14th
INTERNATIONAL
SYMPOSIUM

# MODERN TRENDS IN LIVESTOCK PRODUCTION

2023

PROCEEDINGS

4 - 6 October 2023, Belgrade, Serbia

Institute for Animal Husbandry

Belgrade - Zemun, SERBIA

14th INTERNATIONAL SYMPOSIUM

# MODERN TRENDS IN LIVESTOCK PRODUCTION

2023

PROCEEDINGS

4 - 6 October 2023, Belgrade, Serbia

## PATRONS

Ministry of Science, Technological Development
and Innovation of the Republic of Serbia
Ministry of Agriculture, Forestry and Water Management
of the Republic of Serbia

## ORGANIZER

Institute for Animal Husbandry
Autoput 16, P. Box. 23,
11080, Belgrade-Zemun, Serbia
Tel: +381 11 2691 611; +381 11 2670 121; +381 11 2670 541;
Fax: + 381 11 2670 164;

PUBLISHER
Institute for Animal Husbandry, Belgrade-Zemun, Serbia

Editor
Zdenka Škrbić, PhD, Principal Research Fellow
Institute for Animal Husbandry, Belgrade-Zemun

The Proceedings is printed by the Institute for Animal Husbandry,
Belgrade, 2023

biotechnology.izs@gmail.com
www.istocar.bg.ac.rs
Circulation 100 copies.

ISBN 978-86-82431-80-0

Proceedings of the 14th International Symposium
Modern Trends in Livestock Production
October 4 – 6, 2023, Belgrade, Serbia

# ORGANIC POULTRY PRODUCTION: GENOTYPE CHOICE AND WELFARE

**Simeon Rakonjac[1], Snežana Bogosavljević-Bošković[1], Zdenka Škrbić[2], Miloš Lukić[2], Vladimir Dosković[1], Veselin Petričević[2], Milun D. Petrović[1]**

[1]University of Kragujevac, Faculty of Agronomy in Čacak, Cara Dušana 34, 32 000 Čačak, Serbia
[2]Institute of Animal Husbandry, Belgrade-Zemun, Autoput 16, 11080 Zemun, Serbia
Corresponding author: Rakonjac Simeon, simcepb@yahoo.com
Invited paper

**Abstract:** Organic poultry production has a continuous growth trend that is expected to continue in the following period. Today's consumers expect this method of production to ensure the quality of life and a high level of welfare for the reared animals, which will contribute to the quality of the products produced in this way. Since this is a relatively young and still insufficiently researched rearing system, there are a lot of unknowns and unresolved issues that slow down its faster development. A genotype that would provide optimal production results in this production system has not yet been selected, so either hybrids from conventional production or breeds with poor production characteristics are often used. In addition to the undoubted benefit that the use of the outlet brings, which is reflected in the better quality of the organic products and the greater degree of welfare and vitality of the reared poultry, the negative impact of extreme weather conditions still exists, as well as the increased risk of transmitting various diseases and parasites as well as predator attacks.

**Key words:** organic poultry, slow-growing genotypes, fast-growing genotypes, dual-purpose breeds, welfare, biosecurity

## Introduction

The global organic poultry market will grow from $9.78 billion in 2022 to $10.34 billion in 2023 at a compound annual growth rate (CAGR) of 5.8%. The organic poultry market is expected to grow to $12.65 billion in 2027 at a CAGR of 5.2% *(The Business Research Company, 2023)*.

In European Union, 43.2% of hens are currently reared in cages, 36.2% in barns, 14% free range and 6.5% organic. Of the individual countries, Denmark (32.1%), Luxembourg (24.8%), Germany (14.1%), Austria (13.4%), Sweden

(11.7%) and France (11.2%) have the highest percentage of organic laying hens. By total number, Germany is the leading organic egg producer in Europe with 8.3 million layers, followed by France with 5.4 million layers and the Netherlands with 2.8 million organic layers *(European Commission, 2023)*.

On the other hand, 90% of broilers in the EU are reared in intensive indoor systems, around 4-5% in less-intensive indoor systems, up to 5% in free-range systems, and 1% in organic systems *(Augère-Granier, 2019)*. France leads organic chicken production in the EU, producing 14 million chickens per year, followed by Belgium with 3.6 million and Austria with 1.3 million chickens under the organic certification *(Maguregui, 2021).* The percentage of organic poultry in Serbia is less than 0.1% (*Simić, 2020*).

## Genotype choice

Organic poultry production has a large number of its peculiarities and for this reason, it is significantly different from conventional. This implies that the animals selected and available for conventional rearing may not necessarily be well suited for organic, because different production systems may also require different animal traits, e.g. genes that are beneficial in one production system may not be beneficial in another *(Brunberg et al., 2014)*. *European Commission Regulation No 848/2018 (2018)* stated that "In the choice of breeds or strains, account must be taken of the capacity of animals to adapt to local conditions; their vitality, and their disease resistance. In addition, breeds or strains of animals shall be selected to avoid specific diseases or health problems associated with some breeds or strains used in intensive production. Preference is to be given to indigenous breeds and strains".

The poultry used in intensive production systems is mainly selected for high growth/laying capacity in strictly controlled environments, small opportunities to move and certain group sizes. Typical meat-type chicken grows to twice the size of a bird from 50 years ago in half the time while consuming less feed per kilo of gain. Similarly, egg-type chicken genotypes produce more eggs. This selection process resulted in birds that can provide a large quantity of meat and eggs to meet consumer demand with relatively low production costs *(Fisher, 2016)*. It is debated whether these animals are suitable for less intensive production systems, especially organic *(Rakonjac et al., 2021)*.

Choosing the appropriate genotype for organic egg production is less of a problem than for organic meat production. A large number of studies have confirmed that commercial hybrids can be reared quite successfully in an organic production system, regardless of the fact that they are selected for intensive production in closed facilities *(Sokołowicz et al., 2018; Rakonjac et al., 2021)*. Of

course, a large number of challenges that are not represented in conventional production can occur here, related to reduced laying capacity, reduced egg weight, lack of methionine in the diet *(Rakonjac et al., 2018)*, as well as problems with diseases, parasites and predators *(Bonnefous et al., 2022)*. Due to these facts, dual-purpose breeds are the first choice for organic egg production. Implementing dual-purpose poultry in modern egg production is facing a challenge in exchanging the egg layer genotypes, which for many generations have been intensively bred for a high number of eggs, high feed efficiency, low bodyweight and high egg quality. These parameters are not at the same high levels in dual-purpose poultry. To implement dual-purpose genotypes in egg production, it is necessary to identify genotypes that among other production criteria have high egg qualities, which here are considered as shell strength, yolk-ratio, dry matter of egg albumen, and absence of blood and meat spots *(Hammershøj et al., 2021).* Despite their lower productivity, these genotypes have several advantages: they are agile and can run fast, fly and roost in trees, so can escape predators, they are more resistant to bacterial and protozoan diseases and parasitic infestations than commercial layers are, their eggs are generally preferred to those from commercial birds *(Pym, 2013)*.

There are numerous differences between conventional and organic broiler farming technology, but two facts have the greatest effect on the choice of genotype for this production - the presence of an outlet ($4m^2$ per bird) and the minimum slaughter age (81 days). If the producers apply to these minimum slaughter ages, slow-growing genotypes must be used because commercial broilers grow too fast to be kept until 81 days. Fast-growing broilers at an older age (81 days) are very heavy and have an unbalanced body conformation as a result of intense genetic selection for additional breast muscle and body mass, which render kinetic activity more difficult and unusual. Also, active behaviours, immune responses, and thermotolerance were reduced *(Amato and Castellini, 2022)*. For this reason, many studies have recommended the use of slow-growing genotypes in organic poultry meat production. These genotypes are more adapted to "natural" environments, with a robustness that allows them to survive and reproduce constantly *(Perini et al., 2020)*. Also, slow-growing genotypes are generally preferred for their ability to cope with organic rules while maintaining successful health and welfare states *(Amato and Castellini, 2022)*. Generally, slow-growing chickens are a heterogeneous group of chickens made up of commercial strains, selected by poultry companies for outdoor farming and by local poultry breeds *(Dal Bosco et al., 2021)*. The same authors *(Dal Bosco et al., 2021)* introduce the concept of medium growing, also called the "slower growing" genotype, which emerged to indicate a subject with intermediate characteristics, both from the point of view of production and from the ability of the birds to adapt to organic production.

Slow-growing chickens currently make up only a small fraction (1-3%) of the commercially available chicken genetic stock around the world and many slow-growing genotypes are only available in Europe *(Fisher, 2016)*. In the EU, it is estimated that 2-5% of the broilers are slower-growing birds. Outside the EU, there is little demand for slower-growing birds. Three world's largest breeding companies (Broiler Breeders, Cobb-Vantress and Hubbard) indicate that slower-growing broiler products make up less than 1% of the company's turnover. For both organic and outdoor broiler production, it is expected that the market will only slightly increase *(Hiemstra and Napel, 2013*).

In Italy, big companies use both sexes of slow-growing genotypes and only the females of fast-growing genotypes in organic systems, while the males are used in intensive systems. The reason for this choice is due to the too-high body weight reached by the males at 81 days *(Mancinelli et al., 2020)*. Rearing of slow-growing genotypes, which include native breeds, is also important for maintaining biodiversity and genetic variability *(Mancinelli et al., 2021)* because some of these local breeds could have traits and genes relevant for adaptation to organic rearing system (i.e., resistance to heat stress, higher immune response, kinetic activity, and some meat characteristics) *(Dal Bosco et al., 2021)*.

However, the definition of genotype adapted to the organic system requires the measure of a wide panel of physiological and behavioural traits and not only daily weight gain. A multi-criteria analysis should be developed considering the economic, ecological, social and qualitative performance of different poultry genotypes for identifying which of them better fits with the organic system requirements *(Castellini et al., 2016).*

## The welfare of reared animals

Conventional poultry production is one of the most intensive farming systems, and flocks often comprise several thousand birds reared in large compartments, with high stocking densities. Biosecurity is very high, and the indoor environment, including temperature, humidity and lighting, can be controlled meticulously *(Augère-Granier, 2019)*. From one point of view, this way of production satisfies the condition to be defined as high welfare because breeding companies consider the welfare as trouble-free production, absence of abnormalities that hamper production, low mortality and good performance in the range of customer production environments. They look at animal welfare in the context of the specific market, not on their own *(Hiemsta and Napel, 2013)*. On the other hand, organic poultry production exposes animals to natural light, natural climate conditions, and different temperatures. It is well-known that high temperatures are environmental stress factors that can badly compromise the

welfare, health, and production of broilers *(Amato and Castellini, 2022)*. Also, *Gerzilov et al. (2022)* state that a higher risk of stress exists in the organic rearing system, associated with factors such as changing environmental conditions, parasitic, bacterial and viral infections, contamination, aggression from dominant birds, pecking and risk of cannibalism etc. especially, ambient temperature are being widely recognized as a main stress factor. However, consumers define the welfare of reared animals in a completely different way - priority has animals' quality of life, and positive experiences for animals *(Amato and Castellini, 2022)*. Consumers want to buy a product that is produced in a "natural way", and for such a product they are willing to pay a higher price. This contributed to the perception that the products of "happy animals" are better and healthier for human consumption *(Rakonjac et al., 2018)*. Public concerns about broiler welfare have resulted in the emergence of various 'higher-welfare' systems. Around 10% of the broilers in the EU are currently reared in alternative production systems *(Augère-Granier, 2019)*. These include loose housing indoor systems with e.g. lower stocking densities, slower growing hybrids and/or provision of environmental enrichment, as well as free-range systems. Organic broiler production comprises a relatively small share of the market, approximately 1%, in the EU *(Augère-Granier, 2019)*.

The main problems in free range and organic laying hen farms are uneven distribution of birds on pasture, where they use the area near the house heavily but the rest very little, feather pecking, cannibalism, high risk of infection, pod dermatitis, deformation of the keel bone, and amputated beaks. Moreover, dirty eggs and the loss of birds by predators are common *(Mahboub, 2004)*. The welfare of free-range birds may be poor during extreme winter weather as their egg production is substantially reduced. Furthermore, problems are associated with winter or windy weather conditions as free-range laying houses will cool down rapidly and relative humidity increases. Therefore the regulation of the climatic condition in the house is difficult. The low temperature in the house stimulates the bird to eat more. This will increase the feeding costs of egg production. In addition, wetting of litter in laying houses as a result of outdoor wetness by rain and snow is another problem *(Mahboub, 2004)*.

Mainly organic farming is well able to provide conditions which promote good animal welfare because this system more or less complies with the Five Freedoms (Freedom from hunger and thirst, Freedom from thermal and physical discomfort, Freedom from pain, injury and disease, Freedom to express normal behaviour and Freedom from fear and distress *(Spoolder, 2007*). Organically reared poultry have more space and the possibility to go outside. This gives the animals the possibility to perform more natural behaviour and move more, which generally should be positive for their health. The outdoor system also gives challenges. It is

shown in many studies that different parasites are more common in free-range systems compared to cages *(Ferrante et al, 2009; Brunberg et al., 2014)*, as well as predation *(Ferrante et al, 2009; Bonnefous et al., 2022)*. In organic system, the environmental conditions, such as low density and access to large open spaces, should increase activity levels and improve the leg health of chickens *(Amato and Castellini, 2022)*. Generally, the good health of organic poultry should be maintained, preferably with preventive measures through the choice of breed, good management, and feed and flock sizes *(Brunberg et al., 2014)*.

From the results of numerous authors who have dealt with this topic, it can be said that the choice of genotype is crucial in terms of the welfare of organic-reared poultry. *Kalmendal and Bessei (2012)* and *Goransson (2022)* stated that slow-growing strains have lower mortality, less incidence of leg weakness and cardiovascular diseases, and generally show an improved welfare status in the organic rearing system. *Shim et al. (2012)* also reported higher mortality in fast-growing compared with slow-growing chickens, and 90% of this mortality was due to sudden death syndrome. Regarding broilers, there are clear differences in behaviour between fast and slow-growing genotypes. The slow-growing birds are more active, explorative and often spend more time outside *(Castellini et al., 2002; Fanatico et al., 2008)*. Using a GPS monitoring device to evaluate the outdoor activity of organic chickens, it was observed that the slow-growing birds performed more active behaviours, covering an average daily distance of 1 230 m, compared to the fast-growing birds which covered only 125 m *(Bokkers et al., 2004)*. Similar conclusions were also expressed by *Branciari et al. (2009)*.

Good pasture management is one of the most important measures in organic poultry production, and they provide birds' health and welfare. When outlets are not well managed from an environmental point of view, the pasture is scarcely taken care of (no grass and no shadow point presence) and the chickens' living space is unsafe. Several shelters should be made available to birds to make the outlet more attractive. Providing bushes and trees inside the pens could help chickens to feel safer from predators and more sheltered from the sun and bad weather; this would allow them to move further away from huts and eat and forage longer *(Sossidou et al., 2015)*.

Feather pecking and cannibalism are the two most important unwanted behaviours in poultry production. They are said to be redirected explorative/foraging behaviour and start when the animals cannot fulfil their behavioural needs *(Brunberg et al., 2014)*. Feather pecking and cannibalism may reduce the potential of organic husbandry to enhance the welfare of laying hens. Better feeding management, daily access to the free-range area and improved litter management may reduce the incidence of plumage damage and associated injurious pecking, hence enhancing the welfare of organic laying hens *(Bestman et*

*al., 2017)*. *Mahboub (2004)* established that feather pecking activity was decreased in the outside grass area compared to the outside roofed area. This may be attributed to the green food and its nutritive value that stimulate the birds to eat more grasses and perform foraging-related behaviours like scratching and pecking to be directed to the ground.

Outdoor access for broilers is associated with a lower incidence of foot pad dermatitis *(Dal Bosco et al., 2014)*. Contrary to this, *Sarica et al. (2014)* have demonstrated a negative effect on foot pad health in free-ranging chickens which is likely to be dependent on current weather and outdoor ground conditions. *Goransson (2022)* as a key effect in the occurrence of foot pad states the genotype used in organic production - fast-growing hybrids were much more prone to this occurrence. Similar conclusions are also stated by *Castellini et al. (2016)* - about 60% of the fast-growing genotype, when organically reared, had several body lesions and poor feather condition, whereas slow-growing chickens reared in the same conditions did not have footpad lesions or breast blisters. These studies suggest that the fast-growing genotypes are not suitable for organic-rearing systems. Indeed, these latter genotypes show an imbalance between skeletal and muscle mass that causes articular inflammations and metabolic disorders like myocardial infarcts and respiratory problems. The same conclusions are stated by *Meluzzi et al. (2009),* fast-growing chickens reared in the organic system exhibited many welfare problems such as a higher occurrence of footpad dermatitis and breast blisters, as well as an impaired immune response, compared with slow-growing birds.

# Conclusion

Based on the results of numerous authors whose results are presented in this paper, it can be concluded:

- organic poultry production has a continuous growth trend that is expected to continue in the following period,
- an ideal organic bird that will achieve good production results in conditions that differ significantly from those of conventional production has not yet been defined and created,
- achieving welfare in organic poultry production is still a big challenge because it is not easy to harmonize the quality of life of reared birds with the problems that arise when it is not possible to control the environment.

**Acknowledgement**
This study was funded by the Ministry of Science, Technological Development and Innovation of Republic of Serbia, No. 451-03-47/2023-01/200088 and No. 451-03-47/2023-01/200022.

# References

AMATO G.M., CASTELLINI C. (2022): Adaptability challenges for organic broiler chickens: a commentary. Animals, 12 (11), 1354.
AUGÈRE-GRANIER M.L. (2019): The EU poultry meat and egg sector. In The EU Poultry Meat and Egg Sector: Main Features, Challenges and Prospects; Publications Office: Brussels, Belgium.
BESTMAN M., VERWER C., BRENNINKMEYER C., WILLETT A., HINRICHSEN L., SMAJLHODZIĆ F., HEERKENS J.L.T., GUNNARSSON S., FERRANTE V. (2017): Feather-pecking and injurious pecking in organic laying hens in 107 flocks from eight European countries. Animal Welfare, 26 (3), 355-363.
BOKKERS E.A., KOENE P. (2004): Motivation and ability to walk for a food reward in fast-and slow-growing broilers to 12 weeks of age. Behaviour Processes, 67, 121-130.
BONNEFOUS C., COLLIN A., GUILLOTEAU L.A., GUESDON V., FILLIAT C., RÉHAULT-GODBERT S., RODENBURG T.B., TUYTTENS F.A.M., WARIN L., STEENFELDT S., BALDINGER L., RE M., PONZIO R., ZULIANI A., VENEZIA P., VÄRE M., PARROTT P., WALLEY K., NIEMI J.K., LETERRIER C. (2022): Welfare issues and potential solutions for laying hens in free range and organic production systems: A review based on literature and interviews. Frontiers in Veterinary Science, 9.
BRANCIARI R., MUGNAI C., MAMMOLI R., MIRAGLIA D., RANUCCI D., DAL BOSCO A., CASTELLINI C. (2009): Effect of genotype and rearing system on chicken behavior and muscle fiber characteristics. Journal of Animal Science, 87, 4109-4117.
BRUNBERG E.I., GRØVA L., SERIKSTAD L. (2014): Genetics and welfare in organic poultry production. A discussion on the suitability of available breeds and hybrids. Bioforsk Report, 9 (10), 1-25.
CASTELLINI C., MUGNAI C., DAL BOSCO A. (2002): Effect of organic production system on broiler carcass and meat quality. Meat Science, 60, 219-225.
CASTELLINI C., MUGNAI C., MOSCATI L., MATTIOLI S., GUARINO AMATO M., MANCINELLI A., DAL BOSCO A. (2016): Adaptation to organic rearing system of eight different chicken genotypes: behaviour, welfare and performance. Italian Journal of Animal Science, 15, 37-46.

DAL BOSCO A., MATTIOLI S., CARTONI MANCINELLI A., COTOZZOLO E., CASTELLINI C. (2021): Extensive rearing systems in poultry production: the right chicken for the right farming system. A Review of twenty years of scientific research in Perugia University, Italy. Animals, 11 (5), 1281.

DAL BOSCO A., MUGNAI C., ROSATI A., PAOLETTI A., CAPORALI S., CASTELLINI C. (2014): Effect of range enrichment on performance, behavior, and forage intake of free-range chickens. Journal of Applied Poultry Research, 23, 137-145.

EUROPEAN COMMISSION (2018): Regulation No 848/2018.
http://data.europa.eu/eli/reg/2018/848/oj

EUROPEAN COMMISSION (2023): Eggs market situation.
https://agriculture.ec.europa.eu/farming/animal-products/eggs_en

FANATICO A.C., BILLAI P.B., HESTER P.Y., FALCONE C., MENCH J.A., OWENS C.M., EMMERT J.L. (2008): Performance, livability, and carcass yield of slow- and fast-growing chicken genotypes fed low-nutrient of standard diets and raised indoors or with outdoor access. Poultry Science, 87, 1012-1021.

FERRANTE V., LOLLI S., VEZZOLI G., GUIDOBONO CAVALCHINI L. (2009): Effects of two different rearing systems (organic and barn) on production performance, animal welfare traits and egg quality characteristics in laying hens. Italian Journal Animal Science, 8, 165-174.

FISHER T. (2016): Specialty poultry production: impact of genotype, feed strategies, alternative feedstuffs, and dietary enzymes on the growth performance and carcass characteristics of heritage breed chickens. Theses and Dissertations-Animal and Food Sciences, 66.

GERZILOV V., ALEXANDROVA A., PETROVA P., BONCHEVA V., KERANOVA N., ANDREEVA, M., GEORGIEVA, A., TZVETANOVA E. (2022): Changes in the oxidative status of dual-purpose hens rearing in the free-range system during cold, thermoneutral and hot period. Animals, 12, 2650.

GÖRANSSON L. (2022): Animal welfare in organic poultry production. Doctoral Thesis No. 2022: 61. Faculty of Veterinary Medicine and Animal Science Department of Animal Environment and Health, Skara.

HAMMERSHØJ M., KRISTIANSEN G.H., STEENFELDT S. (2021): Dual-purpose poultry in organic egg production and effects on egg quality parameters. Foods, 10 (4), 897.

HIEMSTRA S.J., NAPEL J.T. (2013): Study of the impact of genetic selection on the welfare of chickens bred and kept for meat production. Final Report. Framework contract: evaluation impact assessment and related services; Lot 3: Food chain.

KALMENDAL R., BESSEI W. (2012): The preference for high-fiber feed in laying hens divergently selected on feather pecking. Poultry Science, 91, 1785-1789.
MAGUREGUI E. (2021): Organic animal production in the European Union (EU). Veterinaria Digital.
MAHBOUB H.D.H. (2004). Feather pecking, body condition and outdoor use of two genotypes of laying hens housed in different free range systems. PhD Thesis, Faculty of Veterinary Medicine University of Leipzig.
MANCINELLI A.C., MATTIOLI S., MENCHETTI L., DAL BOSCO A., CIARELLI C., GUARINO AMATO M., CASTELLINI C. (2021): The assessment of a multifactorial score for the adaptability evaluation of six poultry genotypes to the organic system. Animals, 11 (10), 2992.
MANCINELLI A.C., MATTIOLI S., DAL BOSCO A., CASTELLINI C., MUGNAI C., MOSCATI L., AMATO M.G. (2020): Performance, behavior, and welfare status of six different organically reared poultry genotypes. Animals, 10, 550.
MELUZZI A., SIRRI F., MUGNAI C., DAL BOSCO A. (2009): Effect of genotype on welfare conditions of broilers reared under organic conditions. In Proceedings of the 8th European Symposium on Poultry Welfare, Cervia, Italy, 18-22 May 2009.
PERINI F., CENDRON, F., ROVELLI, G., CASTELLINI, C., CASSANDRO, M., LASAGNA, E. (2020): Emerging genetic tools to investigate molecular pathways related to heat stress in chickens: a review. Animals, 11, 46.
PYM R. (2013). Poultry genetics and breeding in developing countries. Poultry Development Review.
RAKONJAC S., PETROVIĆ M.D., BOGOSAVLJEVIĆ-BOŠKOVIĆ S., ŠKRBIĆ Z., PERIĆ L., DOSKOVIĆ V., PETRIČEVIĆ V. (2018): Effect of age and season on production performance and egg quality of laying hens from different rearing systems. The Journal of Animal and Plant Sciences, 28 (6), 1602-1608.
RAKONJAC S., DOSKOVIĆ V., BOGOSAVLJEVIĆ-BOŠKOVIĆ S., ŠKRBIĆ Z., LUKIĆ M., PETRIČEVIĆ V., PETROVIĆ M.D. (2021): Production performance and egg quality of laying hens as influenced by genotype and rearing system. Brazilian Journal of Poultry Science, 23 (2), 001-008.
SARICA M., YAMAK U., BOZ M. (2014): Effect of production systems on foot pad dermatitis (FPD) levels among slow-, medium- and fast-growing broilers. European Poultry Science, 78.
SIMIĆ I. (2020): Organska proizvodnja u Srbiji 2020. Nacionalno udruženje za razvoj organske proizvodnje Serbia Organika, Beograd.
SHIM M.Y., KARNUAH A.B., MITCHELL A.D., ANTHONY N.B., PESTI G.M., AGGREY S.E. (2012): The effects of growth rate on leg morphology and

tibia breaking strength, mineral density, mineral content, and bone ash in broilers. Poultry Science, 91, 1790-1795.
SOKOŁOWICZ Z, KRAWCZYK J, DYKIEL M. (2018): Effect of alternative housing system and hen genotype on egg quality characteristics. Emirates Journal of Food and Agriculture, 30 (8), 695-703.
SOSSIDOU E., DAL BOSCO A., CASTELLINI C., GRASHORN M. (2015): Effects of pasture management on poultry welfare and meat quality in organic poultry production systems. World Poultry Science Journal, 71, 375-384.
SPOOLDER H.A.M. (2007): Animal welfare in organic farming systems. Journal of the Science of Food and Agriculture, 87, 2741-2746.
THE BUSINESS RESEARCH COMPANY (2023): Organic poultry global market report.https://www.thebusinessresearchcompany.com/report/organic-poultry-global-market-report