



BREEDING AND PERFORMANCE POTENTIAL OF PUŁAWSKA PIGS – A REVIEW*

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Abstract

The aim of the study was to discuss breeding of pigs of the Puławska breed, which is included in a Genetic Resources Conservation Programme, and to analyse performance parameters that are useful in domestic pig production. The Puławska breed is the oldest native breed of pig in Poland. Since 1996 it has been protected by a genetic resources conservation programme, owing to breeding traditions and the production traits characteristic of the breed. The use value of these pigs is currently at the level of maternal breeds: number of live piglets born per litter – 10.54; number of piglets reared per litter – 9.37; daily weight gains – 569 g for breeding boars and 562 g for breeding gilts; meat content – 54.6% for breeding boars and 54.9% for breeding gilts. An important element in favour of the use of this breed in domestic production of fresh pork and pork products is its meat quality parameters. The mean values for physical traits (WHC 22.42%, pH₄₅ 6.47, pH₂₄ 5.63) and chemical parameters (protein 22.70%, fat 2.65%) are characteristic of meat of normal quality. The Puławska breed can be used to produce high-quality fresh meat and meat products, including traditional and regional ones. Puławska pigs are bred and reared according to the principles of sustainable agriculture, which reduces the negative impact of pig production on the natural environment.

Key words: pigs, native breed, Puławska breed, meat quality, Genetic Resources Conservation Programme

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National efforts to protect genetic pig resources are part of European and global trends in conservation of genetic variation within this species. In 1992, the international Convention on Biological Diversity was drawn up in Rio de Janeiro, giving rise to the establishment of a worldwide Livestock Genetic Resources Conservation Programme. Poland, as a signatory to the Convention since 1995, has taken on the obligation to protect native breeds of livestock animals. The term “animal genetic resources” refers to all farm animal species and populations within them which for utilitarian, scientific or cultural reasons have, or may have in the future, significance for humans. These animals include pigs. Programmes created to protect pigs in Poland and around the world concern breeds with a critical population size (total number of females not exceeding 100 or number of males not exceeding 5) and breeds threatened with extinction (100–1000 females or 6–20 males) (Scherf, 2000). These are most often local breeds. In Europe, they include the breeds Cinta Senese, Ibérico (Iberian), Lietuvos Vietinė (Lithuanian Indigenous Wattle), Mangalitsa (Swallow-Belly Mangalitsa), Mora Romagnola, Nero Siciliano, and Schwäbisch-Hällisches (Čandek-Potokar and Nieto Linan, 2019). In Poland, this group includes the breeds Żłotnicka White, Żłotnicka Spotted and Puławska (Szyndler-Nędza *et al.*, 2018).

The history of Puławska pig breeding

Pigs of the Puławska breed are a permanent historical element of the Lublin region, from which they originate. At the turn of the 20th century, primitive prick-eared and long-eared pigs and populations called Nadwieprzańska and Poleska were kept on farms located on the Wieprz River. These pigs had beneficial features such as good health, resistance to disease, an undemanding nature, low requirements in terms of fodder, and a tendency to fatten (Zabielski, 1939). Primitive domestic pigs were often improved using imported breeds of higher use value, mainly Berkshire, but also Tamworth. The progeny presented a relatively unified type constituting a population that was commonly called “spotted”. They are distinguished by early maturity, a rapid growth rate, a cylindrical structure, a broad body, good feed utilization, high fattening and slaughter values, adaptation to local environmental conditions, and disease resistance. The high slaughter efficiency and taste qualities of the meat were particularly valued. Locally, these pigs were known as the Lubartowska, Kocka and Rycka breeds. Through crossbreeding with Large White and Berkshire breeds, the “spotted” population was transformed into a dual-purpose fat–meat type characterized by early maturity and intensive deposition of subcutaneous and internal fat. This type was referred to as the Gołębska pig. Until 1939 the Gołębska pig grew in popularity not only in the Lublin region but in Silesia as well. This was undoubtedly due to qualities such as early maturity, resistance to disease and unfavourable environmental conditions, very good adaptation to the traditional farming system and diet of cereal and potatoes, a large share of adipose tissue (back fat and leaf fat), and meat suitable for production of fresh and cured meats (Walkiewicz *et al.*, 2017). It is worth noting that during World War II Gołębska pigs were the only type of domestic pig which could be bred in the territories of the General Government established on Polish lands (Otterson and Schaal, 1942). In 1951, to emphasize the contribution of the breeding work of the State Research Institute of Rural

Husbandry in Puławy, the name “Gołębska” pig was changed to “Puławska”. Until the 1980s the Puławska breed was maintained not only in the Lublin region but also in central and southern Poland. The decline in interest in this breed for the production of fatteners was mainly due to lower meatiness traits as compared to imported breeds (Duroc, Hampshire, and Pietrain). A similar situation has been observed in many other European countries. For this reason, an inventory of pig breeds has been carried out, making it possible to assess their vulnerability (Simon and Buchenauer, 1993). Actions taken by scientists, breeders and representatives of breeding institutions contributed to the maintenance of the Puławska breed in the Lublin region. Under the Regulation of 29 August 1996 adopted by the Breeding Council for Pig Breeding at the Central Animal Breeding Station in Warsaw, the Puławska breed was placed under protection as a gene pool. Implementation of the Genetic Resources Conservation Programme began on 1 January 1997.

The traditions associated with raising the Puławska/Gołębska breed of pigs in the Lublin region have been passed down from generation to generation. Its restitution was possible owing to breeders who kept these pigs in the 1990s merely to uphold family tradition, and not for economic reasons.

Use value of Puławska pigs

The performance parameters of Puławska pigs meet the criteria for the breeding standard of a maternal component (Figures 1, 2 and 3). The breed currently presents a transitional type between a dual-purpose fat–meat type and a meat type. Although Puławska sows exhibit a stable potential for maternal traits, their reproductive value changed in the later years of maintenance breeding (Figure 1). The average number of live piglets born per litter in 1997–2017 was 10.99. Sows subject to reproductive performance assessment in 1997 gave birth to more piglets per litter (11.6) than sows used in the years 1998–2017.

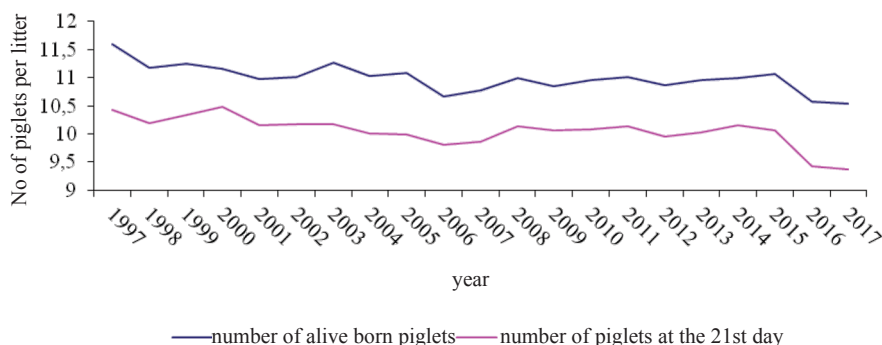


Figure 1. The average litter size on days 1 and 21 of life in successive years (data from the National Research Institute of Animal Production and Polish Pig Breeders and Producers Association “POLSUS” for the domestic Puławska pig population)

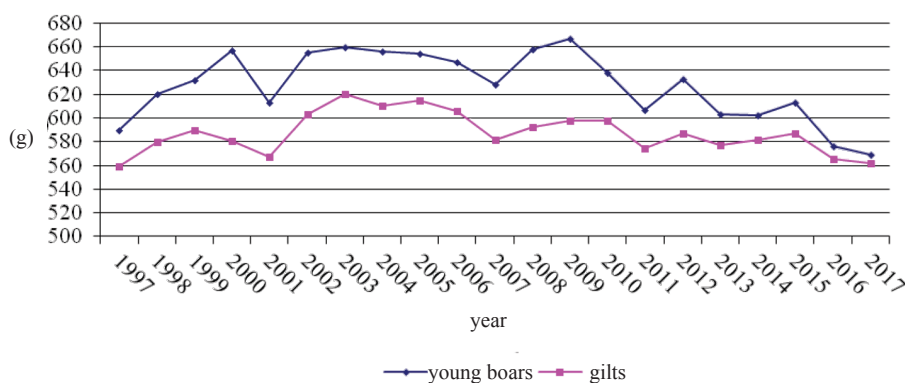


Figure 2. Daily gains of young boars and gilts in the years 1997–2017 assessed in the 150–210 d age range (data from the Polish Pig Breeders and Producers Association “POLSUS”)

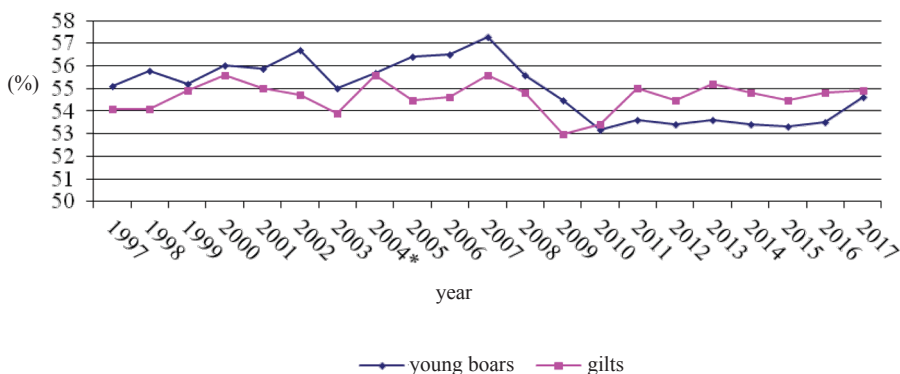


Figure 3. Meatiness of young boars and gilts in the years 1997–2017 assessed at an average body weight of 100 kg (data from the Polish Pig Breeders and Producers Association “POLSUS”)

The average number of born and reared piglets per litter was lowest (10.55) in 2016 and 2017, due to a large proportion (28%) of primiparous gilts in the total number of sows evaluated (Figure 1). Currently, reproductive performance parameters for Puławska sows are slightly lower (14%) than for the breeds Polish Large White (PLW) and Polish Landrace (PL), but they are still high by maintenance breeding standards (Blicharski et al., 2018).

In native breeds, fewer piglets are generally born and reared than in the case of commercial breeds, as confirmed by observations and studies by other authors: an average of 7.5 piglets per litter are obtained from Iberian sows (Piñeiro et al., 2012), 5 piglets from the Mangalitsa breed (Radović et al. 2017), and 8 from the Mora Romagnola breed (Bonanzinga et al., 2012). The litter size of Puławska sows on the first day of life has been shown to be higher than in other conserved breeds, i.e. Złotnicka White and Złotnicka Spotted, by 1.41 piglets (Szyndler-Nędza et al.,

2018). Research has shown significant variation in breeding results in the Puławska (Pul) breed depending on the line of boars and family of sows. Walkiewicz et al. (2005) observed that the largest litters were obtained from boars of the Flet (11.36 piglets) and Wulkan (11.28) lines and the fewest live piglets per litter from the Frykas (10.41) and Rodak (10.53) lines. Analysis of actual fertility showed the highest value of this parameter for the Dazerka family (10.63 piglets per litter), and in the case of crossbreds, in the Akra family (Akra Pul $\times$ PLW 10.61 piglets) and the Dazerka family (Dazerka Pul $\times$ PL 10.63 piglets). A similar distribution of values was noted in the case of the number of piglets reared per litter. The litter size was also shown to depend significantly on meatiness, determined on the basis of the loin eye height and backfat thickness (Babicz et al., 2007).

An important characteristic feature of Puławska sows is the length of their use (Babicz et al., 2016). The fertility of this breed has been observed to reach the highest values in the 4th or 5th cycle and to remain at a similar level for the next 2 or 3 cycles. A decline is recorded on average after the 7th or 8th litter. Research by Stasiak et al. (2006) has shown higher (7%) fertility in Puławska sows that farrowed in the winter, which confirms their high resistance to unfavourable environmental conditions and adaptation to local climatic conditions.

The second group of performance parameters of pigs defines their fattening value. Advantages of Puławska pigs include their capacity for good utilization of domestic legumes (seeds and green forage) (Milczarek and Osek, 2016) and their relatively fast growth rate. Measurements made on live pigs in 1997–2017 showed daily gains of 576–667 g in barrows and 559–620 g in gilts (Figure 2). These values were higher than in the Żłotnicka White and Żłotnicka Spotted breeds in maintenance breeding, whose daily gains ranged from 411 g to 487 g in 2017 (Szyndler-Nędza et al., 2018). These values are similar to those reported for the breeds Mora Romagnola, Ibérico and Lietuvos Vietinė (FAO, 2018). Another group of performance parameters of Puławska pigs, characterizing their suitability for the production of domestic pork, is slaughter value. According to Zabielski (1939), the original “spotted” population had a high slaughter value (74–78%) and produced large amounts of fat and meat, which were especially suitable for the production of cured products. These characteristics were inherited by the Gołębska pig population, which exhibited traits characteristic of heavy-type pigs. The first breeding work aimed at increasing the meatiness of Puławska pigs was carried out in the 1950s and continued until the early 1990s, so that the Puławska breed could be included in the national programme for the production of fatteners. Pigs of the Puławska breed mature in about their fifth month of life (3–4 weeks earlier than in meat breeds raised in Poland), which means that they begin to rapidly accumulate fat earlier than other breeds, providing fatter slaughter material at a higher body weight. Currently, the breed presents a transitional type between a dual purpose fat–meat type and a meat type (Walkiewicz et al., 2017). In the contemporary pork market, however, a premium is placed on raw meat with a high share of muscle tissue, which is a major obstacle to the production of meat products of high eating quality. Performance testing of live animals has shown that the meatiness of young boars and gilts during the 20 years of implementation of the Genetic Resources Conservation Programme was on a similar level, from 53.0–55.6% (gilts)

to 53.2–57.3% (boars) (Figure 3). Such values currently limit the use of the breed for mass production of raw pork. A similar situation was noted for other conserved breeds. In 2017, the meat content of Żłotnicka White and Żłotnicka Spotted pigs was 52.1–49.4% (boars) and 50.9–47.1% (gilts), which also distanced them from high-production pigs commonly used in mass production of fatteners. A characteristic feature of local breeds is their lower muscle parameters, such as the cross-sectional area of the loin (the “eye”). The eye area has been reported as 28 cm² in the Cinta Senese breed (Sirtori et al., 2014), 29 cm² in Ibérico pigs (Ayuso et al., 2018), and 41 cm² in the Schwäbisch-Hällisches pig (Sundrum et al., 2011). In the case of the Puławska breed it was 43 cm² (Wojtysiak and Połtowicz, 2014).

Assuming that protection of the Puławska breed depends mainly on its position in the market, other solutions should be sought for the economic aspect of sustainable use of the Puławska breed. Therefore, following the example of other countries, increasing attention is devoted to the possibility of using domestic breeds for the production of regional and traditional products which are distinguished by their high quality and their unique formula and production technology (Guerrero et al., 2010).

In 2018 there were over 190 traditional products registered in the Lublin voivodeship. Meat products constituted a large portion of them, including Nadwieprzański gammon, Nadwieprzański bacon, Nadwieprzański loin, Nadwieprzanka black pudding, and Nadwieprzański sausage, produced using only domestic breeds, including Puławska. It has been permitted to use this breed for such products since 28 May 2009, when it was included in the List of Traditional Products of the Minister of Agriculture and Rural Development, which is part of the strategy for the identification and promotion of regional products.

In the European Union, traditional products produced from native pig breeds are valued by consumers, so the quality of the raw meat is particularly important. The most valued pork products worldwide are cured hams from the Ibérico breed, and among these “Dehesa de Extremadura”, which obtained the Protected Designation of Origin (PDO) European certificate of quality in 1996 (Collado et al., 2006). The basic indicators of the quality of pork for processing and for eating are its physical properties and chemical composition. In research by various authors (Table 1), the average pH₄₅ and pH₂₄ of the *longissimus dorsi* muscle of Puławska fatteners has ranged from 6.11 to 6.78 and from 5.58 to 5.67, respectively. Such values are characteristic for RFN meat (red, firm, normal), which is most favoured by consumers. In general, research results indicate that post-mortem glycolysis proceeds normally in the meat of domestic pig breeds (both native and domestic white breeds). Wojtysiak and Połtowicz (2014) have reported pH₂₄ values of 5.43 and 5.48 for the PL and PLW breed, respectively. Kapelański et al. (2006) and Grześkowiak et al. (2009), however, emphasize that watery meat is generally not found in native pig breeds. An important parameter determining the suitability of meat for processing is its colour, which is defined by three parameters: L* – lightness, a* – redness, and b* – yellowness. Both consumers and processors value pork which is darker in colour (L* ≤ 50) (Newcom et al., 2004), typical of European domestic breeds. In the Puławska breed (Table 1), the lowest L* value (47.16) has been recorded by Wojtysiak and Połtowicz (2014), and the highest (53.17) by Milczarek and Osek (2016). Similarly, for the Italian lo-

cal breed Casertana, both dark meat with an L^* value of 39.60 (D'Alessandro et al., 2011) and light meat with $L^* = 53.16$ (Barone et al., 2015) have been reported. The raw meat of pigs of native breeds is generally darker in colour than that of Polish white breeds. The L^* value has been shown to be lowest (the darkest colour) in the meat of Złotnicka White pigs ($L^* = 43.88$, Grześkowiak et al., 2009), and higher in Złotnicka Spotted pigs ($46.43 < L^* < 49.29$; Grześkowiak et al., 2009; Florowski et al., 2006; Szulc et al., 2012). Similar results have been reported for the meat of pigs of local Italian breeds, i.e. Cinta Senese ($L^* = 49.7$), Mora Romagnola ($L^* = 42.3$) and Nero Siciliano ($L^* = 46.7$), by Franci and Pugliese (2007), and for the Spanish Iberian breed ($L^* = 39.8$) by Serrano et al. (2008). In the case of the PL breed, the lightness (L^*) of the meat has ranged from 51.14 to 56.52 (Kasprzyk et al., 2013; Wojtysiak and Kaczor, 2011). An L^* value > 51 often indicates reduced water holding capacity (WHC) of meat.

Table 1. Physical properties and technological characteristics of *longissimus dorsi* muscle of Puławska fatteners

n	Colour parameters			Drip loss (%)	Cooking loss (%)	WHC (%)	pH ₄₅	pH ₂₄	References
	L^*	a^*	b^*						
20	48.87	6.95	7.22	4.56	24.88	33.85	6.71	5.64	Grześkowiak et al. (2006)
30	48.75	16.99	5.04	4.20	27.46	20.03	6.38	5.67	Kasprzyk et al. (2013)
30	53.17	13.29	2.02	2.18	—	21.03	6.11	5.58	Milczarek and Osek (2016)
28	47.16	14.36	3.39	1.75	35.92	18.31	6.78	5.63	Wojtysiak and Połtowicz (2014)
Average	49.59	13.42	4.18	3.07	29.84	22.42	6.47	5.63	

WHC – water holding capacity.

Water holding capacity is a parameter determining the suitability of meat for processing. Raw material with low water holding capacity is of inferior quality and its suitability for processing is limited (Florowski et al., 2006). In the case of Puławska pigs, water holding capacity, as determined by the Grau and Hamm method, ranged from 18.31% to 33.85% (Table 1). Similar variability has been found in the meat of Złotnicka Spotted pigs (from 22.10% to 32.66%; Grześkowiak et al., 2009; Florowski et al., 2006; Szulc et al., 2012), while in Złotnicka White pigs the average water holding capacity was 29.88% (Grześkowiak et al., 2009). In PL and PLW pigs, the water holding capacity has ranged from 20.25% to 38.91% (Kasprzyk et al., 2013; Wojtysiak and Kaczor, 2011; Wojtysiak and Połtowicz, 2014). D'Alessandro et al. (2011) also report a higher water holding capacity (lower water loss) in the meat of pigs of the Italian indigenous breed Casertana relative to Large White pigs (15.88% vs. 17.54%). In addition, Franci and Pugliese (2007) report that the meat of the Cinta Senese breed not only has a higher water holding capacity than Large White, but was also characterized by a higher yield during salting and ripening of hams. Drip loss (3.07% on average) and cooking loss (on average 29.84%) are also

lower in the Puławska breed (Table 1) than PLW (3.68% and 38.09%, respectively; Wojtysiak and Połtowicz, 2014) and PL (on average 6.23% and 32.53%; Kasprzyk et al., 2013; Wojtysiak and Kaczor, 2011). Franci and Pugliese (2007) have also reported that the meat of Italian local pigs had lower cooking loss than the meat of improved breeds. For example, the cooking loss from the meat of Cinta Senese pigs ranged from 19.90% to 25.56% (Sirtori et al., 2011; Sirtori et al., 2015), while that of Nero Siciliano pigs was 23.50–25.03% (Pugliese et al., 2004). The chemical composition of meat is the fundamental parameter determining its nutritional value. Analysis of the share of individual chemical constituents of the loin reported by various authors (Table 2) reveals that the meat of Puławska pigs has a high nutritional value. The average shares of the main components were dry matter 26.75%, protein 22.70%, fat 2.65%, and ash 1.13%. Similarly high proportions of dry matter and protein were found in the meat of Żłotnicka Spotted (27.06% and 23.40% respectively; Grześkowiak et al., 2009; Florowski et al., 2006; Szulc et al., 2012) and Żłotnicka White pigs (27.60% and 24.50%, respectively; Grześkowiak et al., 2009). Lower content of dry matter and protein has been found in other domestic pig breeds, i.e. PL (25.40% and 22.50%, respectively; Babicz et al., 2013; Florowski et al., 2006; Migdał et al., 2007) and PLW (25.42% and 22.50%; Migdał et al., 2007; Stasiak and Kamyk, 2001).

Table 2. Chemical composition of *longissimus dorsi* muscle of Puławska breed

<i>n</i>	Dry matter (%)	Protein (%)	Fat (%)	Ash (%)	References
20	–	23.37	2.41	1.13	Babicz et al. (2013)
17	26.30	22.40	2.51	1.20	Florowski et al. (2006)
10	28.40	22.00	3.70	1.20	Florowski et al. (2007)
30	26.01	22.40	2.20	1.11	Kasprzyk et al. (2013)
30	27.19	22.95	3.00	1.10	Milczarek and Osek (2016)
Average	26.75	22.70	2.65	1.13	

As regards the production of traditional products, the share of fat in pork should be given special attention. To achieve sensory characteristics favoured by consumers (marbling, colour, taste, tenderness and juiciness), the optimal level of intramuscular fat is about 3% (Blicharski et al., 2013). European domestic pig breeds generally have a high fat content, e.g. Casertana – 4%, Nero Siciliano – 3%, or Ibérico – about 10% (Pugliese and Sirtori, 2012). In native pig breeds, the average intramuscular fat content according to studies by various authors is 2.65% in the Puławska breed (Table 2), 2.73% in the Żłotnicka Spotted pig (Florowski et al., 2006; Grześkowiak et al., 2009; Szulc et al., 2012), and 1.87% in Żłotnicka White pigs (Grześkowiak et al., 2009). For other Polish pigs of white breeds, it is 1.56% for PL (Babicz et al., 2013; Florowski et al., 2006; Migdał et al., 2007) and 1.41% for PLW (Migdał et al., 2007; Stasiak and Kamyk, 2001).

The share of protein and fat can be used to determine parameters of the nutritional value of meat, i.e. the energy value and nutritional quality index (NQI) (Hans-

en et al., 1979). The average energy value of Puławska tenderloin was found to be 643.38 kJ/100 g, while the NQI for protein and fat was 5.91 and 0.51, respectively (our own calculations based on the values from Table 2, according to the methods of Hansen et al., 1979). The caloric value of the loin of Puławska pigs was shown to be comparable to that of PLW × PL crossbreds, in which it was 633 kJ/100 g (Blicharski et al., 2013). These values are much lower than those presented in the media, which contribute to a negative image of pork.

Breeding of Puławska pigs and the natural environment

The Puławska pig population covered by a maintenance breeding programme is kept on family farms, often with generational traditions associated with this breed. Due to the smaller production scale, farmers take special care to maintain optimal welfare conditions and implement the principles of good agricultural practice, which has specific benefits for the environment. This is also underscored in the breeding and rearing of other local European pig breeds (Čandek-Potokar and Nieto Linan, 2019). Puławska pigs are primarily housed in a deep-litter system, which ensures excellent rearing conditions while at the same time reducing risks associated with contamination of the environment with harmful gases (ammonia, hydrogen sulphide, and carbon dioxide), odours and nitrogen.

Farms which breed or rear pigs in numbers above 240 LU are considered to have a significant impact on the environment. Pig farms with a population of 1000 produce on average 3500 m³ of manure, which corresponds to 12,600 kg of nitrogen produced per year (RRM, 2005). Assuming that the amount of manure used in one year must not exceed 170 kg of pure nitrogen per ha of agricultural area (Dz.U. 2007 nr 147 poz. 1033), 70 ha of agricultural area is needed to rationally use this amount of fertilizer. Excessive stocking density combined with an insufficient crop area can lead to the accumulation of biogenic compounds (nitrogen and phosphorus) in the soil. This results in eutrophication of water bodies and nitrate contamination of groundwater, the main source of drinking water. Manure generally poses no threat to the environment and positively affects soil structure by providing humus.

In the production of pork and pork products from Puławska pigs, high ethical quality is of great significance. Farms currently implementing the Genetic Resources Conservation Programme (Walkiewicz et al., 2017) satisfy the basic principles of ethical quality, i.e. a high level of welfare with maximum limitation of stress factors and a diet of on-farm feeds produced from cereals grown under sustainable farming conditions.

Conclusions

Breeding of Puławska pigs has continued uninterrupted since 1926, making it the oldest breed of pig in Poland. This breeding tradition is one of the elements that should be exploited in marketing of meat and meat products obtained from this breed. Full use can be made of the Puławska breed in domestic pork production, as evidenced by a number of performance traits: the fattening and slaughter value of boars and gilts used for reproduction, the reproductive performance of the sows, and above all the quality of the meat. Domestic research conducted in this area has

shown that physical and chemical characteristics remain at a level characteristic for meat of the quality currently preferred by consumers. The Puławska breed can be used to produce high-quality fresh meat and meat products, including traditional and regional ones.

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