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EVALUATION OF ALTERNATIVE PORK PRODUCTION SYSTEMS ON PASTURE FROM A MULTIPLE PERSPECTIVE: WELFARE, ECONOMY, AND ENVIRONMENTAL PROTECTION

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Abstract

Integrated professional swine farms produce enormous amounts of manure, wich has become a source of environmental pollution. Diversification of production systems, encouragement of alternative exploitation on free land, which contributes to changes in growth and exploitation, lower socio-economic and environmental impact, production with reduced consumption of resources without loss of nutrients and conservation of biodiversity through sustainable development of areas, can be solutions that can reduce pollution. The measures proposed for implementation, to reduce the environmental risk, refer to methods and techniques of statistical filtering and spatial grouping based on the density of swine, well-being, the level of accessibility of food and fodder resources, the level of accessibility of meadows for own pork production and the level of environmental pollution according to nitrogen (N) and phosphorus (P) excretion.

Key words*: environmental risk, exploitation system evaluation, pasture, swine.*

INTRODUCTION

The economic-social importance of raising pigs for meat production resides in the fact that the species, no matter the production system, is valuable from the perspective of obtaining, in conditions of economic efficiency: fresh meat and meat preparations - bacon, ham; fats (lard); edible organs (liver, heart); other raw materials for industry (skin, hair).

Pigs are raised in almost all areas of the Earth and almost everywhere nationally, but areas with intensive corn crops are the main areas for raising pigs. Most pig production in Romania has shifted from extensive systems with open pens in closed, mechanized facilities – industrial-type farms, where exploitation requires the provision of microclimate conditions, welfare and nutrition control, and the resulting manure is a problem for the quality of the building environment if not well managed. The efficiency of production, the increasing need for pork offal means that, because of environmental problems, the classical exploitation systems have been diversified using new alternative exploitation systems in the open air and on pasture (Delsart et al., 2020), with the control of environmental factors and of the degree of supportability of the exploitation area (Giraldi-Díaz et al., 2021; Abrantes Pinto de Brito et al., 2022).

MATERIALS AND METHODS

The evaluation of systems for the exploitation of pigs on pasture for meat production involves the use of methods and techniques of statistical filtering and grouping of the density of pigs to ensure animal welfare and reduce the degradation of meadows according to the degree of supportability of the pasture, by controlling the level of pollution for maintaining biodiversity (Ruckli et al., 2021). The alternative system in open air in group pens with density control are:

• S75H/5B_15H - 75 heads kept in 5 boxes of 15 heads with a useful area of 0.80 m^2;

• S75H/5B_16H - 75 heads kept in 5 common boxes of 16 heads with access to the paddock with a useful surface of 0.70 m^2 per pig.

The statistical parameters evaluated are:

• AWupon entrance - average weight upon entrance in the farm;

• TWupon entrance - a total weight upon entrance in the farm;
• TWupon delivery - a total weight upon delivery to the slaughterhouse;
• AWdaily gain - an average daily gain over 95 days of fattening. The evaluation of the implemented alternative production system (Delsart et al., 2020) was done according to the Krieter method (2002) from a multiple perspective - welfare (environmental conditions), economy, and environment by measuring nitrogen and phosphorus excreta on the pasture (Chen et al., 2020). Monitoring of nitrogen and phosphorus excretion was determined using a nitrogen and phosphorus mass balance based on feed ration, crude protein content of the diet, total phosphorus and animal performance - reduction techniques by feeding in two meals with the provision of a diet food adapted to the requirements for fattening ages (PB = 14% up to 70 kg; PB = 12% until slaughter). Managerial measures were proposed to contribute to the reduction of losses of nutritional elements, by controlling risk factors and implementing the most effective alternative systems for obtaining meat by implementing policies to stop the development of farms and increase individual productions, ensuring welfare conditions for fattening pigs, economic efficiency of exploitation and protection of environmental factors, through the management system of alternative meat production in an integrated system, environmental and total quality management being important parts of technological management (Radhakrishnan et al., 2018; Andretta et al., 2021; Abrantes Pinto de Brito et al., 2022).

RESULTS AND DISCUSSIONS

Although pigs, depending on the production system and on its efficiency, can be fed any type of feed, in intensive and super-intensive farming, maintenance conditions, microclimate, and nutritionally balanced feeding must be ensured to produce fast and healthy growth, with a reduced amount of manure, which is the biggest problem of large holdings (Giraldi-Díaz et al., 2021). Used as granules, flours, dry or wet feed based on mixtures of corn and soybean meal supplemented with antibiotics, minerals, and vitamins (Sampath et al., 2023), feed can contribute to shortening the fattening period and increasing individual productions.
Ensuring welfare conditions in any production system contributes to obtaining high-performance productions with high costs without being able to fully solve the problems related to natural environmental factors (Figure 1).

Figure 1. New directions and changes in pig farming and sustainable development

For these reasons, we propose new solutions for the diversification of the meat production systems, for production efficiency and reduction of the degree of pollution by switching as much as possible from classic energy-consuming systems, where there are local resources to exploit on pastures and in the open air through:
- implementation of spatial planning of pig production in areas with:
• high availability of local fodder resources;
• availability of resources from pastures and arable land;
- implementation of community policies to reduce environmental risk through:
• the integration of environmental management into the integrated management of meat production (Radhakrishnan et al., 2018; Andretta et al., 2021; Abrantes Pinto de Brito et al., 2022);
• the development of the best practices that contribute to the preservation of biodiversity around pig farms (Ruckli et al., 2021; Teodorescu et al., 2023);
- implementation of new managerial measures as principles of action adopted in farms or proposed by product organizations or farmers in three periods of development of classical and alternative production systems (Delsart et al., 2020):

• unmanaged development for small professional meat farms with regulations regarding the welfare and environmental protection of their area; environmental regulations (1961-1978);
• rapid development of medium-sized professional farms that have implemented alternative outdoor and pasture production systems with:
• welfare measures;
• regulation of livestock depending on the creditworthiness of the meadow and on the degree of affordability;
• the possibility of securing resources in crisis conditions;
• the effects on the vegetative carpet, soil (Loss et al., 2019; Yost et al., 2022), and water;
• the possibilities of monitoring environmental factors (Andretta et al., 2021; Abrantes Pinto de Brito et al., 2022);
• stagnation of the development of large farms and the diversification of production systems, through:
• increasing individual productions, using commercial breeds and hybrids with high biological value;
• ensuring microclimate conditions and maintenance;
• implementing the best management of nutrition by increasing the efficiency of feed use and by producing reduced amounts of manure;
• implementing environmental risk management regulations (Radhakrishnan et al., 2018; Machete & Chabo, 2020);
• monitoring livestock production and controlling the degree of pollution in the farm area;
• integrating production, processing and capitalization by perfecting marketing management and production according to the trend of the pork market;
• transition to a more efficient alternative production with the consumption of local resources and environmentally-friendly by implementing the following measures applicable to any farm that adopted the alternative production system on pasture or in the open air by (Delsart et al., 2020; Andretta et al., 2021; Izmaylov et al., 2022):
• implementation of statistical filtering techniques of the pork demand from the potential market;
• density-based spatial clustering of noisy applications (Liu et al., 2023);
• accessibility to fodder and arable land for own production (Govoni et al., 2022);
• population migration (Bai et al., 2019) and consumption trends towards other types of meat and meat preparations;
- food accessibility level:
• traditions regarding the consumption and method of preparing meat;
• distribution and capitalization possibilities;
• the price of meat obtained in alternative systems;
• average level of income;
- pollution level and the negative impact on the environment in the farm area (Andretta et al., 2021; Abrantes Pinto de Brito et al. 2022).

If modern pig farms produce large amounts of manure, which has become increasingly worrisome as a potential source of water, soil (Loss et al., 2019; Yost et al., 2022), and air pollution, for sustainable development (Deviney et al., 2021) we propose other measures to diversify production systems based on the importance of socio-economic aspects of raising and exploiting pigs for meat production, emphasizing that it is a much more complex relationship regarding welfare, efficiency of exploitation, and the degree of pollution of environmental factors (Andretta et al., 2021); therefore, it is necessary to control the following influencing factors of production efficiency in classical systems and alternative systems for the new orientations in obtaining pork, preserving biodiversity, and sustainable development of the areas in the vicinity of the farms (Delsart et al., 2020; Deviney et al., 2021; Giraldi-Díaz et al., 2021; Ruckli et al., 2021):
- absence of available resources on pasture or agricultural land;
- presence of farms with plant and animal production;
- location of pig production as close as possible to the pork markets;
- ensuring the necessary quantities of food;
- ensuring food security and safety;
- demand, income level, and economic and energy crises;
- social economy and epidemics of infectious diseases that affect people (COVID-19) (Teodorescu et al., 2023);
- massive epidemics of infectious diseases affecting pigs (influenza, rubella, classical and

African swine fever) (Jarynowski et al., 2019; Berends et al., 2021);
- manure recycling facilities (optimized treatment, transport, and application);
- implementation of technological innovations (genetically modified animals, animal cloning, gene/genome editing, genetic engineering) along the entire pork production chain (Wu & Bazer, 2019);
- level of cereal imports (basic fodder in the pigs' diet);
- average income (which determines the increase in the demand for animal products);
- culinary habits, tradition, and dietary preferences (which depend on the level of education of the population, the average income, and urbanization rate);
- urbanization rate (city dwellers consume more pork than villagers).

Pigs operated in an alternative system in open air in group pens with density control achieved the following performances in common boxes with access to the paddock:
- 75 heads kept in 5 boxes of 15 heads with a useful area of 0.80 m^2 per head reached:
  - an average weight upon entrance in the farm of 24.60 ± 1.35 kg (Table 1);
  - a total weight upon entrance in the farm of 1,845.00 kg (Table 1);
  - a total weight upon delivery to the slaughterhouse of 7,970.50 kg (Table 1);
  - an average daily gain over 95 days of fattening of 859.72 g (Table 1);

Table 1. Performances obtained by pigs operated in alternative open-air system in group pens with density control in common stalls with paddock access

Evaluated parameters	Alternative system	
	$S_{75H/5B\_15H}$ (0.8 m^2/head)	$S_{75H/5B\_16H}$ (0.7 m^2/head)
$AW_{upon\ entrance}$	24.60±1.35 kg	24.51±1.44 kg
$TW_{upon\ entrance}$	1,845.00 kg	1,835.25 kg
$TW_{upon\ delivery}$	7,970.50 kg	7,901.20 kg
$AW_{daily\ gain}$	859.72 g	851.35 g

- 75 heads kept in 5 common boxes of 16 heads with access to the paddock with a useful surface of 0.70 m^2 per pig reached the following production parameters:
  - an average weight upon entrance in the farm of 24.51 ± 1.44 kg (Table 1);
  - a total weight upon entrance in the farm of 1,835.25 kg (Table 1);
  - a total weight upon delivery to the slaughterhouse of 7,901.20 kg (Table 1);
  - an average daily gain over 95 days of fattening of 851.35 g (Table 1).

To note that ensuring a density of 0.70-0.80 m^2 per head of animal during the fattening period ensures, through balanced nutrition, similar production performances but lower at higher densities. We conclude that, for alternative outdoor production systems, to ensure animal welfare we need:
- a minimum of 0.80-0.85 m^2 per head of animal because production performance is lower in smaller areas;
- access to the paddock and optimal conditions in the stalls, possibilities to adjust the environmental factors (Andretta et al., 2021) and to improve the efficiency of fattening by supplementing the rations with green fodder that is cheaper than the concentrated ones;
- noise reduction from feed conveyors and huma sources, and lower densities based on sound biological and economic research can help reduce feed consumption, as dietary vitamin supplementation reduces stress and improves welfare in fattening pigs;
- fitting the temperature during the fattening period because of its effects on animal welfare and on fattening through:
  - discomfort: disorganization of the stalls, dirtiness, crowding, lack of rest, altercations and exits from the herd through accidents and death;
  - low economic yields because of the spread of pathogens, appearance of technopathies, depreciation of carcasses and meat;
  - reduced yields at slaughter and unsatisfactory financial results;
  - impact on markets through reduced supply of meat obtained in an alternative production system;
  - failure to meet consumption needs on the pork market.

To maintain animal welfare and obtain economic productions that meet the needs of pork consumers on the market, we recommend the development of alternative production systems on pasture and in the open air and the monitoring and control of:
- the operating environment;
- optimal densities;

- the nutritional quality of fodder resources;
- modelling of resting, feeding, and watering places;
- harmonization of production parameters control systems;
- monitoring of environmental factors to preserve the biodiversity of pastoral ecosystems (Andretta et al., 2021; Ruckli et al., 2021).

Regarding meat production in open-air alternative system, environmental issues were monitored by controlling nitrogen (N) and phosphorus (P) excretion (Chen et al., 2020). Research results showed the following (Figure 1):

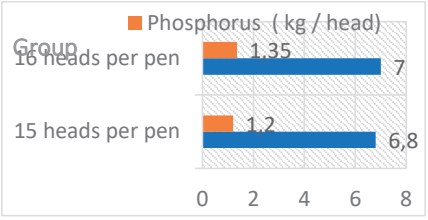

Figure 1. Results obtained by controlling the excretion of nitrogen and phosphorus, with the aim of monitoring environmental problems, in relation to meat production in the alternative system in the open air

- for the group of 15 heads per pen, nitrogen and phosphorus excretion was 6.8 and 1.2 kg, respectively, per pig head;
- for the group of 16 heads per pen, nitrogen and phosphorus excretion was 7.0 and 1.35 kg, respectively, per pig head;
- farming on pasture with the optimization of fattening pig herds and the increase of herds to the degree of supportability increases the welfare score by up to 25% and the cost, the excretion cost, and the excretion of N and P were reduced by 3.50-5.20;
- by monitoring environmental factors, optimizing herds fattening on pasture and using good practices, the risks of managing the natural environment can be reduced (Andretta et al., 2021). For the alternative systems of obtaining meat from the traditional Romanian pig breeds Negru de Strei, Mangalița, and Bazna, in areas with tradition, we propose for implementation a method of assessing the sustainability of pork production systems and practices considering 6 elements (Table 2):
- animal welfare;
- economy of resources, including the production cost;
- quality of the environment, perception, and human culture;
- solving the meat deficit;
- animal health and worker safety;
- food safety.

Table 2. Comparisons regarding the sustainability of classical and alternative production systems

Item	Pig production system	
	inside	outside
Zoonoses	controllable	predominant
Pork quality	good	very good
Environmental impact	0	0
Community interface	0	0
Perception of animal welfare	very good	very good
Productivity	100	20
Security of human resource	very good	good
Food safety	very good	poor
Welfare	very good	good
Climate variability	controllable	uncontrollable

The comparison between the classical and alternative systems shows that food safety concerns make the pig production system in alternative outdoor and pasture systems unable to cover the entire meat requirement but a niche of 10-12% making it unsustainable at the national level, though an important source of meat and meat products for isolated areas, where there is a tradition of consuming dry raw products with a long shelf life.

CONCLUSIONS

A few conclusions can be drawn from the presentation above:

✓ alternative farming systems are above classical farming systems;

✓ alternative farming systems are diversified (farming on straw to silvo-pastoral farming, free-range farming, organic farming);

✓ alternative farming systems differ to confined, conventional, slatted farming; alternative farming systems enjoy a very positive societal image;
✓ alternative farming systems have real strengths;
✓ alternative farming systems have weaknesses (animal welfare, economic profitability, farmer welfare, controlling biosecurity, sustainability).

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TECHNOLOGIES OF THE AGRO FOOD PRODUCTS PROCESSING