

Review and Research Agenda on Supply Chain of Poultry and Meat Products

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Abstract: I conducted a review of the literature with the purpose of revamping poultry and meat products supply chain as a relevant research topic. I performed a review of various academic articles published in refereed peer-reviewed international journals in domain of poultry and meat products and its supply chain management. A review has been developed that emphasized the need for alignment of the major issues and key aspects of poultry and meat products and its supply chain processes and the linkage between its supply chain processes and strategy. A final sample of 22 articles out of 56 articles constituted the knowledge base of the study published from 1998 to 2018. The scope of the research is to study the various levels and distinct forms of poultry and meat products supply chain. Literature Survey indicated that most of research has been conducted in the field of products having longer life cycles than the products having shorter life cycle like perishable (poultry and meat) products. The results showed the publication pattern with respect to time and provided the methodology, evidence about the journals and the content elements of poultry and meat products supply chain. The research findings are applicable to a large extent for managerial decisions. There is a wide research scope available in this area as only a limited research has been done in this field. This research work and future researches in this field would be helpful for managers, students as well as academicians.

Index Terms: Meat products, Poultry, Review Paper, Supply Chain.

INTRODUCTION

Live stock sector facing challenges for increase in demand of animal food products (meat and milk) and the need of reduction in the environmental impact and global warming. Live stock sector at global level accounted for 14.5% approximately in human induced global warming potential. Beef production contributed 41%; milk sector 20%; poultry and pig 8% and 9%, respectively in livestock impact on climate change (Gerber et al., 2013). Beef and milk production increased by approximately 40% and 50% respectively in global level in the last three decades (LEAP, 2015), and it is expecting to grow further. The annual growth rate noticed 12%-15% in the broiler industry. It produces 530 million broilers per year. The demand in Gulf is approximately 60000 tons of frozen chicken per month according to Kuwait based broiler Company. Export demands are in huge quantities is one of the challenging problems faced by Indian exporters. In India, the quantity available per lot for export is very small due to various reasons like having small

maintain a cold chain during the products transportation. (Data extracted from freight forward federation of India). Poultry meat is most consumed meat in Organisation for Economic Cooperation and Development countries (OECD, 2014).

There are various reasons for increased poultry consumptions like, chicken meat is accessible and affordable protein source with low fat content and there are little or no cultural or religious barriers regarding consumption in comparison with beef or pork meat. Easy cooking is also a consideration for poultry meat being more popular among consumers (Haley, 2001). There would be an unpredictable increase in animal protein demand due to increase in global population and increase in income growth among poorer populations as global population is expected approximately 9 billion by the year 2050 (King et al., 2017). Hence poultry industry played an important role in sustainable food supply chain due to the reason that chickens having high feed conversion efficiency in comparison to other live stock or birds (FAO, 2010), raising more food on less land with less input resources than any other animal food industries (FAO, 2010) and chicken meat having low greenhouse gas (GHG) emission food rather than other sources of dietary protein (Caro, Davis, Bastianoni, & Caldeira, 2017). As per current global predictions, poultry meat forecasted to have highest level of production, consumption by 2025 over sheep, beef, veal and pork (OECD, FAO, 2016).

Clean meat is identified as emerging and growing biotechnology area with commercial relevance and high growth potential in the next five to ten years as per the report released by the National Academies of Science, Engineering, and Medicine (NASEM) (Elizabeth A. Specht et al., 2018). Clean meat entails production of cell types that are present in meat including muscle cells, connective tissue, fat cells, etc. using cells derived from species like mammalian, avian, and piscine cell lines through cell culture platform. Food applications of animal cell culture was addressed and appeared in the literature from early 2000s, this field has experienced a keen interest among academician and for profit sector in recent years (M.A. Benjamin et al., 2002; M.S.M. Moritz et al., 2015; I.T. Kadim et al., 2015; Z.F. Bhat et al., 2015). Many companies have formed in past two years to commercialize the clean meat production, moving this endeavor from academics into rapid manufacturing and industrial scale-up.

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To achieve commercialization in the coming five to ten years it is required to consider large scale and scale up the manufacturing in strategic early stage in clean meat production.

A growing demand is noticed by for meat and meat products perceived by consumers as nutritious, tender, safe and healthy (Grunert & Valli, 2001). Meat quality and safety is dependent on the application of packaging technologies and materials used. The reasons of fresh and processed meat packaging is to prevent it from delay spoilage, contamination, reduce weight loss, permit some enzymatic activity and retain aroma and colour (Brody, 1997; Mondry, 1996). For short term chilled storage and retail display, overwrap packaging is used and for long term chilled storage, vacuum packaging, bulk gas flushing and modified atmosphere packaging systems are used in current meat packaging practices with different applications and attributes of each of these practices (Kerry, O'Grady, & Hogan, 2006; Mc Millin, 2008). Recently new packaging materials and technologies have been developed like intelligent packaging, active packaging, biodegradable packaging, edible coatings and nano-material (Arvanitoyannis & Stratakos, 2012; Kapetanakou & Skandamis, 2016; Ghaani, Cozzolino, Castelli, & Farris, 2016; Kerry et al., 2006; Maisanaba et al., 2016; Lee, Lee, Choi, & Hur, 2015; Realini & Marcos, 2014; Sun & Holley, 2012). These materials and technologies are having high potential to ensure prolong shelf life, food safety and quality, increase the attractiveness and reduce environmental impact of the packaged product to consumers and retailers, but only limited number of technologies are relevant to meat products and limited reviews is existed in this area (Arvanitoyannis & Stratakos, 2012; Kerry et al., 2006; Coma, 2008; Quintavalla & Vicini, 2002; Sun & Holley, 2012; Realini & Marcos, 2014;).

Largest exporter of red meat is Australia in the world having 20% of total exports in beef meat and 36% of total exports of sheep meat (FAOSTAT, 2013). Production of red meat is the second economic contributor having value of 13.3 billion Australian dollars to fisheries and farm food production industries after grains in financial year of 2012-2013 (DAFF, 2014). Potential competitor to sheep and beef meat in red meat industry is Chevon. It is compared mutton and lamb in terms of the eating quality and nutrition's of the meat and meat products and growth performance of the animals (Schönfeldt et al., 1993; Lee, Kannan, Eega, Kouakou, & Getz, 2008; Tshabalala, Strydom, Ibb, & de Kock, 2003; Sheridan, Hoffman, & Ferreira, 2003).

II. REVIEW OF LITERATURE

McAuliffe et al. (2018) addressed beef production and presented emissions intensity distribution on pasture-based production systems for individual beef cattle. This paper proposed life cycle impact assessment (LCIA) methodology. Vellinga et al. (2018) addressed green house gas (GHG) emissions in production of milk and beef and presented and evaluated mitigation effectiveness options of climate change for meat production in dairy system. The objective was evaluating the effectiveness of dairy systems mitigation strategies. In this study, compensation of changes in amount

of beef production was taken into account. This paper evaluated commonly used dairy systems mitigation strategies by applying life cycle assessment (LCA) modeling approach. First one was increase in per cow milk production, second was extension of productive life of cows, third was increase in calving interval, and fourth one was change in breed from "Holstein Friesian" to "Jersey". Finally a dairy system case study was considered. King et al. (2018) addressed and reviewed the applicability of nanotechnology in poultry industry and discussed the opportunities and challenges for applying and adopting nanotechnologies in poultry industry with reference to quality assurance in poultry processing plant and applications of nanotechnologies in microbiological food safety. Specht et al. (2018) addressed clean meat production and presented opportunities for application of biomedical production and manufacturing methods in clean meat industry. In this paper, recent manufacturing methods, opportunities for development of synergistic products and applications of new biomedical products are discussed for clean meat in clean meat industry and cell based therapeutics. Fang et al. (2017) addressed meat packaging and discussed future research trends and global patents in this area as well as analyzed the applications and developments in intelligent and active packaging in the meat industry. Zucali et al. (2017) addressed milk and meat (pork) production and presented global warming potential (GWP) and mitigation potential (MP) of meat and milk production. In this study, the objective was to estimate and analyze the global warming potential (GWP) of meat and milk productions in Lombardy (Italy) by applying Life Cycle Assessment (LCA) approach and to evaluate the mitigation potential (MP) of meat and milk productions. Panagiotou et al. (2017) addressed structure of price dependence and offered an empirical evaluation of structure and degree of price dependence between retail and wholesale market levels considering accounting for product differentiation in the beef industry in US. This was analyzed for the time period 2002–2016 by using the statistical tool of monthly and copulas rates of price changes for different quality grades and cuts of the beef products. Manning et al. (2016) addressed food criminals in meat supply chain and highlighted "European Horse meat Scandal (2013)" and discussed the increase in contemporary sophistication and organization of the food criminal. An understanding of the typology of the food criminal in terms of their methods of operation was developed and discussed the networks of organized crime groups and individual's and criminal business models in the context of meat supply. Troy et al. (2016) addressed emerging technologies for meat processing applications and outlined and discussed various non-thermal and thermal technologies used in meat processing applications through a number of process analytical techniques for real-time and rapid assessment of meat quality. Thakur et al. (2015) addressed traceability and temperature monitoring in cold meat chain.



A pilot test was conducted to evaluate the functions of online system based on EPCIS for documenting traceability and monitoring time temperature in cold meat chain. This pilot test was performed for accessing the chilled lamb products transportation. Time temperature monitoring was performed through RFID based temperature sensors to record the ambient temperature of container and the temperature of product during transportation between distribution terminal and a processing plant. Zhang et al. (2015) addressed packaging of yellow feather broiler meat that is a special breed of China for the extension of its shelf-life and evaluating the effect on the shelf life through air and modified atmosphere packaging of yellow-feather chicken. Results in this paper provided information about shelf-life extension of yellow feather broiler meat that has reduced unnecessary waste and benefited the poultry industry. Pu (2015) addressed and reviewed the basic steps for selection of feature wavelengths from hyper spectral data to develop multi spectral imaging systems for safety, authenticity and quality of muscle foods and then described the feature wavelengths derived efficient and effective multi spectral real time imaging system from hyper spectral imaging applications. Realini et al. (2014) addressed active and intelligent packaging for extension of shelf life of muscle foods. This article reviewed various types of active and intelligent packaging, latest packaging innovations, its commercial applications, latest packaging research trends and growth perspectives in active and intelligent packaging market. Buncic et al. (2014) addressed microbial pathogen control and developed and evaluated various novel interventions in beef chain. Research on food borne pathogens in beef chain was conducted within EU research project "Pro Safe Beef", by using a longitudinally integrated approach (fork-to-farm). Soysal et al. (2014) addressed modeling food logistics networks in international beef supply chain with emission considerations and developed a multi objective linear programming (MOLP) model for beef logistics network problem. In this model, objectives are to minimize total logistics cost and minimize total amount of greenhouse gas (GHG) emissions from transportation operations in beef supply chain. This model was solved by using ϵ -constraint method. Kristensen et al. (2014) addressed trends and new challenges in meat science and technology. Challenges included hyper flexible automation for meeting special consumer demands at more accurate and faster measurement systems in the production line. Sustainability is a license to operate, not a consumer trend and optimality of animal welfare system is much more important. Trienekens et al. (2013) addressed European pork chains. Results derived from research in an EU integrated project "Q-Pork chains" are summarized in this paper. This paper showed quality management systems as important aspect for enhancing consumer confidence and integrating the supply chains. Ubilava et al. (2009) addressed quality certification vs. product traceability in pork chains in Republic of Georgia and examined the consumer demand of pork sector. Results conducted on choice experiment data of mixed and conditional logit estimation revealed the interest of Georgian consumers towards quality certification and attributes of product traceability as substitutes. Kerry et al. (2006)

addressed intelligent and active packaging systems and methods for muscle products and meat. Active packaging methods and systems are discussed including carbon dioxide scavengers and emitters, oxygen scavengers, anti microbial packaging technologies and moisture control agents. Time-temperature indicators, freshness, integrity, radio frequency identification and sensor technologies are evaluated as potential indicators used in meat and meat products. Simela et al. (2008) addressed global goat meat production, included recommendations for improve in African goat production. This paper discussed development of more chevon breeds, prioritizing technology transfer and research on goat meat production, improving support from government and policy in this sector and devising methods through pre and post harvest interventions for enhancing the quality of goat meat (African chevon). McDonald et al. (1999) addressed food microbiology (predictive) in meat industry and provided critical review on mathematical modeling development with the emphasis on descriptions, classifications, modeling techniques and recent advances. It was concluded that accuracy and role of food microbiology (predictive) would increase in understanding the complex interactions between micro organisms and food. Azzam (1998) addressed competition in the US meatpacking industry. This paper asked about usage of contemporary studies in informing competition policy. This paper concluded that studies are very much useful in competition policy targeting conduct than its structure.

III. RESEARCH AGENDA & ISSUES ADDRESSED

In recent years most attention with highest frequency on sample papers reviewed has been given to manage poultry and meat products supply chain as poultry and meat products are considered as perishable product due to having shorter life cycle. I have found some research papers on global meat production, clean meat industry and beef production with highest frequency. Figure I represented key research agenda addressed in the domain vs. frequency of research papers.

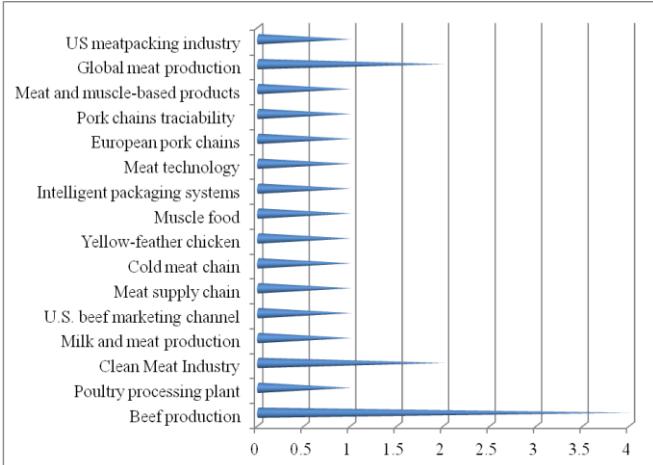


Figure I- Key research agenda in meat supply chain vs. number of research paper reviewed

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I have reviewed 56 research papers in the domain of poultry and meat products and its supply chain. A sample of 22 articles published from approximately two decades (1998 to 2018) constituted knowledge base of this study. I have found some research papers on beef production, GHG emissions of milk and beef production, application of nanotechnology in poultry industry, clean meat production, milk and meat production, price dependence in U.S. beef industry, food criminals in meat supply chain, emerging technologies for meat processing applications, temperature traceability and monitoring in cold meat chain, shelf life extension through packaging of yellow feather broiler meat, multispectral imaging systems of muscle foods for safety, quality and authenticity, active and intelligent packaging methods, microbial pathogen control in the beef chain, modeling food logistics networks with emission considerations, trends in meat science and technology, European pork chains, quality certification vs. product traceability, goat meat production, predictive food microbiology and competition in the US meatpacking industry.

Table I- Year wise potential research issues addressed

Year	Research Issues Addressed- Poultry and Meat Products Supply Chain
2018	Beef production, Meat produced in dairy systems, Poultry processing plant, Clean Meat Industry
2017	intelligent packaging in meat industry, Milk and meat production, U.S. beef marketing channel
2016	Meat supply chain, Beef production,
2015	Cold meat chain, Yellow-feather chicken, Muscle food,
2014	Intelligent packaging systems, Beef chain, International beef supply chain, Meat technology
2013	European pork chains,
2009	Pork chains traceability,
2008	Global meat production
2006	Meat and muscle-based products
1999	Meat industry
1998	US meatpacking industry

Year wise potential research issues have been addressed in literature of poultry and meat products supply chain is presented here in following table (Table I).

Literature Survey indicated that most of research in the field of managing poultry and meat products has been conducted in last five to six year. A shift has been occurred in the research of products having longer life cycles to the products having shorter life cycle like perishable Products (poultry and meat products). Figure II represented year wise number of researches performed in the field of managing poultry and meat products and its supply chains.

I performed critical and systematic review of academic articles, mostly in the domain of poultry and meat products and its supply chain management, published in peer-reviewed international journals. Figure III represented name of peer reviewed international journal vs. frequency of research articles reviewed in the domain.

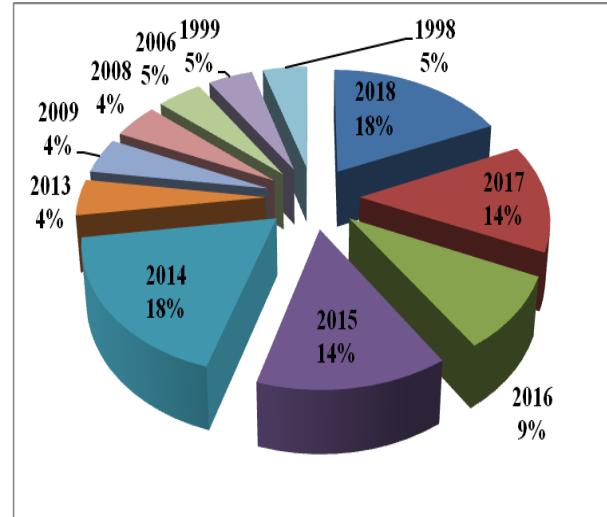


Figure II- Year vs. numbers of research issues addressed

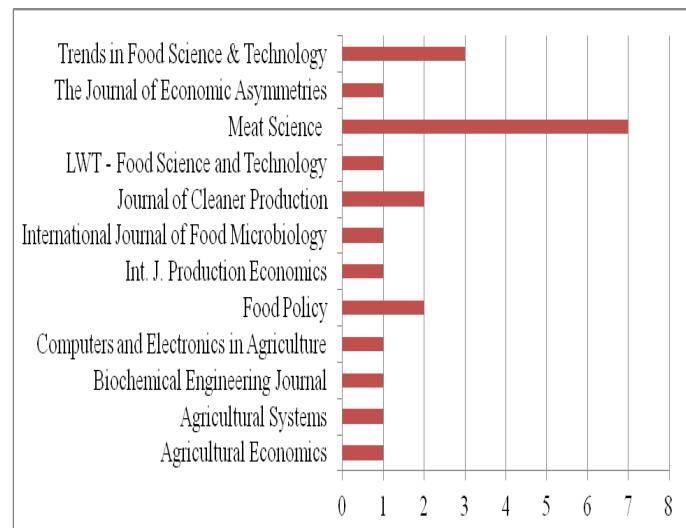


Figure III- Name of peer reviewed journals vs. frequency of research papers reviewed

IV. POTENTIAL ISSUES & FUTURE RESEARCH DIRECTIONS

Most of the researchers have been addressed various research issues in the domain related to milk and beef production, poultry industry, clean meat production, food criminals in meat supply chain, technologies for meat processing applications, traceability in cold meat chain, temperature monitoring, extension of shelf-life, multispectral imaging systems, muscle foods, active and intelligent packaging methods, microbial pathogen control, modeling food logistics networks with emission considerations, trends in meat science and technology, pork chains, goat meat production, predictive food microbiology and competition in meatpacking industry. Based on our literature survey, I am recommending a list (Table II) of potential research issues for future researches in the domain of poultry and meat products supply chain.

Table II- Future Research Directions in Poultry and Meat Products Supply Chain

Self Life and Effect of Temperature on poultry and meat products.	Logistics and inventory routing for poultry and meat products
Trade-off among quality, delivery time and cost of poultry and meat products.	Strategic and environmental issues on poultry and meat products
Meat products inventory management system	Effect of climate change on poultry and meat products
Inventory and pricing of poultry and meat products	Distribution of poultry and meat products
Extension of shelf life and microbial spoilage in poultry and meat products	Emerging technologies for managing poultry and meat production
Food criminals in poultry and meat products supply chain	Clean meat Production
Supply chain coordination and integration issues for poultry and meat products.	Various diseases and health related issues and its impact on poultry and meat products supply chain.
Poultry and meat products Supply Chain Performance Measurement	Trends in intelligent and active packaging methods for poultry and meat products

These are some of the potential research issues that can be addressed in future researches. There have been made many attempts to manage the poultry and meat products supply chain, but a very few attempts, very little guidelines and literature is available to manage the enlisted research issues.

V. CONCLUSION

This research addressed three main questions, presented implicitly in the title; first one was "what does poultry and meat products supply chain mean", second was "what is currently known about poultry and meat products supply chain" and the third one was "what will come next regarding poultry and meat products supply chain". Throughout this paper I managed to provide answers to these questions. First, I have identified key research agenda in poultry and meat products supply chain vs. frequency of research paper (Figure I) decomposed them into various internal and external dimensions. Second, I have presented year wise number of research issues addressed (Figure II) and Name of peer reviewed journals vs. frequency of research papers reviewed (Figure III). The results of an extensive systematic scientific literature review were –potential research issues and future research directions while considering poultry and meat products supply chain. Although this study is primarily oriented towards academic audience and researchers, it is also useful for practitioners, who will be able to obtain understanding about the focus of extant research and gaining access to the most representative research areas in proposed domain.

REFERENCES

1. Azzeddine M. Azzam, (1998), "Competition in the US meatpacking industry: is it history?" Agricultural Economics 18, pp. 107-126.
2. Carolina E. Realini, Begonya Marcos, (2014), "Active and intelligent packaging systems for a modern society", Meat Science 98, pp. 404–419.
3. David Ubilava, Kenneth Foster, (2009), "Quality certification vs. product traceability: Consumer preferences for informational attributes of pork in Georgia", Food Policy 34, pp. 305–310.
4. Declan J. Troy, Kumari Shikha Ojha, Joseph P. Kerry, Brijesh K. Tiwari, (2016), "Sustainable and consumer-friendly emerging technologies for application within the meat industry: An overview", Meat Science 120, pp. 2–9.
5. Dimitrios Panagiotou, Athanassios Stavrakoudis, (2017), "Vertical price relationships between different cuts and quality grades in the U.S. beef marketing channel: A wholesale-retail analysis", The Journal of Economic Asymmetries 16, pp. 53–63.
6. Elizabeth A. Specht, David R. Ilch, Erin M. Rees Clayton, Christie D. Lagally, (2018), "Opportunities for Applying Biomedical Production and Manufacturing Methods to the Development of the Clean Meat Industry", <https://doi.org/10.1016/j.bej.2018.01.015>.
7. G.A. McAuliffe, T. Takahashi, R.J. Orr, P. Harris, M.R.F. Lee, (2018), "Distributions of emissions intensity for individual beef cattle reared on pasture-based production systems", Journal of Cleaner Production 171, pp. 1672-1680.
8. Hongbin Pu, Mohammed Kamruzzaman and Da-In Sun, (2015), "Selection of feature wavelengths for developing multispectral imaging systems for quality, safety and authenticity of muscle foods-a review", Trends in Food Science & Technology 45, pp. 86-104.
9. J.P. Kerry, M.N. O'Grady, S.A. Hogan, (2006), "Past, current and potential utilisation of active and intelligent packaging systems for meat and muscle-based products: A review", Meat Science 74, pp. 113–130.
10. Jacques Trienekens, Nel Wognum, (2013), "Requirements of supply chain management in differentiating European pork chains", Meat Science 95, pp. 719–726.
11. Karl McDonald, Da-In Sun, (1999), "Predictive food microbiology for the meat industry: a review", International Journal of Food Microbiology 52, pp. 1–27.
12. L. Kristensen, S. Støier, J. Würtz, L. Hinrichsen, (2014), "Trends in meat science and technology: The future looks bright, but the journey will be long", Meat Science 98, pp. 322–329.
13. L. Simela, R. Merkel, (2008), "The contribution of chevon from Africa to global meat production", Meat Science 80, pp. 101–109.
14. Louise Manning, Robert Smith, Jan Mei Soon, (2016), "Developing an organizational typology of criminals in the meat supply chain", Food Policy 59, pp. 44–54.
15. M. Soysal, J.M. Bloemhof-Ruwaard, J.G.A.J. van der Vorst, (2014), "Modelling food logistics networks with emission considerations: The case of an international beef supply chain", Int. J. Production Economics 152, pp. 57–70.
16. Maddalena Zucali, Alberto Tamburini, Anna Sandrucci, Luciana Bava, (2017), "Global warming and mitigation potential of milk and meat production in Lombardy (Italy)", Journal of Cleaner Production 153, pp. 474-482.
17. Maitri Thakur, Eskil Forås, (2015), "EPCIS based online temperature monitoring and traceability in a cold meat chain", Computers and Electronics in Agriculture 117, pp. 22–30.
18. Sava Buncic, George-John Nychas, Michael R.F. Lee, Kostas Koutsoumanis, Michel Hébraud, Mickaël Desvaux, Nikos Chorianopoulos, Declan Bolton, Bojan Blagojevic, Dragan Antic, (2014), "Microbial pathogen control in the beef chain: Recent research advances", Meat Science 97, pp. 288–297.
19. T.V. Vellinga, M. de Vries, (2018), "Effectiveness of climate change mitigation options considering the amount of meat produced in dairy systems", Agricultural Systems 162, pp. 136–144.
20. Thea King, Megan J. Osmond-McLeod, Lesley L. Duffy, (2018), "Nanotechnology in the food sector and potential applications for the poultry industry", Trends in Food Science & Technology 72, pp. 62–73.
21. Xinxiao Zhang, Huhu Wang, Nuo Li, Ming Li, Xinglian Xu, (2015), "High CO₂-modified atmosphere packaging for extension of shelf-life of chilled yellow-feather broiler meat: A special breed in Asia", LWT - Food Science and Technology 64, pp. 1123-1129.
22. Zhongxiang Fang, Yanyun Zhao, Robyn D. Warner, Stuart K. Johnson, (2017), "Active and intelligent packaging in meat industry", Trends in Food Science & Technology 61, pp. 60-71.

