Recibido: 19 – 10 – 2020 / Aceptado: 12 – 11 – 2020 / Publicado: 12 – 12 – 2021

ARTÍCULO DE REVISIÓN

The importance of animal welfare in pig transportation – Tolima case study in Colombia

La importancia del bienestar animal en el transporte de cerdos – Caso de estudio Tolima - Colombia

Johanna Trujillo Diaz Cielo Tatiana Lozano Mauricio Becerra Fernandez Flor Nancy Diaz

Cómo citar: Trujillo, J., Lozano, C., Becerra, M y Díaz, F. (2021). The importance of animal welfare in pig transportation – Tolima case study in Colombia. Hashtag, (19), 36-51

Resumen

Colombia se ha convertido en un país importador de carne de cerdo en canal desde países como Estados Unidos el 73%, Canadá el 15% y Chile el 12%, debido a que el transporte porcino en pie tiene uno de los costos más altos en la Cadena de Suministro en Colombia por la falta de regulación en el mismo, la consolidación de carga, la falta de bienestar animal durante el transporte que se ve en las muertes y el estrés porcino sufrido por los cerdos durante el transporte. La metodología de recolección de datos fue cualitativa documental en artículos y patentes; y se visitaron 15 fincas porcinas en el Tolima, para la recolección de la información utilizando un instrumento de entrevista no estructurada. En conclusión, se encontró que para aumentar la competitividad y mejorar la calidad de la carne porcina en Colombia se necesita un diseño de transporte adecuado al bienestar animal, la infraestructura en vías, la accesibilidad a fincas porcinas, la consolidación de carga y el alto costo de intermediación desde las fincas porcinas al siguiente eslabón de la SSC, granjas comerciales o tecnificadas, puntos de sacrificio.

Palabras clave:

bienestar animal, bioseguridad, cadena de suministro porcina, transporte

Abstract

Colombia has become an importer of pork carcass from countries such as the United States 73%, Canada 15% and Chile 12%, because standing pork transport has one of the highest costs in the Supply Chain in Colombia due to the lack of regulation in it, cargo consolidation, lack of animal welfare during transport seen in deaths and pig stress suffered by pigs during transport. The data collection methodology was qualitative documentary in articles and patents; and 15 pig farms in Tolima were visited to collect information using an unstructured interview instrument. In conclusion, it was found that to increase competitiveness and improve the quality of pork in Colombia, a transport design appropriate to animal welfare, road infrastructure, accessibility to pig farms, cargo consolidation and the high cost of intermediation from pig farms to the next link of the SSC is needed. Commercial or technified farms, and slaughter points.

Keywords:

animal welfare, biosecurity, disease transfer, swine supply chain, transport

Introduction

Colombia has become an importer of pork carcasses from countries such as the United States 73%, Canada 15% and Chile 12% (TradeMap 2016). The Colombian GDP between 2012 and 2016 decreased by 2 percentage points, the highest economic growth has been in the branch of *Agriculture, Livestock, Hunting, Forestry, and Fisheries*. The most significant increases are coffee production at 22.3%, live animals at 2.5%, and other agricultural products (DANE 2011, DANE 2012, PLANTING 2012, DANE 2013, DANE 2015, DANE 2017). It is visualized that the consumption of pork has grown concerning beef, one reason may be the short production cycle time compared to cattle, but Colombia has several challenges to industrialize the Swine Supply Chain (SSC). The challenges of industrialization of the SSC are: a) the physical and logistical infrastructure, which includes the state of the transport routes and the lack of adequate transport to ensure biosecurity and animal welfare; (b) the lack of training for small pig farmers on regulations and restrictions on entering the market and on food safety; c) minimize production costs to compete in the domestic market and thus minimize the importation of pork carcass.

In Colombia, pig farmers can receive training from the Colombian Agricultural Institute (ICA) and the National Institute of Drug Surveillance (INVIMA), which have declared some Colombian departments "free of swine fever diseases," boosting the transport of pigs between departments. Pig transport has one of the highest costs in the Supply Chain in Colombia due to the lack of regulation in it, deaths, and pig stress due to the lack of animal welfare during transport. However, the transport of pork between departments in Colombia is common given that the slaughter points approved by the regulatory entities are usually located in large cities where the marketing is of fattening pigs; For other types of pig production, some departments have specialized in cargo consolidation for backyard, commercial family or technified production. A clear example is the case study of the transport of pigs on foot from Tolima to the capital of the department or other cities that are dedicated to large-scale production levels. Tolima since 2021 was declared free of swine fever, and they found the opportunity to market in other departments so much pork or live animals. There is an oligopoly there because transport is carried out by a few companies. (DANE 2015), who consolidate pigs standing from several pig farms which makes it impossible to trace the spread of diseases between farms, and establish animal welfare and biosecurity strategies (Trujillo-Diaz, Diaz-Piraquive et al. 2019, Trujillo-Diaz, Diaz-Piraquive et al. 2019, Trujillo-Diaz, Diaz-Piraquive et al. 2019). This means that in Colombia the *Design of land transport is adapted to the needs of the Colombian market*.

The World Organisation for Animal Health (OIE) has formulated a code for the transport of pigs and other animals that is not being complied with in Colombia. The OIE for all Member Countries transporting pigs are (Trujillo-Diaz, Diaz-Piraquive et al. 2019) they must have: (a) sufficient lighting, due to poor eyesight of pigs; b) suffering from pig stress and dizziness when moving, transporting, and when subjected to high temperatures, therefore it is better to prevent feeding pigs before loading; (c) they are resistant to climbing ramps or steps, it is recommended that the height they climb should not exceed that of the front knee of the animal; d) there is aggression in the mixture of animals; e) they must have enough space in the transport to lie down, in hot areas there are a greater number of pigs lying down than in cold areas; f) not to use electronic instruments to stimulate them (DANE 2015, Trujillo-Diaz, Diaz-Piraquive et al. 2019, Trujillo-Diaz, Diaz-Piraquive et al. 2019, Trujillo-Diaz, Diaz-Piraquive et al. 2019)

With the above, one of the important aspects to increase competitiveness in Colombia is to be able to design a specialized transport for standing pigs, because carcass transport is more expensive and is being done without taking into account national and international regulations. For example, in Colombia, a trailer can transport movable goods on day one, on day two to transport chickens, and on day three to

transport oranges. Thus, the design of bodies in Colombia for the transport of standing pigs is urgent because it allows for maximizing slaughter, reducing stress and weight loss associated with fatigue; and above all complying with international regulations on animal welfare and food safety.

Problem statement

What has made the transport of pigs continue to be traditional in stake trucks in the department of Tolima, is the cost of manufacturing a prototype, and the lack of universities, research centers, and companies interested in this type of research that contributes to animal welfare. Animal welfare not only includes pig stress but the protection of pigs from accidents, bruises, broken legs, dehydration, and deaths that translate into cost overruns for SSC. While it is true, there are entities interested in the design, prototyping, and manufacture of this type of body adapted to Colombian culture, there are no previous studies for the region in the SSC. Figure 1 shows the pig transport process carried out by small pig farmers in the department of Tolima.

Board 1 Pig transport process

Source: Authors.

The need to have an adequate transport design for animal welfare in Colombia for the department of Tolima is based on the fact that in developed countries (Trujillo-Diaz, Diaz-Piraquive et al. 2019, Trujillo-Diaz, Diaz-Piraquive et al. 2019) have proposed utility models for uploading and downloading, and (De Miguel, Durán Lima et al. 2007) they have proposed designs using physical and technological monitoring platforms for loading and unloading pigs directly to the trailers, thus avoiding, a) risks of stress, fatigue, and overcrowding in the final transport, b) improving efficiency in the loading and unloading process (Torrey, Bergeron et al. 2013) and (c) minimizing disease transfer; d) reducing the costs associated with animal welfare and the labor required during these processes (Weschenfelder, Torrey et al. 2013).

The cost of transporting live pigs is lower than transporting by carcass or refrigerated, in the department of Tolima leads the pig farmer to market his pigs through intermediaries or transporters who pay per kilogram less than the price that the slaughter company pays commercially (Randall and Bradshaw 1998).

With the above, the research question is: What are the most important transport factors to improve the competitiveness and animal welfare of pig farmers located in the department of Tolima (Colombia)?
Literature Review

Within the literature review, it was found that the transport design for the Swine Supply Chain has several characteristics that must be taken into account to promote animal welfare, for which patent and scientific articles were reviewed. In the *patent review* it was found that there are technological designs for the loading, unloading, and transport of live pigs for developed countries, the Colombian context needs an economic design, for which within the patent bases *EspaceNet,* SIPO, WIPO *and Google Patent* 39 different body types used for pig transport were found. China, the United States, and Japan stand out as pioneers in the creation of new prototypes in this area; however, Russia, France, Denmark, and Germany also have patents in this sector.

Within the *literature review* it was found that the transport of live pigs is divided into two important parts:

- The first is the loading, transport, and unloading of pigs from the pig farm to slaughter,
- The second is the consequences of transport associated with waiting time before slaughter.

Factors involving transport, infrastructure, labor, animal welfare, and external factors are visualized in

Table 1.Board 2 Factors associated with pig transport

Transport factors	Factors associated with animal welfare	External factors
Infrastructure Number of ramps (Yao 2011, Torrey, Bergeron et al. 2013, Yinglin 2014) Number of pigs transported (Liu 2011, Zhenxiang 2013, Yinglin 2014), Duration of transport (Yao 2011, Weschenfelder, Torrey et al. 2013, Zhenxiang 2013, García-Cáceres, Trujillo-Díaz et al. 2018) (Torrey, Bergeron et al. 2013), Type of trailer or body (Brown, Knowles et al. 2005, Weschenfelder, Torrey et al. 2012, Brandt and Aaslyng 2015, Sonesson, Lorentzon et al. 2016) Ventilation (Brown, Knowles et al. 2005, Weschenfelder, Torrey et al. 2012) Upload and download process (Brown, Knowles et al. 2005, Weschenfelder, Torrey et al. 2012, Torrey, Bergeron et al. 2013, Berti and Mulligan 2016) Load/download time (Randall and Bradshaw 1998, Brown, Knowles et al. 2005, Dalla Costa 2007, Lewis 2008, Weschenfelder, Torrey et al. 2012, Strap 2013, Torrey, Bergeron et al. 2013, Weschenfelder, Torrey et al. 2013) The type of route (Weschenfelder, Torrey et al. 2013) Cargo consolidation (Brown, Knowles et al. 2005, Weschenfelder, Torrey et al. 2012, Torrey, Bergeron et al. 2013, Weschenfelder, Torrey et al. 2013). Transport quality (Brown, Knowles et al. 2005, Torrey, Bergeron et al. 2013) (Brown 2005, Weschenfelder, Torrey et al. 2012) Velocity (Zhenxiang 2013) Frequency of transport (Lewis 2008, Piewthongngam, Vijitnopparat et al. 2014 , Maples, Lusk et al. 2016) **Labor** Labor during the process (Lewis, Hulbert et al. 2008, Trienekens and Wognum 2013) Training (Weschenfelder, Torrey et al. 2013) Intermediation (Brandt and Aaslyng 2015)	Type of feeding (Torrey, Bergeron et al. 2013) Amount of liquid supplied to pigs (Peeters, Deprez et al. 2008, Torrey, Bergeron et al. 2013, Brandt and Aaslyng 2015, Berti and Mulligan 2016) Dehydration levels (Strap 2013, Torrey, Bergeron et al. 2013, Weschenfelder, Torrey et al. 2013, Zhenxiang 2013, García-Cáceres, Trujillo-Díaz et al. 2018) Losses due to death or dehydration are associated with the amount of fluid supplied before loading, (Nannoni, Martelli et al. 2013, Torrey, Bergeron et al. 2013, Brandt and Aaslyng 2015, Berti and Mulligan 2016, McAuliffe, Chapman et al. 2016, Trujillo-Diaz, Diaz-Piraquive et al. 2019) Risk of overcrowding (Brown, Knowles et al. 2005, Lewis 2008, Weschenfelder, Torrey et al. 2012, Torrey, Bergeron et al. 2013, Weschenfelder, Torrey et al. 2013, Berti and Mulligan 2016); Transport time greater than 6 hours which increases fatigue (Weschenfelder, Torrey et al. 2013), average transport time (between 12-24 hours) (Torrey, Bergeron et al. 2013)	**Infrastructure** Accessibility (Brown, Knowles et al. 2005) Road infrastructure **Environmental** Temperature (Randal 1998, Brown 2005, Lewis 2008, Lewis 2008, Weschenfelder, Torrey et al. 2012, Weschenfelder 2012, Torrey, Bergeron et al. 2013, Weschenfelder, Torrey et al. 2013, Brandt and Aaslyng 2015, McAuliffe, Chapman et al. 2016, Sonesson, Lorentzon et al. 2016, Xie 2016, García-Cáceres, Trujillo-Díaz et al. 2018) The weather or season the pig faces (Weschenfelder, Torrey et al. 2012, Torrey, Bergeron et al. 2013, Weschenfelder, Torrey et al. 2013, Brandt and Aaslyng 2015, McAuliffe, Chapman et al. 2016) Exposure to diseases (Randall and Bradshaw 1998, Weschenfelder, Torrey et al. 2012, Torrey, Bergeron et al. 2013, Brandt and Aaslyng 2015, McAuliffe, Chapman et al. 2016) **Commercial** Sale price (Lewis 2005, Lewis, Hulbert et al. 2008, Piewthongngam, Vijitnopparat et al. 2014, Maples, Lusk et al. 2016) Transport price (Trienekens and Wognum 2013, Weschenfelder, Torrey et al. 2013, Piewthongngam, Vijitnopparat et al. 2014, Maples, Lusk et al. 2016) Slaughter price (Lewis, Hulbert et al. 2008)

Source: Authors

Several transport designs for adult pigs were found in the literature (Trienekens and Wognum 2013, Weschenfelder, Torrey et al. 2013, Trujillo-Diaz, Diaz-Piraquive et al. 2019) and piglets (Trujillo-Diaz, Diaz-Piraquive et al. 2019), for developed countries: a) the Flack Deck (Trujillo-Diaz, Diaz-Piraquive et al. 2019), which is a trailer recommended for the transport of pigs over short distances, it generates little fatigue (Trujillo-Diaz, Diaz-Piraquive et al. 2019), b) the Poty-Belly that uses internal ramps, but the pig is exposed to increased fatigue (Trujillo-Diaz, Diaz-Piraquive et al. 2019); and c) the Double Decker Hydraulic Truck (Trujillo-Diaz, Diaz-Piraquive et al. 2019), reduces interventions during the handler/ trainer process, which reduces the possibility of injury or loss (Trujillo-Diaz, Diaz-Piraquive et al. 2019). (d) "double platform" or *double deck*, (Weschenfelder, Torrey et al. 2012, Trujillo-Diaz, Diaz-Piraquive et al. 2019) and has been adopted by other authors by adding lifting platforms (Weschenfelder, Torrey et al. 2013) and baffles (Torrey, Bergeron et al. 2013) to regulate the angle of the ascent and descent ramps to reduce collision and abrasions; e) design with a conveyor belt that leads the pigs from inside to a hitching table arranged at a normal working height avoiding lacerations during loading and unloading (Lewis 2008, Weschenfelder, Torrey et al. 2013); f) and the design with open and closed side doors that keep the infrastructure ventilated to ensure zero deaths from suffocation during transport (Weschenfelder, Torrey et al. 2013). On the other hand, some less expensive transport designs such as g) the design of double-decker cages with ascent and descent ramps, where on the second level the pigs rest, which guarantees that the floor is clean (Torrey, Bergeron et al. 2013, Weschenfelder, Torrey et al. 2013); (h) a low-cost detachable cage (Torrey, Bergeron et al. 2013), but with a high deformation in the short term on uneven roads (Newnam 1927) associated with inertia, where it does not contemplate the stacking of the same, nor does it have fixed supports to the body; Finally, (i) the cleaning of the transport utilizing actuator shovels to collect the manure (Feng 2013, Xiaoming 2014).

The flack-deck (FD) trailer has a three-story design, eight compartments with heights in compartments 1, 2, and 3 of 96.5 centimeters, compartments 4, 5, and 6 of 91.5 centimeters and compartments 7 and 8 of 96.5 centimeters; It has hydraulic-type floors and no internal ramp (Riniker 1984, Bangfeng 2014, Yinglin 2015, Huanhua 2016), This type of trailer offers better temperature control (Cho 2003, Xiaomi 2013), because with high-temperature levels greater than 30 ° C (Fulai 2007), total mortality reaches 42% (Xie 2016), and ramps are high-stress factors during loading and unloading processes.

Studies in Colombia by (Fulai 2007, Chengfang 2016), in China by (Randal 1998, Lewis 2008, Chengfang 2016), and in the United States by (Brown 2005, Goumon 2013), have identified that failures in **infrastructure** In pig farms and especially for transport directly affect the **animal welfare**. A**nimal welfare** is associated with the rest of pigs during transport, overcrowding, and dirtiness (Weschenfelder 2012, Weschenfelder 2013). Consequently, the quality of the meat (Torrey 2013), is affected by the increase in public health diseases (PorkColombia 2015).

Methodology

In the literature review, the designs in pig transport found have been validated using the design of experiments and factorial statistics looking for **Animal welfare** (Castrillon 2005, Fulai 2007, Yinglin 2014, Yinglin 2015), the use of technological tools to perform traceability using video and sensors (Cunningham 1998). However, every pig transport design needs to be adapted to the needs of the market. (Da Silva 1995)Looking to integrate people, technology, and the object of the business (Fulai 2007, Xiaomi 2013). This research proposes the design of a semi-structured interview for the collection of information based on three questions:

- What are the factors associated with the process of transporting, loading, and unloading in the department of Tolima that impact animal welfare for farms in the department of Tolima?

- What are the factors associated with animal welfare for the department of Tolima that affect the cost of intermediation and sale of pigs to the point of slaughter?

- What factors cannot be controlled and improved during transport that affect animal welfare?

Among the limitations of this study is that no generalizations can be made regarding the population since the sample is of 15 pig farms located in the department of Tolima.

Discussion

- What are the factors associated with the transport of pigs in the department of Tolima that impact animal welfare?

The first factor is the **trailer design**, given that there are designs that have been adopted worldwide for their contribution to the increase in animal welfare (Castrillon 2005, FAO 2015, Xie 2016). But the processes of *transport, loading, and unloading in Colombia* are lacking an adequate transport design for the transport of pigs, which integrates technology, this causes deficient practices for animal welfare, generating deaths and public health problems. It is recommended to make transport designs according to the designs found in the literature and patents such as designs with *Platforms* For the output of pigs, which can transfer pigs between bodies, the traditional "double platform" design or *Double-deck* which has been adopted by different authors adding lifting platforms (Weschenfelder, Torrey et al. 2012, Weschenfelder, Torrey et al. 2013). Compartment design (Lewis 2008) ensures that open and closed side doors keep infrastructure ventilated to minimize suffocation deaths. Other compartment designs have double-deck compartments, which offer both cleanliness, constant access to food and drink, and rest on the second level utilizing ramps. (Torrey, Bergeron et al. 2013, Weschenfelder, Torrey et al. 2013). On the other hand, it is recommended to make designs with removable compartments (Brown 2008) for the Colombian context, they are not appropriate for irregular roads such as those of Tolima due to deformation, but this has a low manufacturing cost, but does not have fixed supports to the body. (Chou 2017). Finally, the individual designs (2013, 2015), have difficulty maintaining balance standing, while little space generates an increase in fights pigs (Brown 2005), which would improve animal welfare.

The second factor is the **Accessibility and infrastructure** road in pig farms in the department of Tolima are deficient, the slaughter points are far from the pig farms, therefore, several pig farmers resort to getting any type of land transport to consolidate the sale of pigs for several farms, which generates high **transport costs and a high cost of intermediation**; which shows at the date of the literature review, that the study of (Lewis 2008) in Colombia, by authors such as (Gade 1998, Cho 2003, Feng 2013), in China and (Randal 1998, Weschenfelder 2012) and in the United States, to name just a few, they show that pig farms worldwide also have major failures in **infrastructure** dedicated to the transport of pigs as regards the **animal welfare,** which leads to poor quality meat (Randal 1998, Xie 2016).

The third factor is the **traceability in the transport** of food supply chains (FSC) is one of the most important logistics variables because it allows for controlling the **associated cost** of food security losses

(ISO 1986, Da Silva 1995, Gade 1998, Randal 1998, Golan, Krissoff et al. 2004, Brown 2005, Castrillon 2005, Pinto, Castro et al. 2006, 2007, 2013, Goumon 2013, Torrey 2013, Weschenfelder 2013, Aung and Chang 2014, FAO 2015), and supports capturing, transmitting, and storing information (Commission, Programme et al. 2003, Perez-Aloe, Valverde et al. 2007, Aung and Chang 2014). Studies were found in the literature for SSC in which traceability has been applied for all links (ISO 1986, Apaiah, Hendrix et al. 2005, Aung and Chang 2014), in handling (Ho 1994, van Reeuwijk 1998, Law 2002, Pinto, Castro et al. 2006, Petersen, Spiller et al. 2010, Bosona and Gebresenbet 2013, Olsen and Borit 2013, Aung and Chang 2014), in distribution and transport (Organization 2006), or for the entire life cycle (Bosona and Gebresenbet 2013). One of the most complex FSCs is the cold chain, which seeks to comply with local legislation on food safety. (Standardization 1994, Wilson and Clarke 1998, Law 2002, ISO 2005, Organization 2006, Dalvit, De Marchi et al. 2007).

- What are the factors associated with animal welfare for the department of Tolima that affect the cost of intermediation and sale of pigs to the point of slaughter?

By having to cross several pig productions to minimize the cost of transportation from the pig farms to the slaughter point, there is a **risk of contagion of diseases between them**, temperature change, and pig stress from the loading, transporting, and unloading process, in which pigs are highly likely to fracture, dehydrate, or die. The stress suffered by pigs in transport in stake trucks is due to the density (McKean 2001, Olsen and Borit 2013) and mixing by consolidation (Bosona and Gebresenbet 2013) because, for the hiring of a trailer of stakes, it is necessary to have several farms interested in the transport and commercialization of the same. The consequences of transportation are directly proportional to weight loss, death, and consequently high costs. (Wilson and Clarke 1998), if the pig farmer applies strategies of **Animal welfare** This can increase its usefulness. Pig farmers must have clear medical tests to identify pig stress, which are done on pig's blood and body temperature (Warriss 1998, Sarig 2003, Apaiah, Hendrix et al. 2005, Petersen, Spiller et al. 2010, Olsen and Borit 2013, Aung and Chang 2014), this can be measured during the entire chain cycle: pre- and post-transport feeding; must avoid dehydration and weight loss, for which it is necessary to establish training plans for all pig farmers in the department of Tolima.

It is necessary to control the high levels of creatinine in pigs that indicate that at a longer transport time, there is greater weight loss and damage to the kidney of the same (Vink and ter Beek 2008), therefore it is suggested that the distances be with duration equal to or less than six hours. On the other hand, high levels of cortisol explain pig stress, which increases with only distances of less than an hour. (Cockram 2007, Brandt and Aaslyng 2015). Thus, specialized transport could minimize pig stress (Cook, Schaefer et al. 1996, Hambrecht, Eissen et al. 2004, Mota-Rojas, Becerril et al. 2006, Mota-Rojas, Becerril-Herrera et al. 2009, Becerril-Herrera, Alonso-Spilsbury et al. 2010, Correa, Torrey et al. 2010, Mota-Rojas, Becerril-Herrera et al. 2012, Correa, Gonyou et al. 2013, Weschenfelder, Torrey et al. 2013), fractures (Weschenfelder, Torrey et al. 2013), fatigue (Nyberg, Lundström et al. 1988) and stress during charging (Stephens and Perry 1990). To date, due to the lack of nearby slaughter points or specialized transport, pig farmers carry out transport at night, and unloading at slaughter points at dawn.

- What factors cannot be controlled and improved during transport that affect animal welfare?

The temperature affects the welfare of pigs when transported to Bogotá since they come from a hot zone to a cold zone; also the weather, loading, and unloading time due to lack of infrastructure, lairage (recovery) time that depends on the slaughter point (Warriss 1998, Bergeron and Lewis 1999), therefore, the closer the pig farms of Tolima are to the slaughter point, the process is improved and the lairage time is minimized.

The negotiation price, given that the carrier is the one who determines the price buys the cargo, must access the conditions that the carrier determines in terms of cargo assuming the transport risks. With the above, it is shown that the CSP of the Department of Tolima has a characteristic of *informality*. The hiring of non-specialized vehicles is by telephone and the price of this is formulated by the driver, who wins the utility between the offer and ask price. The outlets are far away, so transportation is all about doing at night. *Pig farmers indicate that the above problem could be solved with the Development of Collaborative Strategies for CSP.*

To reduce the cost of transportation during transport they need monitoring systems to improve the traceability of animal welfare, loading, and unloading. They also need technology and the creation of platforms so that supply and demand are informed of the commercial price and their geolocation of supply and demand.

Conclusions

In the literature review in Colombia, no research centers were found to date that have produced research or patents for the transport of pigs in Colombia, due to the high cost of prototyping; But mathematical and statistical models were found to assess the impact of transport on meat quality. (Cook, Schaefer et al. 1996, Lewis, Berry et al. 2005, Lewis 2008, Weschenfelder, Torrey et al. 2012, Weschenfelder, Torrey et al. 2013), development of traceability platforms (Cook, Schaefer et al. 1996), process management, and knowledge management models (Nyberg, Lundström et al. 1988, Weschenfelder, Torrey et al. 2012).

The transport designs found in the literature have proposed the existence of transport with traceability systems in transport that would be adequate to increase competitiveness in Colombia, then Locate pre- and post-slaughter monitoring systems that improve the slaughter process *lairage* to overcome fatigue caused by transport (Randall and Bradshaw 1998).

SSC is not competitive with cattle; To increase competitiveness, and minimize the cost of transactions with intermediaries, the SSC in the department of Tolima is urgently needed a) public policies for animal welfare in a transversal way throughout the SSC, b) infrastructure, c) innovation projects, d) training, d) development of a technological platform that connects the demand and supply of pigs to counteract the high transactional costs involved in hiring a conveyor with a non-specialized trailer to consolidate cargo from several pig farms; (e) a traceability system including software development; and (f) marketing strategies without intermediaries, given that to date the SSC has subsidies for pig farmers (Oxman and Oxman)(f) loading and unloading infrastructure and a specialized transport design.

Create and formalize more slaughter points near pig farms in the department of Tolima to minimize pig stress (Oxman and Gero 1987, Lawson 2006, Lockwood 2010) and increase the profitability of pig farmers.

Pig farmers are not considered capable of meeting the requirements of entry, support and marketing in the market of the Colombian pig industry, for which they indicate that they need *training*.

References

2007). Transport cage for pig, Google Patents.(2013). Pig cage, Google Patents.

Apaiah, R. K., E. M. Hendrix, G. Meerdink and A. R. Linnemann (2005). "Qualitative methodology for efficient food chain design." Trends in food science & technology **16**(5): 204-214.

Aung, M. M. and Y. S. Chang (2014). "Traceability in a food supply chain: Safety and quality perspectives." Food control **39**: 172-184.

Bangfeng, X. (2014). Live pig carrying cart. Espacenet. China. **CN104249747**.

Becerril-Herrera, M., M. Alonso-Spilsbury, M. T. Ortega, I. Guerrero-Legarreta, R. Ramirez-Necoechea, P. Roldan-Santiago, M. Pérez-Sato, E. Soní-Guillermo and D. Mota-Rojas (2010). "Changes in blood constituents of swine transported for 8 or 16h to an Abattoir." Meat Science **86**(4): 945-948.

Bergeron, R. and N. Lewis (1999). "Farm animal transportation, health and welfare." Cahiers d'Etudes et de Recherches Francophones Agricultures (France).

Berti, G. and C. Mulligan (2016). "Competitiveness of Small Farms and Innovative Food Supply Chains: The Role of Food Hubs in Creating Sustainable Regional and Local Food Systems." Sustainability **8**(7): 616.

Bosona, T. and G. Gebresenbet (2013). "Food traceability as an integral part of logistics management in food and agricultural supply chain." Food control **33**(1): 32-48.

Brandt, P. and M. D. Aaslyng (2015). "Welfare measurements of finishing pigs on the day of slaughter: A review." Meat science **103**: 13-23.

Brown, S., T. Knowles, L. Wilkins, S. Chadd and P. Warriss (2005). "The response of pigs to being loaded or unloaded onto commercial animal transporters using three systems." The Veterinary Journal **170**(1): 91-100.

Brown, S. N. K., T. G.; Wilkins, L. J.; Chadd, S. A.; Warriss, P.D. (2005). The response of pigs to being loaded or unloaded onto commercial animal transporters using three systems. The Veterinary Journal**:** 91-100.

Brown, T. (2008). "Design Thinking. 2008." Harvard Business Review **6**.

Castrillón, W. E. F., Jorge A; Restrepo, Luis B. (2005). Determination of PSE meat (pale, soft and exudative) in pig carcasses. VITAE, University of Antoquia, Medellon. **12:**23-28.

Chengfang, D. X. L. Y. L. W. W. X. Z. X. C. X. G. (2016). Pick up pig manure locomotive futilely I. O. A. H. A. V. F. A. O. A. S. D. Xiaoning. China.

Cho, S. Y. (2003). Pig Transport Vehicle. Espacenet. South Korea.

Chou, D. C. (2017). "Applying design thinking method to social entrepreneurship project." Computer Standards & Interfaces.

Cockram, M. S. (2007). "Criteria and potential reasons for maximum journey times for farm animals destined for slaughter." Applied Animal Behaviour Science **106**(4): 234-243.

Commission, J. F. W. C. A., J. F. W. F. S. Programme and W. H. Organization (2003). Codex Alimentarius: Food hygiene, basic texts, Food & Agriculture Org.

Cook, N., A. Schaefer, P. Lepage and S. M. Jones (1996). "Salivary vs. serum cortisol for the assessment of adrenal activity in swine." Canadian Journal of Animal Science **76**(3): 329-335.

Correa, J., H. Gonyou, S. Torrey, T. Widowski, R. Bergeron, T. Crowe, J. Laforest and L. Faucitano (2013). "Welfare and carcass and meat quality of pigs being transported for two hours using two vehicle types during two seasons of the year." Canadian Journal of Animal Science **93**(1): 43-55.

Correa, J., S. Torrey, N. Devillers, J. Laforest, H. Gonyou and L. Faucitano (2010). "Effects of different moving devices at loading on stress response and meat quality in pigs." Journal of animal science **88**(12): 4086-4093.

Correa, J. A. G., H. W.; Torrey, S.; Widowski, T.; Bergeron, R.; Crowe, T. G. (2013). Welfare and carcass and meat quality of pigs being transported for two hours using two vehicle types during two seasons of the year. Canadian Journal of Animal Science**:** 43-55.

Cunningham, C. (1998). Pig delivery and transport system for subsea wells. Espacenet. F. Corp. United States.

Da Silva, J. E. L., Antonio Carlos; Machado Filho, Zephyrino; Teixeira, Marcelo Jose (1995). Equipment for the interconnection of two lines to allow running of pigs Espacenet. P. B. SA. China.

Dalla Costa, O. A. F., L.; Coldebella, To.; Ludke, J. V.; Peloso, J. V.; Dalla Roza, D. (2007). Effects of the season of the year, truck type and location on truck on skin bruises and meat quality in pigs. Livestock Science**:** 29-36.

Dalvit, C., M. De Marchi and M. Cassandro (2007). "Genetic traceability of livestock products: A review." Meat Science **77**(4): 437-449.

DANE. (2011). "Cattle Slaughter Survey - ESAG." Central Data Catalog, from http://formularios.dane.gov.co/Anda_4_1/index.php/catalog/343.

DANE (2012) "Monthly Bulletin Inputs and Factors of Production." Pork in the world.

DANE. (2013). "Cattle Slaughter Survey - ESAG." Central Data Catalog, from http://formularios.dane.gov.co/Anda_4_1/index.php/catalog/344.

DANE. (2015). "Cattle Slaughter Survey - ESAG." Central Data Catalog, from http://formularios.dane.gov.co/Anda_4_1/index.php/catalog/429.

DANE. (2017). "Cattle Slaughter Survey - ESAG." Strategic Information, from http://www.dane.gov.co/index.php/estadisticas-por-tema/agropecuario/encuesta-de-sacrificio-de-ganado.

De Miguel, C. J., J. E. Durán Lima and A. R. Schuschny (2007). "Colombia, Ecuador, and Peru's Trade Agreements with the United States: Effects on Trade, Production, and Welfare." ECLAC Magazine.

FAO. (2015). "Effects of stress and injury on meat and by-product quality." Retrieved 29-09-2017, from http://www.fao.org/docrep/005/x6909S/x6909s04.htm.

Feng , R. S. W. X. F. X. L. B. F. Y. T. (2013). Two-storey hog house Espacenet. J. A. A. Sci +. China.

Fulai, L. (2007). Transport cage for pig. Espacenet. China.

Gade, P. B. C., L. (1998). Effect of different stocking densities during transport on welfare and meat quality in Danish slaughter pigs. Meat science. **48:** 237-247.

García-Cáceres, R. G., J. Trujillo-Díaz and D. J. R. d. I. Mendoza, Desarrollo e Innovación (2018). "Decision structure of transport logistics problems." **8**(2): 321-331.

Golan, E., B. Krissoff, F. Kuchler, L. Calvin, K. Nelson and G. Price (2004). "Traceability in the US food supply: economic theory and industry studies." Agricultural economic report **830**(3): 183-185.

Goumon, S. F., L.; Bergeron, R.; Crowe, T; Connor, M; Gonyou, H. (2013). Effect of ramp configuration on easiness of handling, heart rate, and behavior of near-market weight pigs at unloading. Journal of animal science. **91:** 3889-3898.

Hambrecht, E., J. Eissen, R. Nooijen, B. Ducro, C. Smits, L. Den Hartog and M. Verstegen (2004). "Preslaughter stress and muscle energy largely determine pork quality at two commercial processing plants." Journal of Animal Science **82**(5): 1401-1409.

Ho, S. K. (1994). "Is the ISO 9000 series for total quality management?" International Journal of Quality & Reliability Management **11**(9): 74-89.

Huanhua, Z. J. C. B. X. G. W. J. C. S. L. (2016). Change pig car J. K. M. A. D. C. Ltd. China.

ISO (2005). Quality management systems-Fundamentals and vocabulary (ISO 9000: 2005): 1.

ISO, I. (1986). "International Organization for Standardization." Geneva, Switzerland.

Law, G. F. (2002). "Regulation (EC) No. 178/2002 of the European Parliament and of the Council of 28 January 2002, laying down the general principles and requirements of food law, establishing the European Food Safety Authority, and laying down procedures in matters of food safety." OJ L **31**(1.2).

Lawson, B. (2006). How designers think: the design process demystified, Routledge.

Lewis, C., L. Hulbert and J. McGlone (2008). "Novelty causes elevated heart rate and immune changes in pigs exposed to handling, alleys, and ramps." Livestock Science **116**(1): 338-341.

Lewis, N., R. Berry, G. Crow and S. Wamnes (2005). "Assessment of the effects of the season of transport on the performance of early-weaned piglets." Canadian journal of animal science **85**(4): 449-454.

Lewis, N. B., R.; Crow, G.; Wamnes, S. (2005). Assessment of the effects of the season of transport on the performance of early-weaned piglets. Canadian journal of animal science. **85:** 449-454.

Lewis, N. J. (2008). "Transport of early weaned piglets." Applied Animal Behaviour Science **110**(1): 128-135.

Lewis, N. J. (2008). Transport of early weaned piglets. Applied Animal Behaviour Science. **110:** 128-135.

Liedtka, J. (2015). "Perspective: Linking design thinking with innovation outcomes through cognitive bias reduction." Journal of Product Innovation Management **32**(6): 925-938.

Liu, L. Z., Jiugang; Zhang, Lijuan; Qiu, Jinjie; Zhang, Lulu; Bai, Xiaoqing+ (2011). Adjustable and mobile type pig loading platform Espacenet. C. A. A. Sci. China.

Lockwood, T. (2010). "Design thinking." New York: Allworth.

Maples, J. G., J. L. Lusk and D. S. Peel (2016). Coordinating Supply Chains to Maximize Value in the Beef and Pork Industries. 2016 Annual Meeting, February 6-9, 2016, San Antonio, Texas, Southern Agricultural Economics Association.

McAuliffe, G. A., D. V. Chapman and C. L. Sage (2016). "A thematic review of life cycle assessment (LCA) applied to pig production." Environmental Impact Assessment Review **56**: 12-22.

McKean, J. (2001). "The importance of traceability for public health and consumer protection." Revue scientifique et technique (International Office of Epizootics) **20**(2): 363-371.

Mota-Rojas, D., M. Becerril-Herrera, P. Roldan-Santiago, M. Alonso-Spilsbury, S. Flores-Peinado, R. Ramírez-Necoechea, J. Ramírez-Telles, P. Mora-Medina, M. Pérez and E. Molina (2012). "Effects of long distance transportation and CO 2 stunning on critical blood values in pigs." Meat Science **90**(4): 893-898.

Mota-Rojas, D., M. Becerril-Herrera, M. Trujillo-Ortega, M. Alonso-Spilsbury, S. Flores-Peinado and I. Guerrero-Legarreta (2009). "Effects of pre-slaughter transport, lairage and sex on pig chemical serologic profiles." Journal of Animal and Veterinary Advances **8**(2): 246-250.

Mota-Rojas, D., M. Becerril, C. Lemus, P. Sánchez, M. González, S. Olmos, R. Ramírez and M. Alonso-Spilsbury (2006). "Effects of mid-summer transport duration on pre-and post-slaughter performance and pork quality in Mexico." Meat Science **73**(3): 404-412.

Nannoni, E., G. Martelli, M. Cecchini, G. Vignola, M. Giammarco, G. Zaghini and L. Sardi (2013). "Water requirements of liquid-fed heavy pigs: Effect of water restriction on growth traits, animal welfare and meat and ham quality." Livestock Science **151**(1): 21-28.

Newnam, W. (1927). Pig-lead truck. Espacenet. N. L. Co. China. **US1626350**.

Nyberg, L., K. Lundström, I. Edfors-Lilja and M. Rundgren (1988). "Effects of transport stress on concentrations of cortisol, corticosteroid-binding globulin and glucocorticoid receptors in pigs with different halothane genotypes." Journal of animal science **66**(5): 1201-1211.

Olsen, P. and M. Borit (2013). "How to define traceability." Trends in food science & technology **29**(2): 142-150.

Organization, W. H. (2006). Codex Alimentarius Commission. Procedural manual, Food and Agriculture Organization of the United Nations (FAO).

Oxman, R. and J. S. Gero (1987). "Using an expert system for design diagnosis and design synthesis." Expert Systems 4**(1): 4-14.**

Oxman, R. E. and R. M. Oxman (1992). "Refinement and adaptation in design cognition." Design studies **13**(2): 117-134.

Peeters, E., K. Deprez, F. Beckers, J. De Baerdemaeker, A. Aubert and R. Geers (2008). "Effect of driver and driving style on the stress responses of pigs during a short journey by trailer."

ANIMAL WELFARE-POTTERS BAR THEN WHEATHAMPSTEAD- **17**(2): 189.

Perez-Aloe, R., J. Valverde, A. Lara, J. Carrillo, I. Roa and J. Gonzalez (2007). Application of RFID tags for the overall traceability of products in cheese industries. RFID Eurasia, 2007 1st Annual, IEEE.

Petersen, B., A. Spiller and L. Theuvsen (2010). "Vom Viehvermarkter zum Dienstleistungsprofi." Medienhaus Plump, Rheinbreitbach.

Piewthongngam, K., P. Vijitnopparat, S. Pathumnakul, S. Chumpatong and M. Duangjinda (2014). "System dynamics modelling of an integrated pig production supply chain." Biosystems Engineering **127**: 24-40.

Pinto, D., I. Castro and A. Vicente (2006). "The use of TIC's as a managing tool for traceability in the food industry." Food Research International **39**(7): 772-781.

PorkColombia (2015). Analysis of the pig industry in Colombia. Colombian pig farming. Colombia. **4:** 1-36.

Randal, J. B., R (1998). Vehicle motion and motion sickness in pigs. Animal science. **66:** 239-245.

Randall, J. (1993). "Environmental parameters necessary to define comfort for pigs, cattle and sheep in livestock transporters." Animal Science **57**(2): 299-307.

Randall, J. and R. Bradshaw (1998). "Vehicle motion and motion sickness in pigs." Animal science **66**(01): 239-245.

Riniker, H. (1984). Anlage zur Betäubung von Schweinen, Google Patents.

Sarig, Y. (2003). "Traceability of food products."

SOWING. (2012). "Consolidated demands of the swine agenda." from http://www.siembra.co/NetCorpoica/WebNetAgroNetTec/WebNetAgroNetTec/(S(1qhbbpauf3rshzywcyvxklan))/Pg_GestDemanda/Pg_Cons_CadDemandas.aspx.

Sonesson, U. G., K. Lorentzon, A. Andersson, U.-K. Barr, J. Bertilsson, E. Borch, C. Brunius, M. Emanuelsson, L. Göransson and S. Gunnarsson (2016). "Paths to a sustainable food sector: integrated design and LCA of future food supply chains: the case of pork production in Sweden." The International Journal of Life Cycle Assessment **21**(5): 664-676.

Standardization, I. O. f. (1994). ISO 8402: 1994: Quality Management and Quality Assurance-Vocabulary, International Organization for Standardization.

Stephens, D. and G. Perry (1990). "The effects of restraint, handling, simulated and real transport in the pig (with reference to man and other species)." Applied Animal Behaviour Science **28**(1-2): 41-55.

Torrey, S., R. Bergeron, T. Widowski, N. Lewis, T. Crowe, J. Correa, J. Brown, H. Gonyou and L. Faucitano (2013). "Transportation of market-weight pigs: I. Effect of season, truck type, and location within truck on behavior with a two-hour transport." Journal of animal science **91**(6): 2863-2871.

Torrey, S. B., R.; Widowski, T.; Lewis, N.; Crowe, T.; Correa, J. (2013). Transportation of market-weight pigs: I. Effect of season, truck type, and location within truck on behavior with a two-hour transport. Journal of animal science. **91:** 2863-2871.

TradeMap. (2016). "Bilateral trade between Colombia and Colombia in 2016." from http://www.trademap.org/Bilateral.aspx?nvpm=1|170|||170||0203|||4|1|1|1|1|1|1|1|.

Trienekens, J. and N. Wognum (2013). "Requirements of supply chain management in differentiating European pork chains." Meat science **95**(3): 719-726.

Trujillo-Diaz, J., F. N. Diaz-Piraquive, M. M. Herrera and J. G. Acero (2019). Modeling the Colombian Swine Supply Chain from a Knowledge Management Perspective, Cham, Springer International Publishing.

Trujillo-Diaz, J., F. N. Diaz-Piraquive, M. M. Herrera and J. G. Acero (2019). Modeling the Colombian swine supply chain from a knowledge management perspective. International Conference on Knowledge Management in Organizations, Springer.

Trujillo-Diaz, J., F. N. Diaz-Piraquive, M. M. Herrera, J. Gomez, J. A. Rodriguez and H. R. Sarmiento (2019). Design of theoretical dimensions for a knowledge management model applied to the Colombian swine industry. 2019 International Congress of Innovation and Trends in Engineering (CONIITI), IEEE.

ONE. (2007). "Safety and quality of fresh fruit and vegetables: A training manual for trainers." United Nations, 2017-05-06, from http://www.unctad.org/en/docs/ditccom200616_en.pdf.com.

van Reeuwijk, L. (1998). Guidelines for quality management in soil and plant laboratories, Food & Agriculture Org.

Vink, R. and V. ter Beek (2008). "Pig transports trapped in issues of time and space." pig PROGRESS **24**: 28-29.

Warriss, P. (1998). "Choosing appropriate space allowances for slaughter pigs transported by road: a review." The Veterinary Record 142**(17): 449-454.**

Warriss, P. (1998). "The welfare of slaughter pigs during transport." Animal welfare **7**(4): 365-381.

Weschenfelder, A., S. Torrey, N. Devillers, T. Crowe, A. Bassols, Y. Saco, M. Pineiro, L. Saucier and L. Faucitano (2013). "Effects of trailer design on animal welfare parameters and carcass and meat quality of three Pietrain crosses being transported over a short distance." Livestock Science **157**(1): 234-244.

Weschenfelder, A., S. Torrey, N. Devillers, T. Crowe, A. Bassols, Y. Saco, M. Piñeiro, L. Saucier and L. Faucitano (2012). "Effects of trailer design on animal welfare parameters and carcass and meat quality of three Pietrain crosses being transported over a long distance." Journal of animal science **90**(9): 3220-3231.

Weschenfelder, A., S. Torrey, N. Devillers, T. Crowe, A. Bassols, Y. Saco, M. Piñeiro, L. Saucier and L. Faucitano (2013). "Effects of trailer design on animal welfare parameters and carcass and meat quality of three Pietrain crosses being transported over a short distance." Livestock Science **157**(1): 234-244.

Weschenfelder, A. T., S.; Devillers, N.; Crowe, T; Bassols, To.; Saco, Y. (2012). Effects of trailer design on animal welfare parameters and carcass and meat quality of three Pietrain crosses being transported over a long distance. Journal of animal science. **90:** 3220-3231.

Weschenfelder, A. T., S.; Devillers, N.; Crowe, T; Bassols, To.; Saco, Y. (2013). Effects of trailer design on animal welfare parameters and carcass and meat quality of three Pietrain crosses being transported over a short distance. Livestock Science. **157:** 234-244.

Wilson, T. and W. Clarke (1998). "Food safety and traceability in the agricultural supply chain: using the Internet to deliver traceability." Supply Chain Management: An International Journal **3**(3): 127-133.

Xiaomin, L. (2013). Conveniently transported pig cage. Espacenet. China. **CN202918832**.

Xiaoming, Y. Z. Z. (2014). Novel high-low dual-rail conveyor for delivery of live pigs. W. M. M. P. C. Ltd. China.

Xie, Z. (2016). Cage is transported to pig Espacenet. L. X. A. H. C. Ltd. China.

Yao, J. (2011). Pig outlet platform. Espacenet. N. H. B. B. C. Ltd. China.

Yinglin, Q. F., Tian; Yulai, Chen; Danglin, Su (2014). Pig transporting truck Espacenet. M. F. C. Ltd. China. **CN203920544.**

Yinglin, Q. Y., Qian; Danglin, Su; Xunwei, Feng; Xiaoshan, Hu; Jianhua, Zhu; (2015). Transport pig car fence equipment. Espacenet. M. F. C. Ltd. China. **CN204701520**.

Zhenxiang, M. (2013). Hydraulic telecontrol pig loading bridge corridor Espacenet. China