is the organoleptic properties (such as color, appearance, flavor, texture, juiciness, firmness, and tenderness etc.) that consumers perceive through their senses [19,20].

In general, meat quality is recognized as a complex and difficult characteristic because it is evaluated across a wide range of characteristics and attributes that are objectively and subjectively composed, and it is difficult to judge clearly [5,9,11,21]. The final determination of product quality can be influenced by various interaction factors among the quality of the production process described above [12,20]. Thus, this review discusses the pork meat quality and the various factors that have an influence to change its quality.

Various factors affecting Pork Meat Quality.

Pork meat quality is influenced by a multitude of factors including genotype (genetic background of pig), rearing conditions (level of feeding, environmental and housing system), pre-slaughter handling, slaughter method, storage conditions, etc.(Fig. 1) [22]. The important factors affecting pork quality before and after slaughter are classified as follows:1) Factors influencing quality before slaughter: genetic, breed, sex, age and weight, rearing system, diet, pre-slaughter handling; 2) Quality influencing factors after slaughter: meat aging, storage condition.

1. Factors influencing pork meat quality before slaughter

1.1. Genetics

The meat industry has long considered genetic considerations in the production of high-quality processed meats for culinary and technological quality as the genetic background of an animal can impact the growth, feed efficiency, carcass composition, and meat quality [23]. Taking into consideration of developments in pig breeding, it is estimated that genetic variables influence pork quality by 10% to 30% [12], with the remainder attributable to environmental factors such as pre-slaughter market circumstances (15-25%) and actual slaughter process (40%) [24]. Although there are large number of pig breeds, the majority of pork industry employs crossbreeding with a restricted number of breeds in order to capitalize on the impacts of hybrid offspring on key economic characteristics [25]. One of the major reasons behind this selection is to prevent the detrimental effects of specific genes on the pork quality. Two widely recognized significant genes that exert a direct impact on technological and organoleptic pork quality after mutation are the Halothane gene (causative mutation recognized as the R615C substitution in the RYR1 gene) and rendement napole(RN) gene (also known as R200Q substitution in PRKAG3 gene. Both of these genes affect post-mortem muscle glycolysis (declining pH), reducing water holding capacity and eventually increasing meat toughness [26]. The halothane gene, also known as the porcine stress syndrome gene, is associated with malignant hyperthermia [27] and the production of pale, soft, and exudative meat (PSE). Pre-slaughter stress causes abnormal lactic acid metabolism and accelerates glycolysis; the temperature of the

carcass is abnormally high due to stress, the glycolysis is accelerated, ultimately resulting in excessive accumulation of lactic acid in a short time [28]. This results in rapid pH reduction and denaturation of muscle cell proteins, ultimately leading to the development of PSE meat with reduced water retention in muscle fiber tissue. Hamilton et al. (2000) reported that halothane genes independently affect growth performance, carcass composition, and pork quality [29]. A number of previous studies have reported that halothane-carrying pigs have advantages over halothane-negative pigs, such as better feed efficiency and carcass yield, but have a higher incidence of PSE [30–32]. The RN-, on the other hand, was discovered in Hampshire breed and is linked with extended pH decline postmortem and hence the meat from animals carrying of RN- gene is often referred to as "acid meat" due to its low pH [27]. The detrimental effects of the Halothane gene and the RN- gene are additive for color and water holding capacity [29].

1.2. Breed

Breeding (selective breeding), feeding, husbandry, and processing are the main traditional methods used to enhance pork quality [26,33]. A study by Li et al. [3] revealed that breed has significant impact on the pork meat quality. In a study comparing three breeds of Duroc, landrace and Yorkshire, Duroc pigs had the highest ultimate pH, carcass back fat thickness, marbling scores, yellowness, and fat content, while Landrace had the highest color lightness and cooking loss values. Gjerlaug-Enger et al. (2010) reported similar results for Duroc and Landrace animals [34]. Jeleníková et al. (2008) looked at the effect of pig breed on meat shear force and found that the Duroc breed was the most tender. Compared to other breeds, Duroc has distinct characteristics[35]. Alfeo et al. (2019) studied the variation in meat quality characteristics between Landrace and Sicilian pigs and found that the meat from Sicilian pigs was more tender than that from Landrace pigs [36]. Though meat quality depends on numerous factors, the majority of which are influenced by the breed and species of an animal.

1.3. Gender

Gender is supposed to have a small impact on the sensory quality of pork, including of boar taint, an off-flavor that is attributed to the presence of aldosterone, skatole and indole in the adipose tissue of mature male pigs [37–40], while gender plays an important role in determining the carcass commercial

value. It is widely recognized that entire males (EM) have the lowest body fat percentage, followed by females (FE) and Castrated males (CM) [41,42]. Although it is generally acknowledged that gender variations exist in carcass traits, research findings vary greatly [43]. The occurrence of boar taint is comparatively low but highly variable (5-25%) in context of standard pig production, the reason behind which is the detection method and production factors such as age of the pig at the time of slaughter, genotype of the pig, diet given to the pig, etc. [40,44]. At present, "human nose" is the way of scoring the strength of the taint from the carcass. However, extensive research is being conducted for developing rapid online methods. Other than the boar taint, the meat from EM can be less tender then meat from CM or FE, which is attributed to the lower content of intramuscular fat (Pauly et al., 2012); however, the difference in texture is not always prominent [41]. Xia et al. [45] studied the gender effects on novel Duroc line pig carcass characteristics and meat quality and found higher ($p<0.05$) carcass weight, slaughter backfat, loin muscle area, loin muscle depth, carcass yield in female pigs compared to castrated males. Kim et al. [46] in his study on the effects of gender and breed on meat quality in Duroc, Pietrain and crossbred pigs found fewer effects based on gender.

1.4. Age and Weight

Age and slaughter weight increases that occur at the same time are linked to higher intramuscular fat content and carcass adiposity, both of which are predicated on better sensory quality. However, as feed restriction lowers fat deposition at both the carcass and muscle levels, a particular increase in age at slaughter brought on by limited feeding may offset the effect on intramuscular fat accumulation [40,47]. The inconsistent effects of higher slaughter weight and age on organoleptic qualities have been recorded and this discrepancy may be due to various confounding variables, such as the different age/weight at the time of pig marketing, variation in diet and rearing systems, or cooking techniques. Hwang et al. [48] in their study evaluated the effects of increasing carcass weight on meat quality and sensory attributes and found that the increase in carcass weight improves the overall taste of pork; and revealed that the carcass weight had a positive correlation with flavor but negative correlation with tenderness.

1.5. Rearing System

The pig production methods when livestock technology was not advanced past were significantly more varied than those of today, and were based on factors such soil, climate, breeds-reared cattle, vegetative and productive qualities of husbandry regions, agricultural conditions, and technologies used. But with the growing competition, and development of pig rearing systems, these distinctions have become less clear [27]. The rearing system can influence the commercial value (variation in lean-to-fat deposition) of pork carcass, along with the organoleptic attributes [40]. The impact of rearing system on organoleptic qualities of pork have been associated indirectly to housing conditions (including space, floor type, outdoor access) and feeding level and composition, which influences feed requirements and physical activity, having combined effects on muscle tissue characteristics of the pork meat [40,47]. The pigs reared in outdoor conditions had enhanced juiciness in their meat [49], and improved taste and texture of bacon in the pigs reared on straw-based floors (indoor conditions) [50]. However, a study by Dostálová et al. [51] did not show any significant effect on carcass features and meat quality among the pigs reared in outdoor and conventional indoor conditions. Similarly, a previous study by Millet et al. [52] have not shown any significant impact of housing condition or production system on meat sensory quality. But, in a study done on Heigai pigs, those grown on grazing farms had a better meat quality and higher nutritional value than those grown on indoor feeding [53]. Since the sample size was small, the results can't be representative.

1.6. Diet (Feed and feed additives)

In recent years, there has been a growing interest in studying the potential of nutrition (feed and feed additives) for enhancing pork meat quality. The kind of diet fed to a pig has an influence on its organoleptic properties of meat and overall pig carcass quality [40,54]. The level of feeding, its pattern, and the protein-energy ratio of the diet, along with the genotype of the pig, determines the rate of growth and the weight gain at both the whole-body and muscle levels in a pig. It is therefore a primary component for modulating body compositions and therefore directly impacting pig carcass value. Also, pigs being mono-gastric animals, many dietary ingredients get easily deposited to muscles and fat tissue, subsequently impacting the quality of pork [27]. Swine feeding is a significant environmental

component that affects both the outcomes of fattening and the amount, and the quality of meat obtained i.e., final product [21]. The feeding strategy, level of feed given as well as dietary nutrient composition all have an impact on carcass quality [47]. Feed intake restrictions, a type of feeding strategy, are frequently implemented during the finishing stage to increase the carcass value, as it decreases body fatness during pig growth. This is because fat deposition increases more rapidly than lean deposition with increasing body weight [47]. Metabolizable energy and protein levels are the two major nutritional parameters that affect tissue composition, quantity, and quality of meat products [21]. Also, according to Ngapo and Gariépy [55], the dietary factors can impact the sensory qualities of pork in several ways by a) direct transfer of flavor/aroma from given feed to pig meat (e.g., when feeding fish oil), b) due to change in quantity of nutritional components in the feed (saturated, monounsaturated and polyunsaturated fatty acids), c) absorption of compounds from their environment, leading to increased boar taint chemicals from the mix of feces and urine, etc. (Table 1). Hertzaman et al. [56] reported that in the sensory evaluation of pork fed a diet containing graded fishmeal up to a 5.5% level, there was a difference in off-flavor in pork stored frozen for 6 months, but there was no difference in fresh meat. Likewise, Valaja et al. [57] also reported that there was no statistical difference in fresh meat samples based on the fishmeal content (5% and 10%) in the feed. However, it was reported that off-flavors increased depending on the fishmeal supply period. According to a review study by Rosenvold and Andersen [27], pigs fed diets high in polyunsaturated fatty acids can have 'soft' characteristics and are more sensitive to oxidation, so the type of fatty acids in the feed is a factor affecting meat quality and storage. Since animal fats are high in saturated fats, and vegetable fats are high in unsaturated fats, dietary fat sources can be controlled to produce the expected meat quality.

Pig diets are supplemented with various types of feed additives in order to enhance the meat quality. Addition of Vitamin E in the diet helps reduce the oxidation of pork and hence increase the shelf-life and quality of pork meat [58]. Lately, there has been significant interest in adding high levels of Vitamin D3 to improve tenderness of meat from cattle. Enright et al. (1998) in a study assessed the effects of feeding high amounts of Vitamin D3 to the finishing pigs during the last 10 days before slaughter [59]. The results did not find any significant effects on palatability qualities. However, there was reduction in drip loss and improvement in muscle color compared to the control group. The oral administration of sodium bicarbonate (an oral electrolyte) has been found to reduce the cases of PSE [58]. The study

by Xia et al. (2017) indicated improvement in the pork meat quality with the addition of sugar can extract as a feed additive [60]. Sugar cane extract administration significantly increased the *Longissimus dori* muscle pH_{24h}, tended to reduce ($p<0.01$) shear force and significantly decreased drip loss, myofiber cross sectional area and lactate dehydrogenase activity. Algae is also used in improving red meat quality. Though algae in pigs have mainly been studied for improving immune status and gut health [61], some studies have even found its impact on fat quality increasing the levels of PUFA in pork [58].

1.7. Pre-slaughter Handling and Slaughter Conditions

Pre-slaughter activities encompass all animal-related activities and procedures from the farm to the slaughterhouse, including transportation, lairage and stunning [62]. At each stage of these activities, pigs are subjected to various stressors, including on-farm feed withdrawal, loading and transport, human interaction, and finally slaughtering, which indues stress in pigs and results in negative changes to carcass and meat quality, thus affecting overall pork meat quality. A study by Driessen et al. (2020) demonstrated that pork quality is affected by housing conditions and various parameters from birth on transport to lairage and slaughtering procedures [63]. The stunning and exsanguination phases are crucial to prevent issues related to undesired meat appearance, such as ecchymosis and petechiae [40]. The important pork characteristics that are impacted by pre-slaughter stress include colour, ultimate pH, water holding capacity, shelf-life, tenderness, which are of significant importance in meat science and technology industry [64]. Pale, soft, exudative (PSE) and dark, firm, dry (DFD) meats are the two major issues faced by meat industry impacting the value of quality of pork meat and is correlated with how the animals were treated before slaughter [65,66]. Both of these conditions are undesirable to consumers due to the subpar quality of the meat and low standard of processing for further processed products [67]. The two most widely used stunning methods for pigs are; Carbon dioxide (CO_2) and electrical stunning; There is a difference in the quality of meat. CO_2 stunning is considered a more advantageous method than electrical stunning in terms of pork meat quality and economics. Electrical stunning causes great physiological stress in pigs, increasing postmortem muscle activity and the release of catecholamines into the blood [68,69]. This results in accelerated glycogen metabolism, leading to a rapid pH decline and low water-holding capacity (WHC) [27], thus increasing

the likelihood of PSE pork [70]. Marcon reported that electrically stunned pork had higher cooking loss and lightness (L*) values. On the other hand, CO_2 stunning has a higher muscle water retention capacity and less drip loss compared to electric stunning. CO_2 stunning appears to be economically advantageous as it reduces PSE meat and lowers the incidence of petechiae [71], thus reducing losses due to disposal at the slaughterhouse [72].

2. After-slaughter factors influencing pork meat quality

2.1. Chilling and electrical stimulation

Many postmortem factors affecting pork quality have been studied, among them cooling and electrical stimulation (ES) of the carcass [73,74]. Because PSE muscle occurs when muscle proteins are denatured by high temperature and low pH immediately after death [75], reducing early postmortem metabolism, temperature, and pH decrease can reduce PSE and produce higher quality products [76,77]. Rapid cooling can quickly reduce temperature and improve pork quality by reducing PSE myogenesis [76,78]. Accelerated cooling methods include flash or cryo-cooling, hot fat trimming, cold water showers, etc., and typically involve accelerated processing using liquid nitrogen, propylene glycol, or cryogenic cooling systems [77]. Although these are all expensive processes, there are conflicting results regarding their impact on pork quality. Previous studies have confirmed that the L* value of quick-frozen pork is lowered compared to regular chilled pork, improving meat color and quality [76,79]. However, previous studies, including those by Gigiel and James [80], reported that cold muscle toughening can occur during rapid cooling [81,82]. Electrical stimulation is a method that can reduce this cold-temperature muscle toughening [74,83]. Several studies have shown that electrical stimulation can improve meat tenderness by increasing the rate of pH drop, creating conditions where cold toughness cannot occur [84–86]. However, it was also reported that the use of electrical stimulation was associated with the problem of increasing pork carcass drip loss, suggesting that the effect of electrical stimulation on pork quality may be ambiguous, and that the correlation between cooling and electrical stimulation requires further research [82,85].

2.2. Meat Aging

Aging is a method that enhances the sensory attributes tenderness, juiciness, and flavor of fresh meat by postmortem proteolysis [87]. The aging process happens to do so through changes in the composition and content of different flavor precursors in the meat [88]. Aging is generally classified into vacuum and dry aging. Wet-aging by vacuum packaging is the widely adopted method across the industry [89]. Setyabrata et al. (2021) in their study evaluated the effects of aging methods (wet-aging, conventional dry-aging, and UV-light dry-aging) and found similar results [89]. Instrumental tenderness was similar across all the three treatments ($p<0.05$); however dry-aging and UV-light dry-aging had a greater water-holding capacity than wet-drying. The consumer panel was unable to discern any differences in overall similarity and sensory attributes across the treatments, even though the metabolomics analysis revealed more flavor- related compounds in dry-aged meat. However, the results from another study suggested that both dry and wet-aging methods affect pork meat quality differently [90]. Though dry aging resulted in greater pH, redness values and moisture content, it exhibited lower drip loss and texture profiles.

2.3. Storage Conditions

Freshness is one of the most crucial considerations for consumers buying meat [91] since meat is one of the most perishable foods because of its high-water content. Freezing, which has seen significant advancements over the past century, is a widely adopted preservation method to preserve pork meat and facilitate the meat trade [92]. One of the positives of freezing is that it prevents microbial deterioration at temperatures lower than -12℃, thus extending the product′s shelf life [93]. In the meat industry, the value of meat exports worldwide is presently over US$ 13 billion, and freezing is crucial to guaranteeing the safety of meat provided to all parts of the globe [92]. The freeing process can also degrade the pork meat quality because of formation of ice crystals, affecting microstructure of frozen meat, due to repeated cycles of freeze-thawing [94]. Freeze-thawing cycles arise due to temperature fluctuations or

mishandling during storage, retail display, transportation, etc. [95]. The repeated freezing-thawing cycles damage the muscle integrity and structure [96], causing destruction of cells and resulting in release of enzymes promoting protein and lipid oxidation, leading to discoloration and deterioration in flavor, affecting the pork meat quality [40,97]. However, the impact of freezing and thawing on pork texture appears to be a subject of discussion [40].

Conclusion

Consumer demands are constantly evolving, and optimizing meat quality is essential to meet these demands. It is important to consider various aspects such as taste, texture, and nutritional value to supply products that satisfy consumers. With the increasing demand for pork, sustainable production and quality optimization are becoming increasingly important. Research that considers both production processes and quality improvement is needed. This will help develop efficient and environmentally friendly production methods while enhancing the quality of meat. Multiple factors influence the quality of pork, and these factors are often interconnected. For example, genetic characteristics can affect feed supply conditions and dietary choices, while gender can influence intake and growth rates. Understanding these interactions is crucial. While past studies have mainly focused on the impact of individual factors, optimizing pork quality requires understanding the complex interactions among these factors. Therefore, future research should focus on integrated studies that consider these interactions. Through such research, comprehensive consideration of various factors influencing pork quality can be achieved, thereby meeting consumer demands and achieving sustainable production and quality optimization.

Declarations

Ethics approval and consent to participate

This article does not require IRB/IACUC approval because there are no human and animal participants.

Competing interests

No potential conflict of interest relevant to this article was reported.

Funding

This work was carried out with the support of "Cooperative Research Program for Agriculture Science and Technology Development (Project No. PJ0162112024)" Rural Development Administration, Republic of Korea

References (Vancouver or NLM style)

1. Kim SW, Gormley A, Jang KB, Duarte ME. Current status of global pig production: an overview and research trends. Anim Biosci 2023;37:719–29. https://doi.org/10.5713/ab.23.0367.

2. Murphy MM, Spungen JH, Bi X, Barraj LM. Fresh and fresh lean pork are substantial sources of key nutrients when these products are consumed by adults in the United States. Nutr Res 2011;31:776–83. https://doi.org/10.1016/j.nutres.2011.09.006.

3. Li YX, Cabling MM, Kang HS, Kim TS, Yeom SC, Sohn YG, et al. Comparison and correlation analysis of different swine breeds meat quality. Asian-Australasian J Anim Sci 2013;26:905–10. https://doi.org/10.5713/ajas.2012.12622.

4. Choe J-H, Yang H-S, Lee S-H, Go G-W. Characteristics of pork belly consumption in South Korea and their health implication. J Anim Sci Technol 2015;57:1–7. https://doi.org/10.1186/s40781-015-0057-1.

5. Henchion M, McCarthy M, Resconi VC, Troy D. Meat consumption: Trends and quality matters. Meat Sci 2014;98:561–8. https://doi.org/10.1016/j.meatsci.2014.06.007.

6. Soladoye PO, Shand PJ, Aalhus JL, Gariépy C, Juárez M. Review: Pork belly quality, bacon properties and recent consumer trends. Can J Anim Sci 2015;95:325–40. https://doi.org/10.4141/CJAS-2014-121.

7. Zhang J, Yujuan W. Economic Management of Pork Consumption Market in High-Grade Pork Supply Chain. Rev Científica La Fac Ciencias Vet 2020;30:805–13.

8. Wood JD, Warriss PD, Enser MB. Effects of production factors on meat quality in pigs. In: D.E. Johnstont., D.A. Ledward, editors. Chem. muscle-based foods, London: Rety of Chemistry; 1992, p. 3–15.

9. Sosnicki AA, Pommier S, Klont RE, Newman S, Plastow G. Best-cost production of high quality pork: Bridging the gap between pig genetics, muscle biology/meat science and consumer trends. Proceeding 2003 Manitoba Swine Semin., 2003, p. 29–31.

10. Hugo A, Roodt E. Significance of porcine fat quality in meat technology: A review. Food Rev Int 2007;23:175–98. https://doi.org/10.1080/87559120701225037.

11. Hofmann K. What is quality? Definition, measurement and evaluation of meat quality. Meat Focus Int 1994;3:73–82.

12. Olsson V, Pickova J. The influence of production systems on meat quality, with emphasis on pork. Ambio 2005;34:338–43. https://doi.org/10.1579/0044-7447-34.4.338.

13. Fischer K. Consumer-relevant aspects of pork quality. Anim Sci Pap Reports 2005;23:269–80.

14. Jankowiak H, Cebulska A, Bocian M. The relationship between acidification (pH) and meat quality traits of polish white breed pigs. Eur Food Res Technol 2021;247:2813–20. https://doi.org/10.1007/s00217-021-03837-4.

15. Tomović VM, Žlender BA, Jokanović MR, Tomović MS, Šojić B V., Škaljac SB, et al. Technological quality and composition of the M. semimembranosus and M. longissimus dorsi from Large White and Landrace Pigs. Agric Food Sci 2014;23:9–18. https://doi.org/10.23986/afsci.8577.

16. Zmudzińska A, Bigorowski B, Banaszak M, Roślewska A, Adamski M, Hejdysz M. The effect of diet based on legume seeds and rapeseed meal on pig performance and meat quality. Animals 2020;10:1–13. https://doi.org/10.3390/ani10061084.

17. Santos TC dos., Gates RS, Souza C de F, Tinôco I de FF, Cândido MGL, Freitas LC da SR. Meat quality parameters and the effects of stress: a Review. J Agric Sci Technol B 2019;9:305–15. https://doi.org/10.17265/2161-6264/2019.05.001.

18. Allen CD, Fletcher DL, Northcutt JK, Russell SM. The relationship of broiler breast color to meat quality and shelf-life. Poult Sci 1998;77:361–6. https://doi.org/10.1093/ps/77.2.361.

19. Cross HR, Durland PR, Seideman SC. Sensory qualities of meat. In: Bechtel PJ, editor. Muscle as food, Academic Press, INC.; 1986, p. 279–320.

20. Narsaiah K, Biswas AK, Mandal PK. Nondestructive methods for carcass and meat quality evaluation. Elsevier Inc.; 2019. https://doi.org/10.1016/B978-0-12-819233-7.00003-3.

21. Łyczyński A, Wajda S, Czyżak-Runowska G, Rzosińska E, Grześ B. Effect of environmental conditions on pork meat quality – a review. Polish J Food Nutr Sci 2006;15:109–16.

22. Freepik. Graphic resources. Freepik 2024. https://www.freepik.com/ (accessed April 16, 2024).

23. Cannon JE, Morgan JB, Heavner J, Mckeith FK, Smith GC, Meeker DL. Pork quality audit: a review of the factors influencing pork quality. vol. 6. 1995. https://doi.org/10.1111/j.1745-4573.1995.tb00581.x.

24. de Vries AG, van der Wal PG, Long T, Eikelenboom G, Merks JWM. Genetic parameters of pork quality and production traits in Yorkshire populations. Livest Prod Sci 1994;40:277–89. https://doi.org/10.1016/0301-6226(94)90095-7.

25. Mote BE, Rothschild MF. Modern genetic and genomic improvement of the pig. Elsevier Inc.; 2019. https://doi.org/10.1016/B978-0-12-817052-6.00014-8.

26. Ciobanu DC, Lonergan SM, Huff-Lonergan EJ. Genetics of meat quality and carcass traits. Genet. Pig Second Ed., 2011, p. 355–89. https://doi.org/10.1079/9781845937560.0355.

27. Rosenvold K, Andersen HJ. Factors of significance for pork quality - a review. Meat Sci 2003;64:219–37. https://doi.org/10.1016/S0309-1740(02)00186-9.

28. Salas RCD, Mingala CN. Genetic factors affecting pork quality: Halothane and Rendement Napole genes. Anim Biotechnol 2017;28:148–55. https://doi.org/10.1080/10495398.2016.1243550.

29. Hamilton DN, Ellis M, Miller KD, McKeith FK, Parrett DF. The effect of the Halothane and Rendement Napole genes on carcass and meat quality characteristics of pigs. J Anim Sci 2000;78:2862–7. https://doi.org/10.2527/2000.78112862x.

30. C. Larzul, P. Le Roy, R. Guéblez, A. Talmant, J. Gogué, P. Sellier GM. Effect of halothane genotype (NN, Nn, nn) on growth, carcass and meat quality traits of pigs slaughtered at 95 kg or 125 kg live weight. J Anim Breed Genet 1997;114:309–20.

31. Fisher P, Mellett FD, Hoffman LC. Halothane genotype and pork quality. 1. Carcass and meat quality characteristics of three halothane genotypes. Meat Sci 2000;54:97–105. https://doi.org/10.1016/S0309-1740(99)00077-7.

32. Fàbrega E, Manteca X, Font J, Gispert M, Carrión D, Velarde A, et al. Effects of halothane gene and pre-slaughter treatment on meat quality and welfare from two pig crosses. Meat Sci 2002;62:463–72. https://doi.org/10.1016/S0309-1740(02)00040-2.

33. Barbut S, Sosnicki AA, Lonergan SM, Knapp T, Ciobanu DC, Gatcliffe LJ, et al. Progress in reducing the pale, soft and exudative (PSE) problem in pork and poultry meat. Meat Sci 2008;79:46–63. https://doi.org/10.1016/j.meatsci.2007.07.031.

34. Gjerlaug-Enger E, Aass L, Ødegård J, Vangen O. Genetic parameters of meat quality traits in two pig breeds measured by rapid methods. Animal 2010;4:1832–43. https://doi.org/10.1017/S175173111000114X.

35. Jeleníková J, Pipek P, Miyahara M. The effects of breed, sex, intramuscular fat and ultimate pH on pork tenderness. Eur Food Res Technol 2008;227:989–94. https://doi.org/10.1007/s00217-007-0810-x.

36. Alfeo V, Velotto S, de Camillis S, Stasi T, Todaro A. Variation in meat quality characteristics between Landrace and Sicilian pigs. Ital J Food Sci 2019;31:800–7. https://doi.org/10.14674/IJFS-1449.

37. Bañón S, Andreu C, Laencina J, Garrido MD. Fresh and eating pork quality from entire versus castrate heavy males. Food Qual Prefer 2004;15:293–300. https://doi.org/10.1016/S0950-3293(03)00069-7.

38. Robic A, Larzul C, Bonneau M. Genetic and metabolic aspects of androstenone and skatole deposition in pig adipose tissue: A review. Genet Sel Evol 2008;40:581–2. https://doi.org/10.1051/gse:2008023.

39. Heyrman E, Janssens S, Buys N, Vanhaecke L, Millet S, Tuyttens FAM, et al. Developing and understanding olfactory evaluation of boar taint. Animals 2020;10:1–17. https://doi.org/10.3390/ani10091684.

40. Lebret B, Čandek-Potokar M. Review: Pork quality attributes from farm to fork. Part I. Carcass and fresh meat. Animal 2022;16. https://doi.org/10.1016/j.animal.2021.100402.

41. Trefan L, Doeschl-Wilson A, Rooke JA, Terlouw C, Bünger L. Meta-analysis of effects of gender in combination with carcass weight and breed on pork quality. J Anim Sci 2013;91:1480–92. https://doi.org/10.2527/jas.2012-5200.

42. Pauly C, Luginbühl W, Ampuero S, Bee G. Expected effects on carcass and pork quality when surgical castration is omitted - Results of a meta-analysis study. Meat Sci 2012;92:858–62. https://doi.org/10.1016/j.meatsci.2012.06.007.

43. Van Den Broeke A, Leen F, Aluwé M, Van Meensel J, Millet S. The effect of sex and slaughter weight on performance, carcass quality and gross margin, assessed on three commercial pig farms. Animal 2020;14:1546–54. https://doi.org/10.1017/S1751731119003033.

44. Aluwé M, Heyrman E, Almeida JM, Babol J, Battacone G, Čítek J, et al. Exploratory survey on european consumer and stakeholder attitudes towards alternatives for surgical castration of piglets. Animals 2020;10:1–26. https://doi.org/10.3390/ani10101758.

45. Xia JQ, Liu DY, Liu J, Jiang XP, Wang L, Yang S, et al. Sex effects on carcass characteristics, meat quality traits and meat amino acid and fatty acid compositions in a novel Duroc line pig. J Anim Physiol Anim Nutr (Berl) 2023;107:129–35. https://doi.org/10.1111/jpn.13680.

46. Kim JA, Cho ES, Jeong YD, Choi YH, Kim YS, Choi JW, et al. The effects of breed and gender on meat quality of Duroc, Pietrain, and their crossbred. J Anim Sci Technol 2020;62:409–19. https://doi.org/10.5187/JAST.2020.62.3.409.

47. Lebret B. Effects of feeding and rearing systems on growth, carcass composition and meat quality in pigs. Animal 2008;2:1548–58. https://doi.org/10.1017/S1751731108002796.

48. Hwang YH, Lee SJ, Lee EY, Joo ST. Effects of carcass weight increase on meat quality and sensory properties of pork loin. J Anim Sci Technol 2020;62:753–60. https://doi.org/10.5187/jast.2020.62.5.753.

49. Lebret B, Prunier A, Bonhomme N, Foury A, Mormède P, Dourmad JY. Physiological traits and meat quality of pigs as affected by genotype and housing system. Meat Sci 2011;88:14–22. https://doi.org/10.1016/j.meatsci.2010.11.025.

50. Maw SJ, Fowler VR, Hamilton M, Petchey AM. Effect of husbandry and housing of pigs on the organoleptic properties of bacon. Livest Prod Sci 2001;68:119–30. https://doi.org/10.1016/S0301-6226(00)00242-6.

51. Dostálová A, Svitáková A, Bureš D, Vališ L, Zdeněk Volek. Effect of an outdoor access system on the growth performance, carcass characteristics, and longissimus lumborum muscle meat quality of the Prestice Black-Pied pig breed. Animals 2020;10:1244.

52. Millet S, Moons CPH, Van Oeckel MJ, Janssens GPJ. Welfare, performance and meat qualify of fattening pigs in alternative housing and management systems: A review. J Sci Food Agric 2005;85:709–19. https://doi.org/10.1002/jsfa.2033.

53. Li J, Liu J, Zhang S, Xie J, Shan T. The effect of rearing conditions on carcass traits, meat quality and the compositions of fatty acid and amino acid of ltl in heigai pigs. Animals 2022;12. https://doi.org/10.3390/ani12010014.

54. Hansen LL, Agerhem H, Rosenvold K, Jensen MT. Effect of Brussels sprouts and inulin/rape seed cake on the sensory profile of pork M. longissimus dorsi. Meat Sci 2002;61:441–8. https://doi.org/10.1016/S0309-1740(01)00218-2.

55. Ngapo TM, Gariépy C. Factors affecting the eating quality of pork. Crit Rev Food Sci Nutr 2008;48:599–633. https://doi.org/10.1080/10408390701558126.

56. Hertzman C, Göransson L, Rudérus H. Influence of fishmeal, rape-seed, and rape-seed meal in feed on the fatty acid composition and storage stability of porcine body fat. Meat Sci 1988;23:37–53. https://doi.org/10.1016/0309-1740(88)90060-5.

57. Valaja J, Suomi K, Alaviuhkola T, Immonen I. Effect of dietary fish meal on the palatability and fatty acid composition of pork. Agric Food Sci 1992;1:21–6. https://doi.org/10.23986/afsci.72426.

58. Ellis M, Floyd McKeith. Nutritional influences on pork quality. Natl Pork Prod Counc n.d.:1–11.

59. Enright KL, Anderson BK, Ellis M, McKeith FK, Berger LL, Baker DH. The effects of feeding high levels of vitamin D3 on pork quality. J Anim Sci 1998;76(Suppl 1:149.

60. Xia Y, Li Y, Shen X, Mizu M, Furuta T, Li C. Effect of dietary supplementation with sugar cane extract on meat quality and oxidative stability in finishing pigs. Anim Nutr 2017;3:295–9. https://doi.org/10.1016/j.aninu.2017.05.002.

61. Corino C, Modina SC, Di Giancamillo A, Chiapparini S, Rossi R. Seaweeds in pig nutrition. Animals 2019;9:1–26. https://doi.org/10.3390/ani9121126.

62. Faucitano L. Preslaughter handling practices and their effects on animal welfare and pork quality. J Anim Sci 2018;96:728–38. https://doi.org/10.1093/jas/skx064.

63. Driessen B, Beirendonck S Van, Buyse J. Effects of housing, short distance transport and lairage on meat quality of finisher pigs. Animals 2020;10:1–18. https://doi.org/10.3390/ani10050788.

64. Muchenje V, Ndou SP. How pig pre-slaughter welfare affects pork quality and the pig industry. News Ind Artic South African Pork Prod Organ 2011:1–44.

65. Adzitey F, Nurul H. Pale soft exudative (PSE) and dark firm dry (DFD) meats: Causes and measures to reduce these incidences - a mini review. Int Food Res J 2011;18:11–20.

66. Karabasil N, Boskovic T, Vicic I, Cobanović N, Dimitrijevic M, Teodorovic V. Meat quality: Impact of various pre-slaughter conditions. IOP Conf Ser Earth Environ Sci 2019;333:4–8. https://doi.org/10.1088/1755-1315/333/1/012033.

67. Viljoen HF, De Kock HL, Webb EC. Consumer acceptability of dark, firm and dry (DFD) and normal pH beef steaks. Meat Sci 2002;61:181–5. https://doi.org/10.1016/S0309-1740(01)00183-8.

68. Troeger K, Woltersdorf W. Electrical stunning and meat quality in the pig. Fleischwirtschaft 1990;70:901–4.

69. Zybert A. Quantification of the Effects of Electrical and CO2 Stunning on Selected Quality Attributes of Fresh Pork: A Meta-Analysis. Animals 2022;12:1–13. https://doi.org/10.3390/ani12141811.

70. Channon HA, Payne AM, Warner RD. Halothane genotype, pre-slaughter handling and stunning method all influence pork quality. Meat Sci 2000;56:291–9. https://doi.org/10.1016/S0309-1740(00)00056-5.

71. Velarde A, Gispert M, Faucitano L, Manteca X, Diestre A. The effect of stunning method on the incidence of PSE meat and haemorrhages in pork carcasses. Meat Sci 2000;55:309–14. https://doi.org/10.1016/S0309-1740(99)00158-8.

72. Marcon A V., Caldara FR, de Oliveira GF, Gonçalves LMP, Garcia RG, Paz ICLA, et al. Pork quality after electrical or carbon dioxide stunning at slaughter. Meat Sci 2019;156:93–7. https://doi.org/10.1016/j.meatsci.2019.04.022.

73. Hildrum KI, Solvang M, Nilsen BN, Frùystein T, Berg J. Combined effects of chilling rate, low voltage electrical stimulation and freezing on sensory properties of bovine M. longissimus dorsi. Meat Sci 1999;52:1–7.

74. Zhang WH, Peng ZQ, Zhou GH, Xu XL, Wu JQ. Effects of low voltage electrical stimulation and chilling methods on quality traits of pork M. longissimus lumborum. J Muscle Foods 2007;18:109–19. https://doi.org/10.1111/j.1745-4573.2007.00070.x.

75. BORCHERT LL, BRISKEY EJ. Protein Solubility and Associated Properties of Porcine Muscle as Influenced by Partial Freezing with Liquid Nitrogen. J Food Sci 1965;30:138–43. https://doi.org/10.1111/j.1365-2621.1965.tb00277.x.

76. Milligan SD, Ramsey CB, Miller MF, Kaster CS, Thompson LD. Resting of Pigs and Hot-Fat Trimming and Accelerated Chilling of Carcasses to Improve Pork Quality. J Anim Sci 1998;76:74–86. https://doi.org/10.2527/1998.76174x.

77. Springer MP, Carr MA, Ramsey CB, Miller MF. Accelerated chilling of carcasses to improve pork quality. J Anim Sci 2003;81:1464–72. https://doi.org/10.2527/2003.8161464x.

78. BORCHERT LL, BRISKEY EJ. Prevention of Pale, Soft, Exudative Porcine Muscle Through Partial Freezing with Liquid Nitrogen Post-Mortem. J Food Sci 1964;29:203–9. https://doi.org/10.1111/j.1365-2621.1964.tb01719.x.

79. Crenwelge DD, Terrell RN, Dutson TR, Smith GC, Carpenter ZL. Effect of chilling method and electrical stimulation on pork quality. J Anim Sci 1984;59:597–705.

80. Gigiel AJ, James SJ. Electrical stimulation and ultra-rapid chilling of pork. Meat Sci 1984;11:1–12. https://doi.org/10.1016/0309-1740(84)90013-5.

81. Møller AJ, Vestergaard T. Effect of delay time before chilling on toughness in pork with high or low initial pH. Meat Sci 1987;19:27–37. https://doi.org/10.1016/0309-1740(87)90097-0.

82. A.A. Taylor, L. Martoccia. The effect of low voltage and high voltageelectrical stimulation on pork quality. Meat Sci 1995;39:319–26.

83. Devine CE, Payne SR, Peachey BM, Lowe TE, Ingram JR, Cook CJ. High and low rigor temperature effects on sheep meat tenderness and ageing. Meat Sci 2002;60:141–6. https://doi.org/10.1016/S0309-1740(01)00115-2.

84. Taylor AA, Nute GR, Warkup CC. The effect of chilling, electrical stimulation and conditioning on pork eating quality. Meat Sci 1995;39:339–47. https://doi.org/10.1016/0309-1740(95)90392-M.

85. Taylor AA, Tantikov MZ. Effect of different electrical stimulation and chilling treatments on pork quality. Meat Sci 1992;31:381–95. https://doi.org/10.1016/0309-1740(92)90022-V.

86. Channon HA, Baud SR, Kerr MG, Walker PJ. Effect of low voltage electrical stimulation of pig carcasses and ageing on sensory attributes of fresh pork. Meat Sci 2003;65:1315–24. https://doi.org/10.1016/S0309-1740(03)00052-4.

87. Sitz BM, Calkins CR, Feuz DM, Umberger WJ, Eskridge KM. Consumer sensory acceptance and value of wet-aged and dry-aged beef steaks. J Anim Sci 2006;84:1221–6. https://doi.org/10.2527/2006.8451221x.

88. Koutsidis G, Elmore JS, Oruna-Concha MJ, Campo MM, Wood JD, Mottram DS. Water-soluble precursors of beef flavour. Part II: Effect of post-mortem conditioning. Meat Sci 2008;79:270–7. https://doi.org/10.1016/j.meatsci.2007.09.010.

554 89. Setyabrata D, Wagner AD, Cooper BR, Brad Kim YH. Effect of dry-aging on quality and
555 palatability attributes and flavor-related metabolites of pork loins. Foods 2021;10.
556 https://doi.org/10.3390/foods10102503.

557 90. Jin SK, Yim DG. Comparison of effects of two aging methods on the physicochemical traits of
558 pork loin. Food Sci Anim Resour 2020;40:844–51. https://doi.org/10.5851/KOSFA.2020.E22.

559 91. Glitsch K. Consumer perceptions of fresh meat quality: cross-national comparison. Br Food J
560 n.d.;102:177–94.

561 92. Leygonie C, Britz TJ, Hoffman LC. Impact of freezing and thawing on the quality of meat: review.
562 Meat Sci 2012;91:93–8. https://doi.org/10.1016/j.meatsci.2012.01.013.

563 93. Mohammad Shafiur Rahman JFV-R. Food preservation by freezing. Handb. food Preserv., CRC
564 press; 2007, p. 653–84.

565 94. Ngamwonglumlert L, Devahastin S. Microstructure and its relationship with quality and storage
566 stability of dried foods. Elsevier Ltd; 2017. https://doi.org/10.1016/B978-0-08-100764-8.00008-3.

567 95. Tippala T, Koomkrong N, Kayan A. Influence of freeze-thawed cycles on pork quality. Anim
568 Biosci 2021;34:1375–81. https://doi.org/10.5713/ajas.20.0416.

569 96. Zhang M, Li F, Diao X, Kong B, Xia X. Moisture migration, microstructure damage and protein
570 structure changes in porcine longissimus muscle as influenced by multiple freeze-thaw cycles.
571 Meat Sci 2017;133:10–8. https://doi.org/10.1016/j.meatsci.2017.05.019.

572 97. Šimoniová A, Rohlík BA, Škorpilová T, Petrová M, Pipek P. Differentiation between fresh and
573 thawed chicken meats. Czech J Food Sci 2013;31:108–15. https://doi.org/10.17221/127/2012-cjfs.

574

Table

Table 1. Feed and feed additives that affect pork quality and their effects.

Feed/Additive	Impact on Flavor/Aroma	Impact on Meat Quality	References
Fish Oil	Direct transfer of flavor/aroma to meat	Not specified	[55]
Algae	Improves fat quality, possibly impacts flavor	Increases levels of PUFA	[58,61]
Vitamin E	Not specified	Increases shelf-life and quality (Reduces oxidation, enhances shelf-life and quality)	[58]
Vitamin D3	Not specified	Improves tenderness, reduces drip loss, improves color	[59]
Sodium Bicarbonate	Not specified	Reduces cases of PSE	[58]
Sugar Cane Extract	Enhances sweetness	Increases pH24h, reduces shear force, decreases drip loss	[60]

Figure

Fig. 1. Schematic diagram of factors affecting pork quality (Generated using images from freepik.com)