PROCESSING OF PORK MEAT IN THE FUNCTION OF VALUE-ADDED CREATION AT THE FAMILY FARMS

Marko **JELOČNIK**[1], Lana **NASTIĆ**[2], Jonel **SUBIĆ**[3]
[1] Research Associate, Institute of Agricultural Economics, Belgrade, Serbia
Email: marko_j@iep.bg.ac.rs,
[2] Research Associate, Institute of Agricultural Economics, Belgrade, Serbia
Email: lana_n@iep.bg.ac.rs
[3] Principal Research Fellow, Institute of Agricultural Economics, Belgrade, Serbia
Email: jonel_s@iep.bg.ac.rs

Abstract
Creation of value-added at the farms could play great role in strengthening of their economic sustainability. Serbia has long tradition in pig farming. This subsector of agriculture in last few decades is facing the negative trend in production capacities (decrease in active farms and number of pigs) and it is mainly based on economically weak family farms characterized by small number of pigs. On the other hand it is obvious the strengthening of their specialization to pig farming. This line of agricultural production is specifically under the higher production risks mainly influenced by pork cycle and some market risks. Thus, the often and expressed price oscillation affects primarily the sustainability of small farms, disabling the proper planning of production and endangering their survival. Processing of pork meat at small family farms could be a good solution for income stabilization, where created value added could induce better competitiveness of the farms.
The main goal of the paper is to present the economic potential of the conduction of pork meat processing at small family farms, in scenarios with or without of employment of external labour. In this context, it was used the analytical calculations based on variable costs (contribution margin). Gained results show that comparing to pig growing, organization of mentioned activity will significantly increase the farm incomes in both cases, impacting the many positive effects on farm sustainability.

Keywords: *Family farms, pork meat, processing, economic sustainability, Serbia.*
DOI: 10.24818/CAFEE/2020/9/10

Introduction

For many decades, stakeholders involved in agriculture, have been responsive only to economic aspects of production. Major support to farms sustainability usually targets intensification of production (tech-tech improvement and modernization) and increase in farms' profit. This approach has led to many issues that endanger entire farms' sustainability and indirectly sustainability of rural communities (e.g. increase in pollution, depletion of available natural resources, destruction of landscape, or growing of regional imbalance), (Andreoli, Tellarini, 2000). Realizing the negative effects of intensified agriculture, among globally relevant objectives of policy makers are also listed the efficient farming sector based on all sustainability principles. So farm sustainability was recognized as the key factor for achieving of durable profitability of farms and their wider surrounding (Van Passel et al., 2007; Yu, Wu, 2018).
Towards the global society goals for securing the use of available natural resources in same quantity and quality to all future generations, agriculture is forcing to act under the three mutually

equal pillars of sustainability. By harmonization of general principles of sustainability at macro and micro level, farm sustainability assumes its ability to maintain production continuity, and to grow in accordance to available natural and social-economic ambience. At first place, farm should equalize conduction of economic, environmental and social function of its business activities (Bachev, 2016; Bachev et al., 2017; Vroegindewey, Hodbod, 2018).

Although there should be equality between the sustainability pillars, in practice the farmers still favour the economic aspect. Not so rare, the economic sustainability is establishing by introduction of value added at the farm.

Logically, value-added could be considered as the integral part of sustainability. Mostly, it is defined as a change in the products' characteristics into a more usable and economically valuable condition. It is a way of a products' adjustment to the end consumers' requirements, where they are simultaneously willing to compensate additional costs of production arisen from the product improvement (Coltrain et al., 2000; Lu, Dudensing, 2015). From the point of view of agriculture, cereals could be a good example of previously mentioned. They can be used as primary agricultural products in human nutrition in their original state. On the other hand, their transformation into the meat (through the fodder) or bread (through the mill and bakery activities) will even satisfy specific consumers' needs, and in same time will additionally strengthen the income potential of the farm.

Farm can create value-added in several ways, by innovating the organization of production or implementing certain tech-tech solutions, by taking over a segment of the vertical integration chain or distribution chain of agri-food products, etc. Farm has two options, to directly create value-added (forming of agri-food product or service somewhat unique from the other products or services present in a particular market) or to capture a part of value-added from the current value chain (to increase its' share in the market price of the final product), (Born, Bachmann, 2006; Anderson, Hanselka, 2009).

In the context of Serbian agriculture, processing of agricultural products at small family farms represents one of the key components of the rural economy development as well as the most common form of diversification of farmers' activities and income. Food processing (including "Cottage food operations") is defined as any activity that maintains or raises the food quality, changing the physical, chemical or biological characteristics of the agri-food product, i.e. activity that adds the value in any way. It can include different levels of complexity, from simple mechanical cleaning and packaging of fruits and vegetables to technologically demanding procedures linked to the processing of meat, milk or fruit and grapes. By creating additional value to the farm products and its transfer into additional farm incomes, processing certainly represents the instrument for strengthening of the farm sustainability. In same time, compared to primary products, their processing at the farm carries higher safety risks, causing that processed agri-food products are often the subject of stricter safety and quality control (DiCaprio, Feiereisel, 2018; Roljević Nikolić, Paraušić, 2019).

Related to previously mentioned, if we consider that the pork meat is a essential product contained in fattened pig that will generate the farms' profit after the selling of live animal or fresh meat, it could be expected additional profit after the processing of pork meat at the farm and generating the value added contained in processed food products that would be sold on the local market. So, the main goal of the paper is to present the economic potential of the organization of pork meat processing at the small family farms, including the scenarios with or without external labour engagement.

Used methodological framework

Data required for the analysis are gained from the small family farm (2 working active members) focused to pig farming and pork meat processing, located at the territory of Pančevo city (South-Banat District). Through the in-depth interview are gained the data that refer to production realized in 2019. Also, it was used the data of official statistics, as well as scientific sources turned to observed sub-sector of agriculture.

As main paper goal is to compare economic effects derived from enlargement of processing activity at the farm level, effects were reconsidered according to analytical calculations based on difference between the incomes and variable costs (i.e. contribution margin) obtained in pork meat processing. Similar methodological framework was previously used for assessment of economic potential of some other food products processing at the farms (Jeločnik et al., 2019a; Jeločnik et al., 2019b). As variable costs in pork meat processing could be considered used inputs and services, such are purchased fattened pigs, energy, salt and spices, packaging material, water, external services and labour, some taxes, etc. It was assumed that volume of produced food products in both cases are in line to available processing facilities and equipment. Besides, as the paper focus was turned to assessment of economic sustainability of processing line practiced at the farm, it was assumed that environmental and social pillars of farm sustainability are at satisfied level. All data and results are presented in adequate tables in EU currency.

Results with discussion

Potentials of pig farming in Serbia

Throughout its history, Serbian agriculture has been traditionally focused on livestock breeding (specifically pig farming), moreover, the initial development of national agriculture (from the second half of the XIX century to World War I) was based on plum production and pig farming (economic growth of agriculture was linked to export of live cattle and processed plum products), (Katić Miljković, 2014). At that time, these two lines of agricultural production were characterised by in certain extent symbiotic conduction, as pigs were used for soil preparation for sowing of field crops within the plum orchards (after season of plums picking, pigs were freely walked in orchards until the early autumn, whereby they were digging the soil surface), (Marković, 2019).

Currently, state of pig farming in Serbia is quite different. According to official statistics, during the period 2012-2019., the number of pigs has declined. Share of pigs in fattening in total number of pigs ranged from 43.3 to 48% (Table 1.). Meanwhile, in mentioned period came to increase in pork meat production, what was primarily the consequence of the pig's breed improvement.

Table 1. Number of pigs and production of pork meat in Serbia (period 2012-2019., in 000 heads, in 000 t)

Year	Pigs (total)	Pigs in fattening	Pork meat
2012.	3,139	1,361	252
2013.	3,144	1,365	249
2014.	3,236	1,533	258
2015.	3,284	1,576	278
2016.	3,021	1,425	301
2017.	2,911	1,301	307
2018.	2,782	1,305	303
2019.	2,903	1,382	298

Source: SORS, 2020.

Within the group of slaughtered pigs in Serbia, over 60% were slaughtered at family farms. In observed period, average weight of pigs slaughtered in slaughterhouses is slightly increasing, what is primarily the result of producer's adjustment to technological requirements (Table 2.).

Table 2. Number of slaughtered pigs and average weight of slaughtered pig in slaughterhouses in Serbia (period 2012-2019., in 000 heads, in %, in kg)

Year	Slaughtered pigs (total)	Slaughtered pigs in slaughter houses	Share of pigs slaughtered in slaughterhouses	Average weight of pigs slaughtered in slaughterhouses
2012.	5,453	1,714	31.43	98
2013.	5,684	1,783	31.37	97
2014.	5,657	2,031	35.90	97
2015.	5,654	2,218	39.23	98
2016.	5,853	2,212	37.79	98
2017.	5,706	2,079	36.44	99
2018.	5,745	2,217	38.59	101
2019.	5,538	2,219	40.07	102

Source: SORS, 2020.

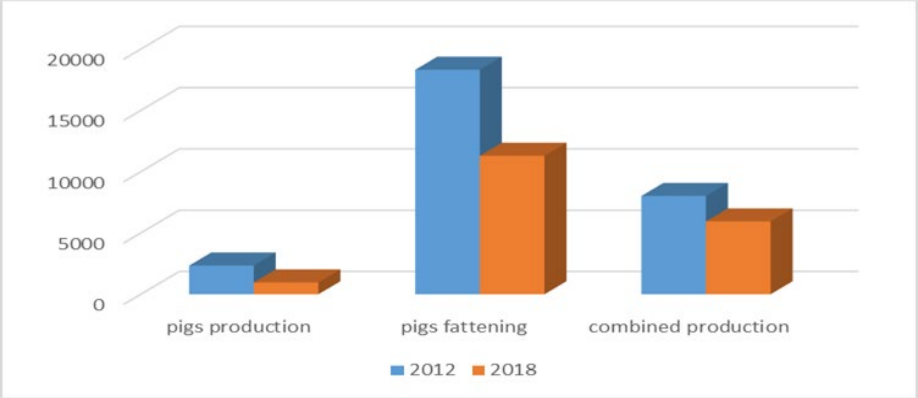
According to official statistic (SORS, 2019b), in line to data related to other types of activities (besides the production of milk, meat, fruit, etc.) that generate the farm incomes, there are 7,659 farms in Serbia that are involved in meat processing. In 2018. there were about 2.56 million of heads raised on family farms. Number of family farms that have pigs was almost 319,300, where almost 5.7% of them were specialized in pig breeding.

Last census of agriculture (2012.) shows that in average there were almost 8 pigs per family farm (regardless of the level of specialization). Besides, family farms that raised sows had in average 2 heads. Focusing to specialized family farms for pigs production, they were raised in average almost 11 pigs, while farms specialized just to pigs fattening had in average almost 14 pigs. Farms specialized for combined production had in average almost 20 pigs.

Same indicators for 2018. show a significant increase in production capacities, considering that in average farms have on disposal slightly over 8 pigs (regardless of the level of specialization), or little over 2 sows. Regarding the specialized family farms involved in pigs production they had in average almost 13.5 heads, while those one specialized in pigs fattening had almost 30 heads, or those one specialized for combined production had in average almost 25 heads of pigs.

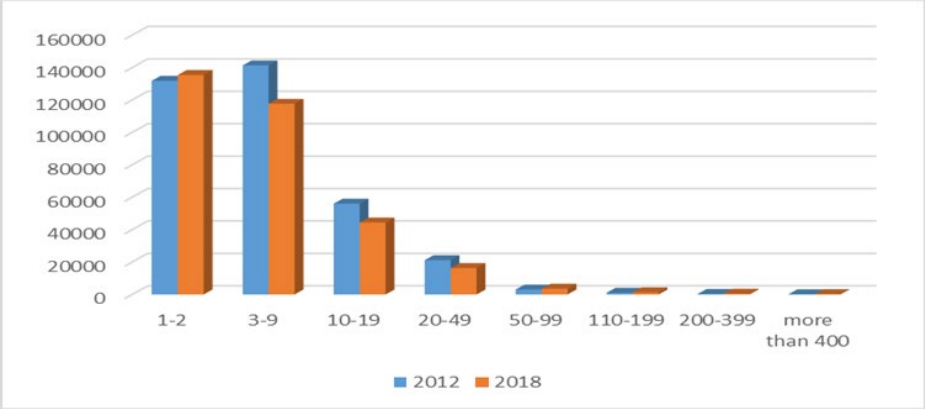
Meanwhile, the number of family farms specialized in pig farming (regardless the category of specialization) decreased in 2018., compared to 2012. (Graph 1.).

Graph 1. Number of family farms specialized in pig farming



Source: SORS, 2020.

Graph 2. Farm structure related to number of pigs



Source: SORS, 2020.

In previous period there has been come to strengthening of specialization in pig breeding, given that the number of specialized farms has decreased, while in same time there has been an increase in the number of pigs per individual farm (farms are strongly focused to pig fattening). Observed by regions, pig farming is concentrated in Vojvodina, as on that territory are locate the most of pigs' heads and majority of specialized farms (SORS, 2019a). Regarding the farm structure related to number of pigs (Graph 2.), the most of the family farms have up to 9 pigs.

Technological descriptions and analytical calculation

Currently, farm members are capable to slaughter, and later process and sell on market meat products that come from 84 pig fatteners (7 heads monthly) – Scenario I. Farm capacities are allowing fattening of 30 pigs, while the other heads are locally purchased as second class fattened pigs (over-weighted pigs with more than 120 kg, or in case of observed farm with weight of 150 kg), (Subić, Tomić, 2019). In line to available processing capacities, farmer reconsider to employ one external worker and to increase processing activity to 10 pigs per month (120 heads annually) – Scenario II.

Slaughtering is conducting three times per month (36 cycles per year). Additional fattened pigs will be also locally purchased.

After slaughtering of one fattened pig, over 30% of its weight represents unusable parts, while processing (production of dried and smoked meat products) involves halves weighing around 100 kg. Available input considers following structure of meat and processed products: 20 kg of sausages; 5 kg of meat pieces and 20 kg of bones suitable for drying; 5 kg of ribs; 10 kg of bacon; 15 kg of fat; 5 kg of cracklings; and 20 kg of fresh meat that will be sold unprocessed (aitchbone, meat for steaks, pork hocks, etc.). During the production of meat products there comes to additional shrinkage (5-20%), so at the end there are next volume final products: 16 kg of sausages; 4 kg of dried meat; 4.5 kg of dried ribs; 9 kg of dried bacon; and 19 kg of dried bones. The most of meat products are previously immersed in brine for 7 days, and later one day rinse with fresh water. Cycle of fresh products' smoking in smokehouse lasts for 5-12 hours, and later they are drying by the draft for several days. Processing season lasts for whole year, and all processed meat products are selling at the farm gate to known buyers, mostly local restaurants and retails.

Process of smoking requires the beech wood (each cycle of slaughtering is followed by smoking cycle), while electric-energy is mostly needed for lighting, refrigerators, used equipment, etc. Spices used in sausages production consider garlic, cayenne pepper, black pepper, and salt. Packaging material considers butcher paper, pvc bags and rap-foil, and pet boxes. Disinfection of facility is conducting after each cycle of slaughtering (approximately 3 times per month), while deration is organizing two times per year. Transfer of one fattened pig (slaughtering, meat cutting and chopping, preparing of meat products and additional mostly sanitary activities) into the final products requires 28 hours/pig (with engagement of two persons). Estimation is that by involvement of third person, required time per fattened pig will decrease to 26 hours. In next table (Table 3.) could be seen economic results (based on contribution margin) gained in pig fattening at observed farm.

Table 3. Contribution margin in pig fattening (in EUR/fattened pig)

Description	Quantity	UM	Price per UM	Total
A - Incomes				
Fattened pig	150	kg	1.20	180.00
Subsidy			8.50	8.50
Total				**188.50**
B - Variable costs				
Piglet	25	kg	1.70	42.50
Fodder				112.50
Veterinary services				3.75
Other costs				2.25
Total				**161.00**
C - Contribution margin (A-B)				**27.50**

Source: IAE, 2020.

Farmer is buying 25 kg piglets from local pig producers. They are fattened up to the 150 kg (for almost 6 months), when they are slaughtered and processed into the traditional pork meat products. Feeding considers use of concentrates and larger volumes of pigs' wash. Unfortunately, in line to low price of live animals on local market, the farmer is gaining positive but very limited contribution margin, which is not appropriate to the risk level that affects the livestock production. In other words,

regarding the farm capacities for pig farming (two cycles of fattening per year with up to 30 pigs per one cycle), in observed moment pigs fattening and selling of live animals cannot support decent life to farm members.

In next table (Table 4.) are presented economic results (based on variable costs) gained in pork meat processing at observed small family farm, for both scenarios (usual volume of processing done by farm members (processing of 84 fattened pigs per year) and enlarged volume of processing done after engagement of one external worker (processing of 120 fattened pigs per year)).

As was previously mentioned, incomes consider selling of fresh and processed meat at the farm gate to the known local buyers. Farm products' selling prices are slightly underestimated related to current market prices, what primarily comes from weak bargaining position of the farm linked to its low economic potential, small volume of production and level of marketing (modest packaging and labelling), etc.

As the primary input, second class (over-weighted) fattened pigs are raised in some number at the farm, or they are mostly purchased from local pig farmers. In line to traditional processing requirements used pigs are slightly fatter than the industrial standards (pigs unsuitable for industrial production of pork meat and meat products).

For the smoking of meat products, the beech wood is used. Process of smoking is conducting in 36 cycles during the year (up to 12 hours of active wood burning per one cycle). Larger volume of meat products that has to be smoked in Scenario II caused for 20% higher costs of wood. Costs of spices and additives, and packaging material are directly proportional to derived volume of pork meat products.

In order to better perceive labour costs, in both scenarios are included the costs of internal workers (farm members). Total fund of working hours are based on assumption that entire cycle of processing of one fattened pig in scenario I requires 28 hours, while in Scenario II it falls to 26 hours. Comparing to Scenario I (total annual labour fund of 2,352 working hours, or 1,176 working hours per employee), Scenario II is slightly more productive (total annual labour fund of 3,120 working hours, or 1,040 working hours per employee). Costs of labour are based on gross wage per working hour locally paid for this kind of activities.

Table 4. Contribution margin in pork meat processing (in EUR, annually including both scenarios)

Description	Quantity	UM	Price per UM	Total
Processing of pork meat gained from 84 fattened pigs				
A - Incomes				
Fresh meat	1,680	kg	3.4	5,712.0
Sausages	1,344	kg	5.1	6,854.4
Dried meat	336	kg	7.2	2,419.2
Dried ribs	378	kg	3.0	1,134.0
Dried bacon	756	kg	5.1	3,855.6
Fat	1,260	kg	1.0	1,260.0
Cracklings	420	kg	5.1	2,142.0
Dried bones	1,596	kg	1.3	2,074.8
Total				**25,452.0**
B - Variable costs				
Fattened pigs (150 kg)	12,600	kg	1.2	15,120.0
Energy (beech wood)				305.1
Spices and additives				405.2

Description	Quantity	UM	Price per UM	Total
Packaging material				285.0
Disinfection and deration				652.5
Labour	2,352	hour	2.3	5,409.6
Costs of electricity				355.9
Costs of fresh water and sewage				43.9
Costs of taxes and fees				152.5
Other costs				63.6
Total				**22,793.3**
C - Contribution margin (A-B)				**2,658.7**
Processing of pork meat gained from 120 fattened pigs				
A - Incomes				
Fresh meat	2,400	kg	3.4	8,160.0
Sausages	1,920	kg	5.1	9,792.0
Dried meat	480	kg	7.2	3,456.0
Dried ribs	540	kg	3.0	1,620.0
Dried bacon	1,080	kg	5.1	5,508.0
Fat	1,800	kg	1.0	1,800.0
Cracklings	600	kg	5.1	3,060.0
Dried bones	2,280	kg	1.3	2,964.0
Total				**36,360.0**
B - Variable costs				
Fattened pigs (150 kg)	18,000	kg	1.2	21,600.0
Energy (beech wood)				366.1
Spices and additives				578.9
Packaging material				407.1
Disinfection and deration				652.5
Labour	3,120	hour	2.3	7,176.0
Costs of electricity				508.5
Costs of fresh water and sewage				62.8
Costs of taxes and fees				217.9
Other costs				90.8
Total				**31.660.6**
C - Contribution margin (A-B)				**4,699.4**

Source: IAE, 2020.

As in pig fattening, in both presented scenarios of pork meat processing is achieving positive value of contribution margin. Calculated per processed pig, contribution margin linked to Scenario II is for 24% higher (31.6 EUR/processed pig compared to and 39.2 EUR/processed pig). This is mainly caused by better productivity achieved by engagement of third worker (within the structure of variable costs labour costs are dominating).

Unlike the price of live animals (expression of pork cycle), (Zawadzka, 2010) the price of pork meat products are much more stable in long distance. So, in period of low prices of fattened pigs, their processing at farm could be a good solution for stabilisation of farms' income. Good example is previously presented, as farmer could capture from almost 15% to more than 42% higher

contribution margin per fattened pig in meat processing than in pig farming. On the other hand, by completion of entire process of agri-food products production at the farm, farmer could obtain the contribution margin from 59.1 to 66.7 EUR/fattener.
Besides the fact that engagement of external labour leads to growing of farms' economic sustainability, there is also visible a social component of this action, as it reflects the farms' proactive relation to the issue of employment of the local rural community members.

Conclusion

There is a strong tradition in pig farming in Serbia. During the last couple decades sector of pig farming is generally pressed by negative production trend (mostly by decrease in number of pigs and number of farms active within the sector). On the other hand there is visible farm specialisation, with growth of pigs' heads per average farm.
Organisation of processing of primary agricultural products could be one of the successfully used tools for the creation of value-added at farm level. By implementation of activities from certain segment or complete vertical integration, farm could be in position to maintain its economic (profit) sustainability, or to ensure its own survival.
Typically, pig farming is limited by expressed cyclicity. So in condition of low prices of pork meat, the precondition for profit stability at small family farms could be organisation of pork meat processing.
In order to economically assess the validity of introduction of pork meat products production and its potential expansion at small family farms, it was used the differential analytical calculations based on variable costs (contribution margin). Gained results shown that both assumed scenarios (implementation of pork meat processing with or without engagement of external labour) are in line with strengthening of farm economic sustainability. Even more, second scenario directly corresponds to boosting of social pillar of farm sustainability.

Acknowledgements

Paper is a part of research financed by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

References

1. Anderson, D. P. & Hanselka, D. (2009). *Adding value to agricultural products*. Texas Farmer Collection, no. E-573/RM1-8, Texas AgriLife Extension Service, Texas A&M University, College Station, USA, pp. 1-4, available at: https://oaktrust.library.tamu.edu/handle/1969.1/86940, retrieved at: 2nd October 2020.
2. Andreoli, M. & Tellarini, V. (2000). Farm sustainability evaluation: Methodology and practice. *Agriculture, ecosystems and environment*, 77(1-2):43-52.
3. Bachev, H. (2016). An Approach to Assess Sustainability of Agricultural Farms. *Turkish Economic Review*, 3(1):28-53.
4. Bachev, H., Ivanov, B., Toteva, D. & Sokolova, E. (2017). Agrarian sustainability in Bulgaria: Economic, social and ecological aspects. *Bulgarian Journal of Agricultural Science*, 23(4):519-525.
5. Born, H. & Bachmann, J. (2006). *Adding value to farm products: An overview*. National Sustainable Agriculture Information Service (NSAIS), Butte, USA, pp. 1-12, available at: http://nationalgoodfoodnetwork.com/resources/ngfn-database/knowledge/valueovr.pdf, retrieved at 1st October 2020.
6. Coltrain, D., Barton, D. & Boland, M. (2000). *Value added: Opportunities and strategies*. Arthur Capper Cooperative Center, Kansas State University, Manhattan, USA, pp. 1-18, available at:

http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.619.3252&rep=rep1&type=pdf, retrieved at 1st October 2020.
7. DiCaprio, E. & Feiereisel, K. (2018). *Value-Added On-Farm Processing: Regulatory considerations*. University of California, Davis, USA, pp. 1-8, available at: https://ucfoodsafety.ucdavis.edu/sites/g/files/dgvnsk7366/files/inline-files/287951.pdf, retrieved at: 2nd October 2020.
8. IAE (2020). *Pig fattening and pork meat processing at small family farms*. Internal documentation, Institute of Agricultural Economics (IAE), Belgrade, Serbia.
9. Jeločnik, M., Subić, J. & Kovačević, V. (2019a). Competitiveness of sauerkraut production. *Western Balkan Journal of Agricultural Economics and Rural Development*, 1(2):113-123.
10. Jeločnik, M., Subić, J. & Kovačević, V. (2019b). Competitiveness of apple processing. *Ekonomika*, 65(4):41-51.
11. Lu, R. & Dudensing, R. (2015). What Do We Mean by Value-added Agriculture?. *Choices*, 30(4):1-8.
12. Marković, M. (2019). *Kakve veze imaju svinje i šljivici?*. portal "Bolja zemlja", Novi Beograd, Serbia, available at: www.boljazemlja.com/kakve-veze-imaju-svinje-i-sljivici/, retrieved at: 3rd October 2020.
13. Miljković Katić, B. (2014). *Poljoprivreda Kneževine Srbije (1834-1867)*. Monograph vol. 65, Institute of History, Belgrade, Serbia.
14. Roljević Nikolić, S. & Paraušić, V. (2019). *Diversifikacija ruralne ekonomije: Institucionalni okvir i nacionalni podsticaji u sektoru prerade poljoprivrednih proizvoda u Srbiji*. In: Kovačević, V., Unapređenje transfera znanja radi dobijanja bezbednih i konkurentnih poljoprivrednih proizvoda, koji su dobijeni preradom na malim gazdinstvima u sektorima mleka, mesa, voća i povrća, Institut za ekonomiku poljoprivrde, Beograd, Srbija, pp. 7-22.
15. SORS (2019a). *Farm structure survey: Serbia - 2018: Livestock breeding*. Statistical Office of the Republic of Serbia (SORS), Belgrade, Serbia.
16. SORS (2019b). *Farm structure survey: Serbia 2018 - Confirmation, refutation and indications*. Statistical Office of the Republic of Serbia (SORS), Belgrade, Serbia.
17. SORS (2020). *State of pigs farming*. Portal of the Statistical Office of the Republic of Serbia (SORS), Belgrade, Serbia, available at: https://data.stat.gov.rs/, retrieved at: 3rd October 2020.
18. Subić, J. & Tomić, V. (2019). *Programi investicija u preradu bezbedne hrane na malim poljoprivrednim gazdinstvima za mleko, meso, voće i povrće*. In: Kovačević, V., Unapređenje transfera znanja radi dobijanja bezbednih i konkurentnih poljoprivrednih proizvoda, koji su dobijeni preradom na malim gazdinstvima u sektorima mleka, mesa, voća i povrća, Institut za ekonomiku poljoprivrde, Beograd, Srbija, pp. 93-158.
19. Van Passel, S., Nevens, F., Mathijs, E. & Van Huylenbroeck, G. (2007). Measuring farm sustainability and explaining differences in sustainable efficiency. *Ecological economics*, 62(1):149-161.
20. Vroegindewey, R. & Hodbod, J. (2018). Resilience of agricultural value chains in developing country contexts: A framework and assessment approach. *Sustainability*, 10(4), 916.
21. Yu, J. & Wu, J. (2018). The sustainability of agricultural development in China: The agriculture-environment nexus. *Sustainability*, 10(6), 1776.
22. Zawadzka, D. (2010). The history of research on the" pig cycle". *Problems of Agricultural Economics/Zagadnienia Ekonomiki Rolnej,* 1(322):207-217.