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What is meat in Serbia?

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ABSTRACT

Ensuring meat safety is a significant concern in Serbia, as in any country. To address this issue, the Serbian government has implemented several measures, including regular inspections of slaughterhouses and meat processing facilities and adhering to EU regulations on meat safety. These regulations stipulate that all meat products must meet stringent hygiene, storage, and labeling standards. In addition, consumers are advised to buy meat products only from trustworthy sources to safeguard their health. While the issue of meat safety in Serbia remains a concern, the government and consumers are taking steps to mitigate the risks associated with consuming meat products. Serbia's meat processing industry focuses on developing new, healthier products with "clean label" formulations and innovative packaging films. However, the welfare of animals during the slaughtering process has been a topic of concern among animal rights organizations. Although regulations exist to ensure the humane treatment of animals during the slaughtering process, enforcing these regulations has been criticized as inadequate. Efforts are being made to educate and enforce humane treatment, but much more work is needed to ensure that animals are treated with dignity and respect. From a research perspective, it is evident that the Serbian meat sector significantly impacts natural resources, especially water, and energy. The industry also pollutes the environment through wastewater discharge and contributes to climate change in terms of global warming, acidification, and eutrophication. Future research should focus on finding ways to minimize the environmental impact of the meat value chain.

1. Introduction

Meat has been an essential part of the Serbian diet for centuries. Serbian cuisine is known for its rich and hearty meat dishes, and meat consumption is deeply ingrained in the country's culture and traditions. Meat has been an integral part of Serbian cuisine since ancient times, and the preparation and consumption of meat dishes are deeply embedded in the country's culture and traditions (*Baltic et al.*, 2018). Meat dishes such as "pljeskavica," *"ćevapčići" (Trbovic et al.*, 2021), "Pirotska peglana kobasica" (*Bogdanović et al.*, 2023), "Sjenički sudžuk" (*Ikonić et al.*, 2023) and "Uzice pršuta" (*Tomić et al.*, 2008) are some of the most popular and beloved foods in Serbia. These dishes are often prepared and served during special occasions and family gatherings, reinforcing the cultural signifi-

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cance of meat in the Serbian diet. The importance of meat is also evident in Serbian folklore and literature. Many Serbian folk tales and songs are centered around hunting and consuming meat, highlighting the cultural significance of meat as a source of sustenance and pleasure (*Mijatović*, 2008).

Meat production and consumption play a significant role in the Serbian economy. The country has a long history of livestock farming, and the meat industry is a vital part of the agricultural sector. In addition, producing and selling meat and meat products provide employment opportunities for many people in the country, contributing to the local and national economy. Serbia has a high per capita meat consumption rate, with an average of 85 kg per person per year, according to a report by the Food and Agriculture Organization of the United Nations (*FAO*, 2019). This rate is significantly higher than the global average of 34 kg per person per year. The consumption of red meat, in particular, is widespread, with pork being the most popular, followed by beef and poultry. Serbia is known for its high-quality meat products, which consumers in countries worldwide seek after. As a result, the country's meat exports have grown significantly in recent years, with major markets including Russia, China, and the European Union (*Mitic et al.*, 2018).

Serbia's meat production industry is dominated mainly by small and medium-sized farms, which often use traditional farming methods and raise livestock on pasture (*Karabasil et al.*, 2018). However, larger commercial farms have emerged in recent years, which use more modern farming methods and technologies to increase efficiency and productivity. This has led to concerns about the impact of commercial farming on the environment and the welfare of animals raised for meat production (*Đekić & Tomašević*, 2017; *Djekic et al.*, 2016; *Skunca et al.*, 2018). In response to these concerns, the Serbian government has regulated and monitored the country's meat production industry, focusing on improving animal welfare and reducing the environmental impact of farming practices. In addition, the government has also encouraged the adoption of more sustainable and eco-friendly farming methods, such as organic farming and agroforestry (*Nikolić et al.*, 2017; *Živanović Miljković & Crnčević*, 2019).

Therefore, this narrative review aims to provide a critical overview of previously published research on meat quality, meat safety, animal welfare, and the impact on the environment of the meat produced in the Republic of Serbia.

2. Materials and methods

We conducted a scoping review, performed using different databases named Scopus (www.scopus.com), Web of Science Core Collection –WOS (www.webofscience.com/), Google Scholar (https://scholar.google.com), and Kobson (https://kobson.nb.rs). For grey literature identification, we used databases available at Google search (www.google.com). According to data availability, documents and other related information were surveyed, considering a 15-year gap from 2008 to 2023. Aggregative synthesis was used to analyse papers and documents.

3. Results and discussion

3.1. Quality

Carcass quality (after bleeding and dressing) is regulated by the Regulation on the slaughter of livestock, poultry, and game (*Serbian Regulation*, 1974), the Regulation on the quality of slaughtered pigs and pork categorization (Serbian Regulation, 1985), and Regulation on the quality of poultry meat (*Serbian Regulation*, 1981). These acts also define significant meat cuts from the carcasses and minimum requirements for packaging, labeling, storage, and transporting the meat.

The population of domestic Simmental breed represents a dominant population of cattle in Serbia (more than 70%) as a breed of combined production traits. A particular emphasis has been given to the importance of organizing beef production from male calves in the cow-calf in an intensive system (*Kučević et al.*, 2019). On the other hand, meat produced from small ruminants (sheep and goats) in Serbia is obtained mainly from young lambs, lambs, and kids. Meat sheep and goat farming systems are characterized by rearing autochthonous breeds (Pramenka and Tsigai sheep and Balkan and Serbian White goat) and using natural resources through grazing. Also, most lamb and kid meat come from male animals of dairy breeds (East Friesian sheep, Alpine, Saanen, and German fawn goat), which are kept in modern dairy farms (*Tomović et al.*, 2016). Bearing in mind that genetics (breed) is one of the most critical factors affecting carcass and meat quality, genetic improvement of cattle, sheep, and goats in Serbia, i.e., replacement of traditional breeds by high-performance industrial breeds for meat, is necessary. Pig (pork meat) and poultry (broiler chicken meat) production systems have reached high-performance levels over the last two decades. Production system change refers to developments and innovations in

all aspects of meat production, from breeding, housing, feeding, and pre-slaughter handling to slaughter-line, chilling, and deboning time (*Dokmanović et al.*, 2014) (*Leskovec et al.*, 2019; *Perić et al.*, 2022; *Tomović et al.*, 2013; *Tomović, Petrović, & Džinić*, 2008; *Tomović et al.,* 2011). However, pale, soft, and exudative (PSE) meat was determined predominantly in pork and chicken meat (*Popović et al.*, 2019; *Tomovic et al.*, 2014; *Tomović et al.*, 2013; *Tomović et al.*, 2008). Thus, the main objective for the economic consideration of pork and chicken meat production in Serbia primarily comprises the absence of PSE meat.

Meat product quality is regulated by the Regulation on the quality of minced meat, semi-finished meat products, and meat products (*Serbian Regulation*, 2019). Among other things, this act regulates the following: classification, categorization, and product name; physical, chemical, physicochemical, and sensory properties, as well as the product composition; physical, chemical, physicochemical, and sensory properties of raw materials, as well as the type and amount of raw materials, additives and other substances used in the processing; storage conditions; etc. Raw materials include meat, fat, connective tissue, offal, blood, and blood products, mechanically separated meat, and freeze-dried meat. Processing meat is defined as the skeletal muscle suitable for human consumption with naturally included or adherent tissue of domestic ungulates (Artiodactyla and Perissodactyla), bird and lagomorphs, and game species. This regulation does not apply to traditional meat products and products from fish, shellfish, sea urchins, sea cucumbers, frogs, turtles, and snails. The types and amounts of additives (preservatives, colours, emulsifiers, stabilisers, etc.) are regulated by the Regulation on food additives (*Serbian Regulation*, 2018). This act is fully harmonised with the European Union Regulation (*Regulation (EC) No 1333/2008*). The quality and uses of other ingredients, such as salt, spices, aromas, sugars, starch, non-meat proteins, starter cultures, enzymes, etc., are described by special national regulations. Meat products were classified into 12 main groups. Certain meat products have been accredited with protected status. Any products using this name must comply with the compositional (what it contains) requirements. Some meat products must have a minimum amount of meat proteins, and some can only include certain types of meat and/or specific animal cuts. For example, the requirements for cooked sausages are summarised in Table 1.

Table 1. Requirements for cooked sausages

Sub-group	Product name	Type of meat	MP	TMP	CC in MP or CC in TP	Storage wtemperature
Finely chopped cooked sausages	'Viršla'	Not specified	≥ 11%	≥ 11%	≤ 20% ≤ 10% (poultry)	0–4°C
	Frankfurter	Pork	≥ 11%		≤ 20%	
	Parisian sausage	Not specified	≥ 10%		≤ 20% ≤ 10% (poultry)	
	White sausage 'Weisswurst'	Not specified	≥ 10%		≤ 20% ≤ 10% (poultry)	
	Other products	Not specified	≥ 10%	≥ 10%	≤ 25% ≤ 15% (poultry)	
Roughly chopped cooked sausages	Serbian sausage	Pork	≥ 16%		≤ 15%	
	Tyrol sausage	Not specified	≥ 12%		≤ 20% ≤ 10% (poultry)	
	Mortadella	Not specified	≥ 12%	≥ 12%	≤ 30%	
	Other products	Not specified	≥ 12%	≥ 12%	≤ 25% ≤ 15% (poultry)	
Cooked sausages with large pieces of meat	Ham sausage	Not specified	≥ 14%		≤ 15% ≤ 10% (poultry)	
	Other products	Not specified	≥ 14%	≥ 14%	≤ 20% ≤ 15% (poultry)	
Meatloaf	Meatloaf	Not specified	≥ 10%	≥ 10%	≤ 25% ≤ 15% (poultry)	

Legend: MP – minimum meat protein content; TMP – minimum total meat protein content; CC – maximum collagen content.

Novel technological developments include decreasing salt content, avoiding nitrite addition or partial replacement of nitrite, adding dietary fiber, probiotics, prebiotics, and other functional components, adding natural antioxidants and other bioactive ingredients, the substitution of saturated fats with unsaturated fats, coating meat products, etc. (*Danilović et al.*, 2021; *Jokanović et al.*, 2020; *Novakovic et al.*, 2020; *Novakovic et al.*, 2020; *Sojic et al.*, 2022; *Sojic et al.*, 2020; *Stajić et al.*, 2022; *Stajić et al.*, 2020; *Šojić, Pavlić, et al.*, 2020; *Šojić et al.*, 2020; *Šojić et al.*, 2021; *Tomović et al.*, 2020; *Tomović et al.*, 2022).

3.2. Safety

Food safety management systems (FSMS) are programs designed to prevent food safety hazards and protect consumers from adverse health effects. FSMS also helps food businesses comply with international standards and regulations, such as IFS, ISO 22000, and the Hazard Analysis and Critical Control Points (HACCP). Ensuring due diligence is one of the primary importance of FSMS. Not all food processing companies meet the required regulations and standards set by law, and FSMS ensures that food processing companies take necessary measures to prevent food safety hazards from occurring. The most important of FSMS is that it ensures the production and service of safe food to consumers, protecting them from foodborne illnesses and related injuries. Therefore, food safety management systems are crucial in protecting public health, ensuring compliance with regulations and standards, and maintaining consumer confidence in the food industry.

Out of 77 Serbian meat producers who participated in the survey, 93.5% claimed to have a fully operational and certified HACCP system in place. In contrast, 6.5% implemented HACCP without third-party certification(*Tomašević et al.*, 2013). ISO 22000 was implemented and certified in 9.1% of the companies, and only 1.3% had implemented and certified the IFS standard. The primary motivation for implementing food safety management systems among Serbian meat producers was to increase and improve the safety and quality of meat products. The initial set-up costs, including investment in new equipment, civil work in the plant, and the redesign of production facilities, were the most significant expenses. According to the results, the main difficulty during HACCP implementation and operation was financial, with companies unable to recoup the costs associated with implementing and operating the HACCP system. The most significant identified benefit was the increased safety of food products, with a mean rank score of 6.45. The increased quality of food products and improved working discipline of staff in food processing were also significant benefits of implementing and operating HACCP in the Serbian meat industry. Overall, the study suggests that HACCP implementation, whether as a standalone food safety system or as part of ISO 22000, is high in Serbia and provides widespread and significant benefits to the meat industry (*Tomašević et al.*, 2013).

Over a span of 10 years, a total of 7351 meat preparations and freshly processed meat products were examined from 555 different Serbian meat producers, with 4.5 years prior and 5.5 years after the obligatory implementation of Hazard Analysis and Critical Control Points (HACCP). The results demonstrated that implementing HACCP has improved compliance with legal regulations. Before HACCP implementation, 18.6% of the samples did not comply with legal requirements, which decreased to 8.3% following the implementation of HACCP. The average sulfite concentrations in all meat preparations and freshly processed meat products decreased by 43%, from 33.6 to 19.3 mg kg−1. The misuse and abuse of sulfites were common regardless of the season. HACCP implementation in the Serbian meat industry brought attention to the misuse of sulfites, leading to better control and minimization of sulfite exposure (*Tomasevic et al.*, 2018). Also, over thirteen years, 20,106 cured meat product samples were examined from 268 different Serbian meat processing plants, covering 7.5 years before and 5.5 years after mandatory HACCP implementation. The findings demonstrate that the compulsory introduction of HACCP had a significant positive impact on the use and regulation of nitrites in the Serbian meat industry. All cured meat products' average residual nitrite levels fell by 30.65%. In addition, the period following mandatory HACCP implementation saw a decrease of 52% in products with residual nitrite levels above 80 mg/kg. Although the proportion of non-compliant samples (0.19%) remained unchanged, the use and control of nitrites in the Serbian meat industry increased due to the application of HACCP principles, resulting in reduced exposure. However, further improvements are necessary to reach the standards observed in cured meat products from more advanced meat industries (*Tomasevic et al.*, 2017).

Over seven years, we collected 48,246 microbiological test results from 130 meat processing plants and 220 meat retail facilities. This data was collect-

ed 41 months before and 43 months after implementing mandatory HACCP (Hazard Analysis and Critical Control Points). Our findings demonstrate a significant improvement in process hygiene indicators in meat establishments due to implementing HACCP. We observed decreased hygiene indicator organisms on all surfaces and meat establishments. The improvement in process hygiene was evident with at least a 1.0 log10CFU/cm2 reduction in aerobic colony counts for food contact surfaces and over two log10CFU/cm2 reduction for cooling facilities such as refrigerators, freezers and other meat cooling devices. Although the improvement in hand hygiene of meat handlers was less evident, there was a steady decline of positive Enterobacteriaceae and Staphylococcus samples after the mandatory HACCP implementation. The improvement in process hygiene for meat processing plants and retail meat facilities was similar (*Tomasevic et al.*, 2016).

We also assessed the food safety knowledge of meat handlers at various stages of the meat chain in Serbian meat establishments, including slaughterhouses, meat processing plants, and retail stores. A self-administered questionnaire was used to evaluate the food safety knowledge of 352 meat handlers, with 31% (110) from slaughterhouses, 36% (125) from meat processing plants, and 33% (116) from retail stores. The questionnaire was structured and consisted of questions measuring the knowledge level among the handlers. The findings indicated that the average knowledge score for all participants was 64%. Handlers from slaughterhouses and meat processing plants obtained significantly better scores (65% and 66%, respectively) than handlers from retail stores (60%). The knowledge score among meat handlers was associated with age, education, and previous food safety training. Moreover, the results revealed that 57.9% of meat handlers knew that bacteria multiply rapidly at 25°C. Still, only 5.5% knew that food contaminated with food poisoning bacteria could not be recognized by visual, olfactory, or taste checks (*Smigic et al.*, 2016).

Finally, all Serbian meat-producing companies claimed that meat safety was not compromised during the Covid-19 pandemic. However, less than half of the food companies had documented any emergency plans related to pandemics or health issues. Staff awareness and hygiene emerged as the most crucial factors in combating Covid-19, whereas temperature checks and World Health Organization health protocols were deemed less important. Companies reported implementing more stringent hygiene protocols and increasing their purchase of personal protective equipment during the pandemic. Retailers were identified as the most affected link in the food supply chain, while food storage facilities were the least affected (*Tomasevic et al.*, 2020).

3.3. Welfare

As global meat production and market growth (*FAO*, 2022) and intensive farming systems increase, the impact of/on livestock is a worldwide concern on various issues such as the environment, animal welfare and protection, carcass/meat quality, meat price, and consumption (*Karabasil et al.*, 2019; *Liu et al.*, 2023). Consumers' awareness about the livestock impact depends on the context – is it low/middle or high-income countries (*Liu et al.*, 2023; *Parlasca & Qaim*, 2022; *Salmon et al.*, 2020). In law- and middle-income countries, livestock is often perceived positively as it provides food and essential nutrients (*Salmon et al.*, 2020). On the other hand, in developed countries, there is a continuous increase in meat production and consumption and awareness of animal welfare and protection (*Parlasca & Qaim*, 2022). Welfare is a growing issue of concern worldwide. It is one of the criteria used to decide whether a system is sustainable because the general public will not accept systems that cause poor welfare and the absence of animal protection (*Broom*, 2011). Along the meat chain, in the pre-slaughter and slaughter phases, many activities lead to stress reactions depending on the species, breed, sex, and age of the animal (*Karabasil et al.*, 2019). Factors that compromise animal well-being and influence animal homeostasis include exposure to unfavorable environmental conditions (farm, market, transport, lairage), improper handling and social mixing, food and water deprivation, and slaughter (*Cappellozza & Marques*, 2021). All these factors (psychological, physical, or physiological) vary in duration (acute, intermittent, or chronic), leading to the stress response and having the potential to disrupt homeostasis and the animal's capability to cope and adapt to the stressors (*Nielsen et al.*, 2020). Stress is an inevitable consequence of livestock production (*Kumar et al.*, 2022), and the key goal is to minimise animals' negative experiences towards "a life worthy of living" (*Mellor*, 2016) so that the housing and management systems result in good welfare (*Broom*, 2021). Nowadays, consumers believe that only such systems can provide products of good quality where the welfare of the farm animals is appropriate (*Broom*,

2021; *Kumar et al.*, 2022). So there is a challenge for the meat sector and stakeholders in preslaughter stress mitigation, ensuring good animal welfare, and producing good quality carcass/meat (*Kumar et al.*, 2022). Therefore, evaluating the stress in livestock through the appropriate indicators and eliminating factors that cause stress-induced responses (*Kumar et al.*, 2022). The important issue is how these situations influence products and their acceptability, as poor welfare led to some important defects such as the death of animals, body weight loss, carcass lesions and composition, and meat quality defects, i.e., pale, soft, exudative (PSE) and dark, firm, dry (DFD) meats (*Čobanović et al.*, 2019; *Čobanović et al.,* 2021; *Čobanović et al.,* 2023; *Karabasil et al.*, 2019; *Karabasil et al.*, 2017; *Urrea et al*, 2021; *Vicic et al.*, 2021; *Zappaterra et al.*, 2022). According to (*Čobanović et al.*, 2023), carcass lesions (severe, moderate or low) are connected with alterations in blood measurements in slaughtered pigs and compromised animal welfare, affected by both animal characteristics and pre-slaughter conditions. As pointed out by the same authors, the presence of carcass lesions, severe or moderate, led to the alterations in meat quality with the higher occurrence of DFD or PSE meat and consequently to economic and financial losses. Good communication between stakeholders (slaughterhouses, transporters, and farmers), providing feedback of information among others, e.g., results of carcass lesions in slaughtered pigs from abattoir to previous steps in the meat chain could contribute to identifying critical points and eliminating negative factors with improved animal welfare in each phase (*Čobanović et al.*, 2021; *Čobanović et al.*, 2023; *Karabasil et al.*, 2017). The application of regular, educational and training programs (animal behaviour, good management practice, standard operating procedure) to train operators (on the farm, during transport, at slaughterhouse) for prudent management of livestock is of great importance for good practice and proper handling (*Čobanović et al.*, 2023; *Kjosevski et al.*, 2021; *Zappaterra et al.*, 2022). Good practice should be embodied in appropriate standards and national regulations that are enforced in consistent science-based knowledge and information, cost-effective and applicable, competent and well-trained personnel for livestock husbandry and management, to apply high animal welfare and protection standards and to fulfill public expectations (*de Witte*, 2009; *Sundermann et al.*, 2023). Transport and slaughter of animals is an unavoidable process step in meat production. National regulations and standards in animal welfare and protection are updated in continuity to meet consumer and public expectations. Official controls of Food business operators (FBOs) are in charge of providing clear evidence and confirmation that animals are spared any pain/distress/suffering during the transport, killing, and related operations (*Sundermann et al.*, 2023). FBOs know that a successful manufacturer has an attitude "as an industry that cares," and consumer trust is the foundation.

3.4. Environment

It has been scientifically confirmed that meat production has a severe environmental impact and is identified as a leading polluter among food sectors (*Djekic & Tomasevic*, 2016). Although livestock farms are pointed as the most significant contributors to environmental pollution, other actors in the meat chain continuum also have their eco-roles. Considerable interference with natural spheres — atmosphere, lithosphere, hydrosphere, and biosphere, is mainly observed at the farm level through exploiting and polluting natural resources (*Röös et al.,*2013). Environmental impacts occurring in the following supply chain stages – slaughterhouses and meat processing plants are not as high and dominant but may not be neglected and are the focus of the academia (*Djekic et al.*, 2016). The Serbian meat industry has been analyzed from two perspectives, as depicted by *Djekic & Tomasevic* (2016) – in terms of life-cycle assessment (LCA) of meat and meat products and based on various environmental practices occurring at different actors of the value chain – livestock farms, slaughterhouses, and meat processors.

Life cycle assessment is a scientifically validated method outlined in ISO 14040 (*ISO*, 2006) covering the goals and scope of the LCA, inventory analysis of all inputs, processes, and outputs, impact assessment for selected environmental indicators, and interpretation of the results. Analysis of meat products from a "farm to fork" perspective shows that it consists of five main subsystems – farms, slaughterhouses, meat processing plants, retailers, and consumers (*Djekic & Tomasevic*, 2016). When it comes to environmental impacts associated with meat LCA, four of them prevail (*Djekic & Tomasevic*, 2018). Global warming potential (GWP) measures the emission of greenhouse gasses, represents the damage level expressed in kg CO2 equivalent (*IPCC*, 2013), and is mainly linked with enteric fermentation and manure management on farms as well as feed pro-

duction (*Gerber et al.*, 2015). However, it's important to emphasize that besides the impact of meat production on climate change, there is a vice versa effect of climate change on meat production, mainly at farms through increased depletion of resources for combating heat stress of animals, biodiversity loss, and shifting towards sustainable agriculture associated with feed production (*Djekic & Tomasevic*, 2020). Acidification potential analyzes the impact of various acidifying substances on the ecosystem (soil, water, flora, and fauna) expressed as kg SO2 equivalent (*Čuček et al.*, 2015). This is mainly associated with nitrates and ammonia from manures (*Dalgaard et al.*, 2007). Eutrophication potential calculates excessive levels of macronutrients (from livestock feed production) in air, water, and soil, expressed as kg PO4 equivalents (*Djekic & Tomasevic*, 2018). Finally, ozone depletion potential computes the destructive effects of halogenated hydrocarbons (used in meat cold chains – both refrigeration and deep freezing). It is determined in association with R-11 equivalent (*Hischier et al.*, 2010). Inadequate temperatures in the cold meat supply chains cause an increase in the biological activity of microorganisms and thus increase their growth, causing unsafe meat (*Ren et al.*, 2022). Current logistics innovations in the food sector are shifted towards developing low-carbon and eco-friendly supply chains (*Han et al.*, 2021). LCA study of Serbian pork farms at the farm gate (expressed in kg of livestock weight as a functional unit — FU) shows that this meat sector contributes to the emission of 3.50 kg CO2e / FU, 31.257 g SO2e / FU, 55.030 g PO4e / FU and 0.151 mg R11e / FU (*Djekic et al.*, 2021). The primary indicator of a studied life cycle is a FU, as it represents a benchmark point for comparing different types of food. Its appropriate choice is paramount (*Djekic et al.*, 2019). In meat science, three functional units occur – one kg of livestock (at farms), one kg of the carcass (at slaughterhouses), and one kg of meat/meat products (stages from meat processing plants to consumers) (*Djekic & Tomasevic*, 2016). From the perspective of consumers, a look at the other side of the coin was performed by analyzing pork meat dietary habits in Serbia based on reported weekly consumption. Results show that an average Serbian meat consumer contributes to 4.032 kg CO2e / week, 35.972 g SO2e / week, 63.466 g PO4e / week, and 0.17435 mg R11e / week (*Djekic et al.*, 2021).

The survey that covered 16 slaughterhouses and 14 meat processing plants participating with more than half of national Serbian meat production shows that environmental practices (energy and water consumption, waste management, and wastewater discharge) are implemented on a higher level in large companies, in slaughterhouses and in companies with implemented environmental management system (*Djekic et al.*, 2016). Water is used throughout all meat production steps, from feeding animals to slaughtering and meat processing (*Kupusovic et al.*, 2007). Energy is needed mainly for meat processing and maintaining the meat cold chain (*IPPC*, 2006). Wastewater is rich in various pollutants, both organic (blood, fat, manure, undigested stomach contents, meat, and meat extracts) (*Djekic & Tomasevic*, 2016) and inorganic from cleaning chemicals needed for good hygiene practices (*CAC*, 2020). *Aleksić et al.* (2020) performed an interesting study on water consumption and wastewater characteristics of the Serbian meat slaughtering industry. Their study covered 41 slaughterhouses, revealing that more than half have no wastewater treatment and that wastewater quality in some of the observed objects exceeded prescribed legal limits for chemical and biochemical oxygen demands mainly due to the presence of organic matter such as blood, tallow, and mucosa. The freshwater consumption varied depending on the type and size of the slaughterhouse, but the highest need was associated with good hygiene.

4. Conclusion

Meat safety is an important issue in Serbia, as in any country. The Serbian government has implemented several measures to ensure the safety of meat products, including regular inspections of slaughterhouses and meat processing facilities. The country has also adopted EU regulations on meat safety, meaning that all meat products must meet strict hygiene, storage, and labeling standards. Consumers in Serbia are advised to purchase meat products only from reputable sources and to ensure that the meat is properly cooked before consumption. Additionally, individuals are encouraged to practice good hygiene when handling meat products, such as washing their hands thoroughly before and after handling raw meat. While meat safety is a reasonable concern in Serbia, the government, producers, and consumers are taking steps to mitigate the risks associated with consuming meat products. The current situation and prospects for the meat processing industry in Serbia are based mainly on the development of new healthier products ('clean label') with altered and novel formulations and on the development of new pack-

aging films. The welfare of slaughtering animals in Serbia has been a concern among animal rights activists and organizations. While there are regulations to ensure the humane treatment of animals during the slaughtering process, enforcing these regulations has been criticized as insufficient.

In some cases, animals may be subjected to overcrowding and rough handling before being slaughtered, which can cause distress and pain. Additionally, there have been reports of illegal slaughtering practices that further compromise the welfare of animals. Efforts are being made to improve the situation through education and enforcement, but there is still much work to be done to ensure the humane treatment of animals in Serbia. Regardless of the research perspective (meat-based or meat company-based), it is evident that the entire Serbian meat sector has severe pressure on natural resources (mainly water and energy), pollutes the environment by discharging wastewater, and influences climate change concerning global warming, acidification, and eutrophication potentials. Future research should focus on finding solutions how to decrease the environmental burden of the meat value chain.

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