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SIGNIFICANCE OF LOCAL LIVESTOCK GENETIC RESOURCES IN THE CONTEXT OF GLOBAL FOOD SECURITY – A REVIEW

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Abstract

This paper aims to review the current state of knowledge on the significance of livestock genetic resources in the context of increasing global food availability. The still unresolved problem of world hunger and the rapidly rising human population, especially in underdeveloped areas, mainly in Africa and Southeast Asia, requires numerous measures to ensure food security. Global production of food of animal origin is generally determined by international breeds selected for high performance in the production of a particular product (meat, milk, or eggs). These breeds, as well as industrial food production systems, are crucial to ensuring global food security. Unfortunately, they exert significant pressure on the environment. In developing countries, extensive, low-input production systems relying on local animal breeds are also important in food production. These breeds are less productive, but having lived in a given region for decades, they have acquired many adaptive traits, i.e. better utilization of poorer quality feed, adaptation to adverse climatic conditions (high/low temperature or drought), and resistance to parasites or diseases. These breeds are also often used for crossbreeding with imported exotic high-yielding breeds to increase productivity while retaining the adaptive traits of the local breed. Local breeds have found their niche in food production in developed countries as well. Meat, meat products, cheese, and other dairy products from these breeds are increasingly reaching consumers with quality labels, including information about their origin, and consequently obtaining higher prices.

Key words: food security, local breeds, poultry, pigs, ruminants, horses

Food security is defined by the FAO as a situation in which all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and preferences, enabling them to live an active and healthy life (Peng and Berry, 2019). According to the most recent report on the state of global food security and nutrition (FAO, 2023), drawn up by a number of organizations (FAO, IFAD, UNICEF, WFP and WHO), global hunger levels far exceed those recorded before the COVID-19 pandemic. It is estimated that from 690 to 783 million people worldwide faced hunger in 2022, i.e. 122 million more than before the pandemic. Nevertheless, the increase in global hunger levels observed over the course of two years has stopped, with around 3.8 million fewer people facing hunger in 2022 than in 2021. This can be attributed to the post-epidemic economic recovery; however, this modest progress was hampered by rising food and energy prices caused by the war in Ukraine. The problem of increasing hunger affects all of Africa, West Asia, and the Caribbean. It is projected that there will still be almost 600 million people facing hunger in 2030, i.e. 119 million more than in a scenario in which neither the COVID-19 pandemic nor the war in Ukraine had occurred, and around 23 million more than in a scenario without the war. In addition, it was estimated that 148 million children are suffering from stunted growth due to food deficiencies, 45 million are emaciated, and 37 million are overweight. Therefore, over the years, the problem of world hunger is becoming an increasingly pressing issue that requires rapid action. One of the factors determining the ongoing problem of hunger is the very rapidly increasing global population, which has increased nearly 2.5-fold over the past 50 years, from 3.3 billion people in 1965 to over 8.1 billion in 2024 (FAOSTAT, 2024; Worldometers, 2024). The human population is expected to reach 9.55 billion in 2050, with the increase primarily affecting countries in underdeveloped regions, mainly in Africa and Southeast Asia. It is estimated that population fluctuations in developed countries over the next four decades will be negligible, whereas in the least developed regions, this number will double (Barłowska et al., 2016). This increase, as well as the limited capacity to provide food, is escalating concerns about the fundamental issue of global food security

(Kidane and Kejela, 2021). Food insecurity causes serious demographic and environmental problems (Jambo et al., 2021). A study by Akbari et al. (2022), conducted using an extensive analysis of changes in global food security, indicates that the problem of world hunger is highly complex and multifactorial. The numerous causes of hunger and malnutrition include the lack of food availability, insufficient purchasing power (Khanna, 2020), inadequate food distribution, misuse of food (Anghinoni et al., 2021), poverty (Jenderedjian and Bellows, 2021), natural disasters (Anghinoni et al., 2021; Chen et al., 2021; Pakravan-Charvadeh et al., 2021), political violence, and geopolitical factors (Nabuuma et al., 2021). Warfare also poses a huge challenge for food security. As highlighted in the FAO report (2022) concerning the current situation in Ukraine, significant problems in agriculture have arisen as a result of the physical reduction in the availability of inputs (including fuel) and the destruction of homes, farms, and civilian infrastructure. This has resulted in the disruption of local and national supply chains, causing a growing problem of hunger and malnutrition in the area. Moreover, the war in Ukraine is having a "domino effect", so that its consequences will also be felt in other, distant regions interconnected by global trade. Typically, these are low-income countries in North Africa and the Middle East, where the problem of hunger and malnutrition is already severe (Hassen and El Bilali, 2022). Akbari et al. (2022) demonstrated that the issue of adequate food distribution was initially analyzed in the context of the availability of individual food products and price stability at national and international levels. However, a recent study indicates that in view of the complexity of the problem of hunger and malnutrition in the world, analyses also address the local level and the situation of individual households (Xie et al., 2021). An analysis by Xie et al. (2021), which assessed trends in research topics related to food security taken up during the period of 1991–2019, shows that there has been a significant increase in interest in the role of small farms in the food security chain since 2016. The analysis shows that it is not possible to ensure a sufficient amount and quality of food globally without the contribution of low-production farms. In addition, Ardakani et al. (2020) report that small agricultural farms play a significant role in the global food security chain. At the same time, the dominance of intensive production systems is progressively marginalizing both low-production farms and others classified as alternative farms (Ickowitz et al., 2019). In view of the specific nature of low-production farms and others keeping livestock of native breeds, e.g. organic farms, the negative impact of the intensification of production on agro-ecosystem diversity must be taken into account. Hence there is a need for discussions on the preservation of local livestock breeds in the context of global food security.

Livestock provide approximately 12.9% of total calories and 27.9% of protein, through the consumption of meat, milk, eggs and offal, and also contribute to crop production by providing transport and manure (FAO, 2011). The human diet should include products of animal origin; this particularly applies to children and to pregnant and breastfeeding women. According to the latest recommendations for individuals who have had COVID-19, their diet should include high-quality animal proteins (Barrea et al., 2022). As mentioned above, many people suffer from hunger due to a deficiency of nutrients that can be supplied with food products of animal origin. These products are a source of highly digestible, high-quality proteins with a favorable balance of amino acids, particularly essential amino acids. The recommended daily dietary protein allowance is 56 g for men and 46 g for women. Meat, fish, eggs, and dairy products are valuable sources of minerals as well, including calcium, zinc, iron, and vitamins A, B_{12} and B_2. Liver and eggs are also an important source of essential fatty acids (α-linolenic, linoleic, eicosapentaenoic and docosahexaenoic acids), which are crucial for the development of the brain and nervous system (Mottet et al., 2017; Scanes, 2018). It should be noted that both animal species and production systems contribute, in an unequal manner, to the supply of animal protein. Cattle and buffalo account for the largest proportion (45%, including meat and milk), followed by chickens (31%, including meat and eggs) and pigs (20%). Small ruminants produce only about 4% of global animal protein (Mottet et al., 2017).

This study reviewed the current state of knowledge on the significance of livestock genetic resources, with particular emphasis on the role of native breeds and the validity of efforts to protect them in the context of increasing global food availability.

The state of animal genetic resources

Animal genetic resources (AnGR) are defined as a fundamental component of global food security (FAO, 2007). Data presented in the Global Plan of Action for Animal Genetic Resources demonstrates the significant role of livestock genetic resource diversity for human survival and well-being and, above all, in combating the global problem of hunger and malnutrition (FAO, 2021).

According to a document issued by FAO (2023) entitled "Status and trends of animal genetic resources – 2022", based on the data of the DAD-IS (Domestic Animal Diversity Information System), coordinated by the Food and Agriculture Organization (FAO), a total of 8859 breeds were reported worldwide in 2022, of which 7739 were local breeds (reported in only one country), and 1120 were transboundary breeds (reported in more than one country). Of the transboundary breeds, 564 were regional transboundary breeds (reported in only one region), and 555 were international transboundary breeds (reported in more than one region). Of the local breeds, 4954 represented mammals, and 2199 represented birds. Among mammals, 458 breeds were entered as regional transboundary breeds, as were 97 breeds of birds. Among the international transboundary breeds, 396 mamma-

lian breeds and 160 bird breeds were identified. A total of 2360 breeds are classified as endangered (27% of all breeds, including the extinct ones), and 54% have an unknown risk of extinction.

The largest numbers of local livestock breeds are found in Europe and the Caucasus, amounting to 3322–2154 breeds of mammals and 1168 breeds of birds. In many cases, e.g. in Asia, Africa, the Near and Middle East, and the Southwest Pacific, a large percentage of breeds do not have a specified conservation status.

However, despite numerous studies and scientific papers emphasizing the need for the implementation of conservation programs, the significance of livestock genetic resources is controversial. According to Blasco (2008), it is not economically justifiable to maintain so many breeds which represent a cost with no guarantee of immediate profit. What is more, the funds allocated for conservation measures could be used for other, more urgent needs, e.g. for regional development or directly for human food. Referring to the definition of "breed", the author emphasizes that it is a group of individuals sharing common characteristics, and that the determination of a distinct breed is the result of a human decision. Moreover, he emphasizes that in the process of recreating a breed recognized as extinct, the animals selected and crossbred exhibit similar characteristics to the extinct breed. Therefore, it is not necessary to maintain so many costly native breeds in order to reintroduce them using breeds currently in use.

Distinguishing traits of local animal breeds

Despite the low levels of genetic variability resulting from crossbreeding among related individuals, native breeds have retained unique gene combinations (Dovc, 2007; Rossetti et al., 2021), whose interactions determine the expression of certain traits typical of these animals, e.g. improved health, longevity, and other functional traits (Demir et al., 2022). Furthermore, the uncertainty about which genetic variants will be necessary in the future is an important argument in favor of the further protection of native breeds. Given the current challenge of feeding the growing human population, we cannot be certain that the costs currently associated with preserving native breeds are not economically justified. In the future, the cost of preserving them may actually prove to be lower than the cost associated with the loss of these breeds and their unique genetic traits (Mariante and Egito, 2002). Animal genetic diversity allows farmers to select herds or create new breeds in response to environmental changes, the risk of disease, new knowledge of human nutritional requirements, and changing market and social conditions, all of which are largely unpredictable. What is predictable, however, is the future human demand for food. This projection is based on population growth rates, urbanization trends, changing lifestyle patterns, and rising incomes (Wollny et al., 2003).

Local breeds, which are mainly kept on small farms, arose under difficult conditions linked to shortages of fodder and water resources, high seasonal and annual variability of precipitation, and contact with pathogens or parasites. As a result, they have developed a number of adaptive traits that increase their survivability. This promotes the survival of the population, and the genes responsible for this may play a significant role in enabling the animals to live under stressful conditions (Naskar et al., 2012; Solomon and Hussen, 2018). Table 1 presents examples of breeds representing the livestock species most important to humans, together with their adaptive traits for living under harsh climatic conditions. The table shows that animals kept in tropical and subtropical climates have the most adaptive traits.

Gaughan and Cawdell-Smith (2015) state that high-yielding breeds are not adapted to natural grassland and pastures or low-input systems and generally require artificial supplementation (veterinary medicines) to achieve satisfactory production results. The adaptation process often occurs at the expense of productivity, and survivability is often higher in "low" productivity animals, due to their lower input needs (mainly fodder) and lower level of internal heat production.

Materials sourced from local animal breeds kept under traditional husbandry systems (including the use of grasslands) and the products made from them are distinguished by more favorable parameters of importance to the consumer and for processing.

Numerous authors have reported that beef, pork, poultry meat, and eggs derived from native breeds are more palatable (Moreno-Indiasa et al., 2011; Afolabi, 2013; Czarniecka-Skubina and Pielak, 2017; Razmaitė et al., 2024; Szulc et al., 2024; Szyndler-Nądza et al., 2021; Therkildsen et al., 2021). Szyndler-Nędza et al. (2021) assessed the quality of meat from two groups of pigs of the native Złotnicka Spotted breed – kept in an intensive fattening system vs a free-range system (fed extensively with bulky feed consisting of grass silage, whole-grain corn silage, and hay, together with a grain mixture, with small amounts of whole acorns additionally provided in the last two months of fattening). The authors showed that meat derived from the extensively-fed animals had a higher content of fat, which is a carrier of flavor and, indirectly, juiciness. They also emphasized that the meat of these pigs can be described as healthier due to its significantly higher content of monounsaturated fatty acids (MUFAs) and low atherogenic and thrombogenic indices. The same conclusions were reached by Therkildsen et al. (2021). Ariza et al. (2019), who compared the sensory properties of hen's eggs from the Spanish rustic Utrerana breed with those of commercial and organic eggs from the Leghorn Lohmann LSL-Classic line, demonstrated that the eggs from the native breed scored higher than the other categories in terms of yolk color, odor, flavor, texture, and the overall visual impression of a whole egg and a broken egg on a plate.

Table 1. Examples of farm animal breeds and descriptions of their adaptive traits for difficult living conditions

Genus	Species	Breed	Country of occurrence	Trait	References
1	2	3	4	5	6
Cattle (*Bos*)	*Bos taurus*	Namchi (Doayo)	Cameroon	Tolerance to trypanosomiasis (innate immune response to protozoa *Trypanosoma congolense*, *T. vivax* and *T. brucei*)	Achukwi et al., 2009
	Bos indicus	Kenana	Sudan	Resistance to tropical theileriosis (innate immune response to protozoa *Theileria annulata* transmitted by the tick *Hyalomma detrium*)	Bakheit and Latif, 2002
	Bos indicus	Arsi	Ethiopia	Enhanced immunity to tuberculosis (innate immune response to bacteria *Mycobacterium bovis*)	Vordermeier et al., 2012
	Bos taurus	Yanbian	China	Low temperature tolerance (presence of candidate genes *CORT*, *FGF5* and *CD36*, responsible for hair follicle development, hair length, and membrane transport of long-chain fatty acids)	Shen et al., 2020
	Bos indicus	Boran	Ethiopia	High temperature tolerance (a number of adaptive traits at the morphological, behavioral, physiological, neuroendocrine, blood chemistry, metabolic, cellular and molecular levels)	Bayssa et al., 2021
Sheep (*Ovis*)	*Ovis aries*	Santa Inês	Brazil	High temperature tolerance (light carpet-like wool, helpful in inducing the cutaneous evaporative cooling mechanism)	McManus et al., 2009
	Ovis aries	Djallonké	Cameroon	Immunity to animal African trypanosomiasis (innate immune response to *Trypanosoma* protozoa transmitted by the tsetse fly, *Glossina* spp.)	Yaro et al., 2016
	Ovis aries	Oula	Tibet	Adaptation to high mountain conditions (increased expression of the BRINP3, CDH18, BDH1 and CYP2J genes, responsible for alleviating oxidative stress and increasing oxygen supply to tissues at high altitudes)	Liang et al., 2024
Goat (*Capra*)	*Capra hircus*	Salem Black	India	High temperature tolerance (significantly reduced respiratory rate, expression of heat shock protein HSP70 responsible for testicle thermoregulation)	Aleena et al., 2018
	Capra hircus	Turkish hair goat	Türkiye	Adaptation to conditions of limited water availability (reduction in dry matter intake, drying of feces and thickening of urine in order to maintain water balance in the body and limit water loss)	Kaliber et al., 2016
	Capra hircus	Dwarf goats	Nigeria	High resistance to nematode parasites (*H. contortus*)	Chiejina and Behnke, 2011
Pig (*Sus*)	*Sus domesticus*	Min	China	High resistance to diseases caused by gram-positive and gram-negative bacteria, low animal mortality rate (high expression of cathelicidins – antimicrobial peptides)	Ma et al., 2014
	Sus domesticus	Niang Megha	India (Eastern Himalayas)	High and low temperature tolerance (low alanine aminotransferase (ALT) activity and high alkaline phosphatase (ALP) activity, higher thyroid hormone (T_4) secretion, low cortisol concentration in high temperature conditions)	Govindasamy et al., 2022
	Sus domesticus	Kakhetian pig	Georgia	High resistance to helminthiases: ascaridosis, oesophagostomosis, trichocephalosis and metastrongylosis.	Ujmajuridze et al., 2019
Chicken (*Gallus*)	*Gallus gallus domesticus*	Alfa Midir and Negasi Amba	Ethiopia	Adaptation to extremely low temperatures and high altitudes (presence of 9 candidate genes on chromosome 9 – CLP1, YPEL4, P2RX3, ENSGALG00000007381, SLC43A3, PGR2/3, RTN4RL2, UBE2L6 and TIMM10 – associated with reactions such as hypoxia, thrombosis, low temperature and repair and growth of lung tissue under the influence of oxidative stress)	Gheyas et al., 2021
	Gallus gallus domesticus	Nigerian indigenous chicken	Nigeria	High temperatures tolerance (presence of numerous genes encoding: LOC112530469 and LOC101749846, SFTPB, HSF1, CDC37, HIF3A, TSHR, SLC44A2 and ILF3, involved in biological processes, i.e. oxidative stress, hypoxia, immune response and metabolic activity)	Rachman et al., 2024

Table 1 – contd.

1	2	3	4	5	6
Horse (*Equus*)	*Equus ferus caballus*	Jinjiang	China	High temperature and high humidity tolerance (presence of candidate genes NFKBIA on chromosome 1, SOCS4 on chromosome 24, HSPA1A on chromosome 20 and IL6 on chromosome 4, involved in defense mechanisms in response to heat shock)	Wang et al. 2022
	Equus ferus caballus	Langkazi	Tibet	Adaptation to life at high altitudes (Increased levels of LDL (low density lipoprotein) receptor and α-HBDH3 (D-beta-hydroxybutyrate dehydrogenase), determining a greater capacity for anaerobic fermentation of glucose and production of ATP (adenosine triphosphate))	Liu et al., 2019
	Equus ferus caballus	Polish Konik	Poland	Adaptation to conditions of limited food availability (presence of the G allele in the coding region of the ACOX1 gene, associated with efficient fatty acid metabolism in winter)	Mycka et al., 2020

Researchers (Barłowska, 2023; Litwińczuk et al., 2012; Król et al., 2010, 2013; Brodziak et al., 2020) assessing milk from local breeds of cows kept under traditional rearing systems (with the use of grasslands) have reported that it had higher content of biologically active substances (a more favorable amino acid profile and higher levels of whey proteins and fat-soluble vitamins). Some of the results of these studies are provided in Table 2. In addition, milk from cows of local breeds exhibits more favorable milk coagulation and rennet curd texture parameters (Barłowska and Litwińczuk, 2006; Bittante et al., 2012; Chiofalo et al., 2000; De Marchi et al., 2007; Litwińczuk et al., 2012; Stocco et al., 2018; Teter et al., 2019; Weerasingha et al., 2020; Wolanciuk et al., 2016). Some of the results of these studies are provided in Table 3. In addition, Dinc et al. (2013) and Barłowska et al. (2022) demonstrated that in cows of native breeds, the desirable A2 β-casein allele occurs more frequently than in individuals of high-yielding breeds (higher frequency of the A1 variant). This is important because the consumption of milk from cows synthesizing A1 β-casein may increase the risk of autoimmune diseases in some individuals.

Table 2. Content of health-promoting substances in milk from cows of local breeds in comparison to the Polish Holstein-Friesian breed (Barłowska, 2023)

Milk constituents	Local breeds		Highly productive (international) breed
	Polish Red	White-Backed	Polish Holstein-Friesian
Fat (%)	4.35 B[1]–4.71 C[2]	3.95 A[1]–4.03 A[2]	4.16 B[2]–4.37 B[1]
CLA[1]	2.24 C	1.61 B	0.34 A
SFA[1]	60.73 A	63.15 B	66.87 C
SFAsmc[1]	12.77 A	17.21 B	16.22 B
SFAlc[1]	48.76 B	45.94 A	50.65 B
UFA[1]	38.78 B	36.59 AB	33.10 A
MUFA[1]	33.48 B	32.31 B	30.12 A
PUFA[1]	5.30 C	4.27 B	2.98 A
β-carotene (mg/L)[2]	0.256 B	0.219 B	0.190 A
Vitamin A (mg/L)[2]	0.556 B	0.539 B	0.352 A
Vitamin D_3 (mg/L)[2]	1.212 B	1.205 B	0.700 A
Vitamin E (mg/L)[2]	1.709 C	1.656 B	1.117 A
Total protein (%)[2]	3.49 B	3.46 B	3.34 A
Whey proteins (%)[2]	0.78 B	0.74 B	0.67 A
Total albumins (g/L)[2]	5.17 C	5.12 B	4.65 A
β-lactoglobulin (g/L)[2]	3.58 B	3.54 B	3.07 A
α-lactalbumin (g/L)[2]	1.17 b	1.13 b	1.08 a
Lactoferrin (mg/L)[2]	130.62 C	118.34 B	95.09 A
Lysozyme (μg/L)[1]	11.05 C	8.85 B	5.94 A

[1]Litwińczuk et al. (2012); [2]Brodziak et al. (2020); CLA – conjugated linoleic acid, SFA – saturated fatty acids, SFAsmc – short- and medium-chain saturated fatty acids, SFAlc – long-chain saturated fatty acids, UFA – unsaturated fatty acids, MUFA – monounsaturated fatty acids, PUFA – polyunsaturated fatty acids; A, B, C – values differ significantly at P≤0.01, a, b – at P≤0.05.

Table 3. Milk coagulation parameters of cows of different breeds (Barłowska, 2023)

Cow breed	Milk coagulation parameters		
	RCT (min)	k_{20} (min)	a_{30} (mm)
International breeds			
Holstein-Friesian[1]	18.0	8.2	17.5
Holstein[2]	15.4	7.9	28.5
Polish Holstein-Friesian Black-and-White[3]	20.16	5.55	21.94
Brown Swiss[1]	16.1	6.4	24.1
Simmental[1]	16.2	7.1	21.9
Simmental[3]	19.25	6.51	23.06
Local breeds			
Rendena[1]	13.5	5.9	27.0
Alpine Grey[1]	16.0	7.6	21.2
Modicana[2]	10.5	3.7	42.8
Polish Red[3]	16.31	4.51	28.04
White-Backed[3]	19.29	5.19	25.44

[1]De Marchi et al. (2007); [2]Chiofalo et al. (2000); [3]Teter et al. (2019); RCT – rennet coagulation time; k_{20} – curd formation time; a_{30} – curd firmness.

Sheep and goats are generally kept in extensive pastoral systems in areas where cattle grazing is not possible (Sejian et al., 2019; Wodajo et al., 2020). Therefore, they spend most of the lactation period on grassland, with green forage as their basic bulky feed. Sheep's milk has a higher content of solids, including protein and fat, than cow's milk, which makes it a good energy and protein source as well as a good material for cheese production (Barłowska et al., 2011). It also contains more polyunsaturated fatty acids (PUFAs), including CLA. Table 4 provides data from various literature sources on the content of basic components of milk from local sheep breeds and its fatty acid profiles. It should be noted that grazing on natural mountain and upland pastures (where sheep and goats are usually grazed), which have greater floristic richness and in particular a greater number of meadow plant and herb species, increases the proportion of beneficial fatty acids in milk, including CLA (Barłowska et al., 2018; 2019; Collomb et al., 2002).

Meat from cattle, pigs and poultry of native breeds (especially if the animals are raised in an extensive or free-range system) has been shown to have a more favorable fatty acid profile and satisfactory physicochemical properties (Monteiro et al., 2013; Litwińczuk et al., 2016; Domaradzki et al., 2017; Luković et al., 2023; Szulc et al., 2024; Fortina et al., 2005; Franci et al., 2005; Razmaitė et al., 2024; Szyndler-Nędza et al., 2021; Ciurescu et al., 2022; Calik et al., 2015; Węglarz et al., 2020; Motsepe et al., 2016) (Tables 5–7). However, this is not always the case, as Nuraini et al. (2018) noted low quality of meat from local breeds of cattle and buffalo kept in Indonesia. According to the authors, however, this is explained by poor feed quality, older slaughter age, and improper handling before and during slaughter. Kopuzlu et al. (2018) confirmed that the slaughter age of cattle significantly affects meat parameters such as tenderness, acceptability, juiciness, number of chews, and Warner-Bratzler shear (WBS) force. Tenderness, juiciness, flavor intensity and acceptability were shown to increase up to 19 months of age, while lower values were noted in older animals for tenderness, flavor intensity and acceptability. Li et al. (2020) assessed the quality of meat of Da-Heng meat chickens reared to a slaughter age of 60, 90, 120, 150 and 180 days and demonstrated that the breast muscles of older chickens had a higher pH, lower water loss, greater shear force, and a darker and redder color. Kawęcka and Pasternak (2022), in an assessment of the quality and composition of the meat of goat kids of the native Polish Carpathian breed, slaughtered at 9 and 12 months of age, reported higher slaughter yield in older kids than in younger ones. They found no differences between the age groups in basic parameters such as moisture content, protein, ash, and vitamins A and E. Meat from older kids was darker and had a slightly higher pH. The meat of younger goats had higher MUFA and CLA c9-t11 contents, whereas the meat of older goats was richer in PUFAs. Belhaj et al. (2021) assessed the meat of sheep of two breeds from eastern Morocco (Beni-Guil and Ouled-Djellal), slaughtered in three age groups (from 6 to 12 months, from 1 to 2 years, and from 3 to 4 years), and also demonstrated that, as slaughter age increased, the meat had a higher pH and a darker, redder color.

Table 4. Chemical composition and fatty acid profile of milk from sheep of different breeds

Milk components	Sheep breed								
	Polish Merino[1]	Polish Mountain Sheep[1]	Polish Mountain Sheep[2]	Colored Mountain Sheep[2]	Podhale Zackel[2]	Apulian Merino[3]	Altamurana[3]	Comisana[3]	Sarda[3]
Fat (%)	7.82	7.04	8.58	8.58	8.30	8.13	8.10	7.13	6.91
Protein (%)	7.72	4.32	6.70	6.60	6.59	7.07	6.78	6.32	6.16
Casein (%)	–	–	5.07	4.91	4.99	–	–	–	–
Lactose (%)	5.13	5.01	4.21	4.14	4.12	–	–	–	–
Total solids (%)	18.24	16.98	19.87	19.71	19.48	19.85	20.32	18.38	18.42
SFA (g/100 g FA)	58.95	60.34	–	–	–	70.51	69.54	70.72	71.36
MUFA (g/100 g FA)	33.46	28.52	–	–	–	24.22	25.69	24.53	24.75
PUFA (g/100 g FA)	3.88	5.97	–	–	–	5.27	4.78	5.44	5.56
PUFA n-3 (g/100 g FA)	0.69	34.49	–	–	–	1.09	0.88	1.14	1.17
PUFA n-6 (g/100 g FA)	2.63	2.52	–	–	–	2.05	1.83	2.04	2.06
CLA (g/100 g FA)	0.56	0.90	–	–	–	0.81	0.74	0.85	0.86

[1]Radzik-Rant et al. (2011); [2]Kawęcka et al. (2020); [3]Di Trana et al. (2015); SFA – all identified saturated fatty acids; MUFA – all identified monounsaturated fatty acids; PUFA – all identified polyunsaturated fatty acids; CLA – conjugated linoleic acid.

Table 5. Physicochemical properties of the *longissimus lumborum* muscle of young bulls after 7-day aging[1] and after 14-day aging[2] (Barłowska, 2023)

Breed	pH	Conductivity (mS/cm)	Drip loss (%)	Cooking loss (%)	Free water G-H (mg)	WB shear force (N)	Shear energy (J)	CIE color		
								L* – metric lightness	a* – red	b* – yellow
Mertolenga[1]	5.40	–	–	30.5	35.6	–	–	34.80	19.00	6.71
Polish Holstein-Friesian[2]	5.66	14.43	4.52	28.28	30.01	65.3	0.33	37.17	25.02	5.3
Simmental[2]	5.55	12.95	6.89	27.81	48.47	65.7	0.29	39.54	27.46	4.73
Polish Red [2]	5.74	11.14	6.47	29.20	60.36	61.7	0.27	38.75	25.96	2.60
White-Backed[2]	5.58	12.59	4.14	27.79	36.54	56.3	0.28	37.02	24.86	5.29
Polish Black-and-White[2]	5.61	12.40	4.61	28.27	37.71	59.0	0.30	37.55	25.00	5.49

[1] Monteiro et al. (2013); [2] Domaradzki et al. (2017).

Table 6. Physicochemical properties and fatty acid profile of meat from pigs of different breeds

Variables	Large White[1] *longissimus lumborum* muscle	Local pig breed					
		Cinta Cenese [1] *longissimus lumborum* muscle	Casertana[2] *longissimus thoracis* muscle	Mora Romagnola[2] *longissimus thoracis* muscle	Lithuanian White[3] *longissimus dorsi* muscle	Lithuanian Indigenous Wattle[3] *longissimus dorsi* muscle	Złotnicka Spotted[4,5] *longissimus dorsi* muscle
Water (%)	74.3	73.2	71.3	70.1	73.23	74.09	71.3[4]/71.7[5]
Protein (%)	23.9	22.8	23.4	23.3	23.10	21.24	25.10[4]/23.2[5]
Fat (%)	0.9	3.2	4.7	6.1	2.55	2.90	2.25[4]/3.6[5]
pH_{45}	6.31	6.22	6.38	6.57			6.39[4]
pH_{24}	5.64	5.78	5.96	6.15	5.34	5.45	5.50[4]
Color							
*L**	51.35	49.66	43.26	42.32	51.87	53.10	42.31[4]/49.62[5]
*a**	9.17	11.40	9.39	8.76	16.13	15.13	10.09[4]/12.14[5]
*b**	4.48	4.62	2.59	2.24	7.05	6.01	4.19[4]/12.22[5]
chroma	10.25	12.35	9.76	9.03	17.64	16.31	
hue	0.44	0.38	0.27	0.25			
Fatty acids							
total SFA	37.65	36.16	39.97	41.31	36.84	36.94	41,72[5]
total MUFA			48.23	47.63	53.26	52.95	53.98[5]
total PUFA	11.11	10.4	11.78	11.04	8.24	8.56	4.25[5]

[1]Franci et al. (2005); [2]Fortina et al. (2005); [3]Razmaitė et al. (2024); [4]Janiszewski et al. (2015); [5]Szyndler-Nędza et al. (2021); SFA – all identified saturated fatty acids; MUFA – all identified monounsaturated fatty acids; PUFA – all identified polyunsaturated fatty acids.

Table 7. Physicochemical and sensory properties and fatty acid profile of meat from chickens of different breeds

Variables	Ross 308 (broiler)[1] Green-legged Partridge[2]		Local chicken breed			
			Polish Crested[3]	Potchefstroom Koekoek[4]	Ovambo[4]	
	breast	thigh	breast	breast	breast	breast
1	2	3	4	5	6	7
Moisture (%)	76.60	76.09	73.06	72.98	–	–
Protein (%)	21.68	18.13	24.87	24.39	–	–
Fat (%)	1.72	5.78	1.48	1.72	1.26	1.02
Collagen (%)	0.69	1.02	-	–	–	–
pH_{24}	5.97	6.22	5.75	5.79	5.64	5.48
Color						
*L**	55.44	55.65	53.84	55.93	51.21	48.23
*a**	10.87	11.40	10.80	10.45	5.72	9.56
*b**	12.27	9.28	6.59	10.18	14.11	19.15
Textural properties						
shear force (N)	–	–	14.61	30.43	–	–
toughness (N)	–	–	7.69	–	–	–
springiness (mm)	–	–	7.32	0.68	–	–
cohesiveness	–	–	0.53	0.52	–	–
gumminess (g)	–	–	4.13	–	–	–
chewiness (N)	–	–	30.41	4.73	–	–
hardness (N)	–	–	–	13.44	–	–

Table 7 – contd.

1	2	3	4	5	6	7
Sensory analysis						
aroma (pts.)	–	–	4.30	3.48	2.90	2.83
juiciness (pts.)	–	–	3.95	3.73	3.03	2.98
tenderness (pts.)	–	–	4.05	3.50	2.98	2.75
flavor (pts.)	–	–	4.00	-	3.08	2.95
Fatty acids						
total SFA	30.14	34.67	–	–	35.47	36.90
total MUFA	40.32	45.74	–	–	32.68	29.19
total PUFA	28.81	18.23	–	–	31.85	33.91

[1]Ciurescu et al. (2022); [2]Calik et al. (2015); [3]Węglarz et al. (2020); [4]Motsepe et al. (2016); SFA – all identified saturated fatty acids; MUFA – all identified monounsaturated fatty acids; PUFA – all identified polyunsaturated fatty acids.

In the case of eggs, research by most authors (Moula et al., 2010; Lordelo et al., 2020; Rizzi et al., 2023) does not indicate significant differences between eggs from hens of local breeds and hens of commercial lines. On the other hand, Sokołowicz et al. (2019) found that eggs from native breeds contained more vitamin A, and that their fat had a lower n-6/n-3 PUFA ratio.

Significance of local animal breeds in food production

Recent decades have seen a steady increase in demand for animal products. It is predicted that by 2050, a 50–70% increase in food production will be needed to feed approximately 9 billion people. This will mainly apply to Latin America, South Asia and China (Mottet et al., 2018). Food production from livestock is primarily concentrated in a small group of species. Although more than 30 species of mammals and birds have been domesticated, just three (cattle, chickens and pigs) account for approximately 88% of annual global meat production, two (cattle and buffalo) for about 96% of milk production, and just one (chickens) for about 92% of egg production. Within these species, single breeds account for a large part of animal food production; for example, Holstein cattle are kept in 132 countries and Leghorn chickens in 52 countries (FAO, 2017). International, transboundary breeds are selected for the production of a single product (e.g. milk, meat or eggs) and are mostly raised in high-input industrial systems (Leroy et al., 2018). The intensive landless production systems under which international breeds are generally kept are believed to account for more than half of global pork production and 70% of global poultry meat production. These systems are estimated to be evenly divided between countries with higher, lower, and medium incomes (Steinfeld et al., 2006). However, sustainable animal production and future food security require access to a wide range of animal genetic resources (Hoffmann, 2010; Pilling and Hoffman, 2011; Kantanen et al., 2015). According to Tscharntke et al. (2012), global food security in developing countries should be based on realizing the potential of small farms rather than relying on further agricultural intensification. Given the still inefficient use of food, whereby approximately 30% is wasted and another 30% is used for livestock feed, causing additional adverse environmental impacts, it is necessary to seek a compromise between the intensification of production and the preservation of biodiversity. Thus not only the lack of food in the world but its improper distribution is an important problem to be solved, given that food is actually produced in excess in some countries (Tscharntke et al., 2012). In addition, Perfecto and Vandermeera (2010) stress that the problem of food shortages and food sovereignty mainly affects populations living in rural areas with low potential for agricultural production. Therefore, world hunger does not result from too little food production, but from poverty (Sachs et al., 2009). Furthermore, according to the State of Food Security and Nutrition in the World Report (FAO et al., 2021), it is essential to involve indigenous peoples in global discussions on food security due to their valuable knowledge.

In developing countries, the animal production sector is represented by almost one billion small livestock producers, who often make use of their own grassland. These are predominantly family-run, low-input farms that employ mixed or grass systems. They provide a livelihood for poor rural populations and at the same time ensure the food security of their country (Steinfeld et al., 2006; Alders et al., 2021). The breeds kept there are locally adapted breeds that provide many food products. These breeds are also used for food production in "landless" industrial systems. It was estimated that the proportion of these breeds or their crosses (mainly kept in industrial systems) accounted for over 80% of production of pork, poultry meat and eggs in 2005 (Leroy et al., 2018). However, native breeds are important in countries facing a serious problem with ensuring the nutritional security of their inhabitants. According to Wollny et al. (2003), livestock (poultry, small ruminants and cattle) living under various ecological and economic conditions play an important role in sustaining the livelihoods of most people in developing countries and have the potential to increase productivity in an environmentally friendly way. Paiva et al. (2016) confirm that the primary means of satisfying food security needs in developing countries will be to improve animal productivity. The authors report that in the least developed countries, scattered across different regions, animal productivity has thus far stagnated or declined, especially in the case of ruminant species. They also suggest that more emphasis must be placed on vari-

ous mechanisms that increase animal productivity, and that choices concerning breeds and their improvement are needed.

Food security will also be affected by climate change (Jones and Thornton, 2009; Godfray and Garnett, 2014). For example, Seo and Mendelsohn (2008) found that in climate change scenarios a shift from cattle breeding to small ruminant production is likely in parts of sub-Saharan Africa. Mapiye et al. (2020) point to the vital importance of livestock in ensuring food security in the Southern African Development Community. This region is inhabited by 345 million people, of whom 30.6% have severe food problems, 8% are malnourished, and 50% live on less than 1 USD a day. The majority of the region's population (about 70%) are involved in agriculture. A large number of livestock are kept there, especially ruminants, accounting for up to 20–25% of all ruminants worldwide. The cattle population in the region numbers about 64 million head, 75% of which are kept in small-scale husbandry systems and mainly comprise native tropical breeds. These cattle contribute directly to food security by providing food (meat, blood, and milk) and indirectly through the sale of live animals, products, and/or by-products to generate monetary income for the purchase of staple foods and agricultural inputs. They are also a source of manure, transport and traction. However, most native cattle breeds are rapidly becoming genetically diluted or are at risk of extinction, often due to random crossbreeding with imported exotic high-yielding breeds. Projections indicate that by 2050, 61% of milk will be produced in developing countries, including tropical ones (Alexandratos and Bruinsma, 2012). In order to satisfy the demand for milk in those parts of the world, the introduction of high-yielding dairy cattle breeds will be required to improve milk production in intensive systems. However, maintaining these cattle breeds under tropical conditions requires costly investment, to obtain good quality feeds, manage herds, and mitigate heat stress (Berman, 2011). For this reason, Michael et al. (2022) suggest that a better solution is 50:50 crossbreeding of indigenous cattle breeds, whose lactation performance ranges from 1200 to 2000 kg in various tropical regions, with various *Bos taurus* lines (Friesian, Holstein-Friesian, or Jersey). This increases milk yield and the lactation period by a factor of 2.4 and 1.2, respectively, while at the same time the crossbreds retain the ability to adapt to the tropical environment. Jian et al. (2014) point out that some of the desirable and adaptive traits observed in cattle of the Sanga and Zebu (Sahiwal) breeds, such as resistance to ticks and tick-borne diseases, are retained in crossbreds of the temperate and tropical zones. Changes in hair coat characteristics are also important adaptive traits that help to mitigate heat stress.

Small ruminants (goats and sheep) represent an important niche in ensuring food security in developing countries, because farmers regard them as an alternative means of increasing their income (Wodajo et al., 2020). Furthermore, there are no religious restrictions on the meat or milk of these animals or products obtained from them (Devendra, 2005). Small ruminants prove to be well-suited to pastoral production systems owing to their unique biological characteristics, e.g. a short gestation period, high fertility, fast growth rate, high feed conversion rate, high disease resistance, and high marketability (Sejian et al., 2019). A comparative economic analysis of small farms raising cattle and small ruminants showed that, in terms of resource efficiency, the production of cattle and small ruminants is almost equally efficient (Wodajo et al., 2020). According to a 2023 FAO report entitled "Status and trends of animal genetic resources – 2022", there are 100 local goat breeds and 102 local sheep breeds registered in Africa, and 203 and 269, respectively, in Asia. Goats are deeply embedded in almost every African culture and are of vital economic significance, especially for poor farmers. They are kept in small herds (of approximately 10 head) on mixed farms throughout Sub-Saharan Africa, from the humid coastal zones in West Africa to the highlands of Ethiopia. They can graze freely during the day on communal pastures or seasonally on fallow land, and are used for dairy and meat production (Ngambi et al., 2013). According to Adane and Girma (2008), 1,078,000 sheep and 1,128,000 goats are used annually in Ethiopia for domestic consumption. A significant proportion of the world's goat (60%) and sheep (23%) populations is found in Asia, with 77% of all goat breeds and 39% of sheep breeds found in China, India and Pakistan (Devendra, 2005; Devendra and Liang, 2012). According to Liang and Paengkoum (2019), goats are kept under harsh environmental conditions, are an important source of food, and have a significant impact on the socioeconomic status of many families. The authors report that goat's milk is sold at a price two to three times that of cow's milk in many countries of East and Southeast Asia, such as China, Japan, Malaysia, Indonesia, Thailand and Vietnam. Goats also perform well in the context of ongoing climate change, which in a few countries with long coastlines, such as Vietnam, Indonesia and the Philippines, has caused the sea level to rise and at the same time has prolonged the dry seasons, thus increasing salinization of the groundwater and soil. This leads to changes in vegetation (a reduced proportion of grasses), which are acceptable to goats but less so by cattle and sheep. Djemali (2024) note that sheep and goats in developing countries are a reservoir of valuable genetic resources which are exceptionally adapted to harsh environmental conditions and low-input production systems. However, in order to ensure food security in these countries, breeding programs should be developed to disseminate better genes within the breed, which will promote the improvement of desirable traits. Sustainable use of these breeds also requires strategic selection for crossbreeding with commercial breeds.

In poor countries, local pig and poultry breeds also play a significant role in ensuring food security. In the

least developed countries, where agriculture plays an important role in national employment, pigs and poultry not only provide daily food but also ensure income for households. This applies in particular to vulnerable social groups (Wong et al., 2017; Xayalath et al., 2020; Aryee et al., 2019).

Small-scale poultry production has been an integral source of livelihood for humans for thousands of years, improving the diet and income of the rural poor, as well as their food and nutrition security (Alders and Pym, 2009; Wong et al., 2017). Birhanu et al. (2023) reported that in lower-income countries, 55% of households kept poultry (mainly chickens), followed by cattle (50%) and goats (42%). The authors also concluded that a greater proportion of households in South America, the Caribbean, East Asia and the Pacific kept poultry than in Sub-Saharan Africa (SSA), i.e. 75% of rural households in East Asia and the Pacific, 78% in South America and the Caribbean, and 57% in Sub-Saharan Africa. According to Afolabi (2013), native chickens are better adapted to local conditions, can develop with minimum feed supply, and are more resistant to local pests, parasites and diseases than exotic breeds or crossbreds. Such chickens reach 460–1840 g mature body weight within 30 weeks. Padhi (2016) suggest that the small body size of native hen chickens is a desirable trait in tropical and subtropical environments. Mapiye et al. (2008) report that the reproductive performance of native hens in Zimbabwe is generally low, as they lay 30–80 eggs per year under smallholder conditions, as compared to commercial lines that produce up to 300 eggs. The number of eggs hatched by the hens ranges from 8 to 14, with an average of 2–3 hatches per year. The average weight of the eggs is 52 g (ranging from 35 to 60 g). Thieme et al. (2014) classify family poultry production into four categories: small extensive scavenging (1–5 adult birds), extensive scavenging (5–50 birds), semi-intensive (50–200 birds) and small-scale intensive (> 200 broiler chickens or > 100 laying hens). Afolabi (2013) claim that meat and eggs from local chickens are very tasty, low in cholesterol, and nutritious, providing energy, essential amino acids, vitamins, and other animal-derived micronutrients to poor rural and urban inhabitants. In addition, they are cheaper than production under intensive conditions. Guan et al. (2013) assessed the meat quality traits of four genotypes of native Chinese chickens, i.e. Ninghai chicken (NC), frizzle chicken (FC), Ninghai xiang chicken (XC) and Zhenning loquat chicken (LC), reared for 110 days, and one commercial broiler genotype, the Arbor Acres plus broiler (AAB), reared for 42 days. The authors showed that NC, FC, XC and LC had significantly higher content of inosine-5′-monophosphate (IMP), a smaller muscle fiber diameter, and lower pectoral muscle shear force than AAB. According to Sokołowicz et al. (2016), native chicken breeds are a source of good quality meat, especially when reared under extensive conditions with access to the outdoors. In addition, the use of native chicken breeds in extensive (free-range and organic) production systems increases the diversity and appeal of poultry products on the food market. Furthermore, the meat of native chicken breeds reared in free-range systems contains less fat but has a higher proportion of polyunsaturated fatty acids. Afolabi (2013) and Wong et al. (2017) claim that local poultry breeds kept on a small scale in home conditions contribute to food security not only directly, but indirectly. This is because income from the sale of local chickens and eggs is often used to pay for other essential goods, services and obligations (seeds, salt, broadcloth, fuel, medicines, school fees and textbooks, transportation fares, taxes, etc.). Moreover, they contribute to the empowerment of women and enable access to healthcare and education. Wong et al. (2017) point out their role in the achievement of several objectives of sustainable development and future food security through the preservation of genomic biodiversity. Mujyambere et al. (2022) claim that products derived from local breeds (meat and eggs) are of good quality and are preferred by local consumers in East Africa. Guèye (1998) reports that in Dakar and Senegal, native chicken meat was 13% more expensive in markets and 27% more expensive in supermarkets compared to commercial chicken meat. The author noted that consumers from higher-income groups would pay more to buy native meat. Sayila (1998) reports that in Zambia, native chickens cost twice as much as hybrid chickens. Regarding eggs, in north-western Nicaragua, prices were approximately 30% higher for eggs from traditional family poultry production than for eggs from semi-industrial systems (Kyvsgaard et al., 2000).

Next to poultry meat, pork is equally important in ensuring the food security of Africans. Despite the religious restrictions that have historically limited pig farming in some parts of Africa, it is still significant (Adesehinwa et al., 2024). Africa is known for having a wide range of local pigs genetically adapted to survive under harsh conditions, such as high temperatures, diseases, and limited access to food (Hlongwane et al., 2020; Mujibi et al., 2018). Only in North Africa is pig production not popular, for religious and cultural reasons (Adesehinwa et al., 2024). These genetic resources offer the opportunity to select climate-tolerant animals within tolerant breeds or to identify resistance genes for incorporation into commercial lines or other strains (Pius et al., 2024). As noted by Mbuthia et al. (2015), pig production has a high potential for increased productivity due to the animals' fast growth rate, shorter generation interval, good feed conversion efficiency, and large litters compared to cattle. Moreover, local pig production is becoming an attractive option for many small-scale livestock farmers because of the ease of management and fertility of the species. Aryee et al. (2019), in a study on the structure of pig breeds kept in Ghana, found that less than 20% of farms kept local breeds (e.g. Ashanti dwarf pigs), and

less than 20% kept exotic breeds (mainly Large White, Landrace and Duroc), with crosses between local and exotic pigs accounting for the remaining share of over 60%. Some farms still keep pigs solely to provide food for the household, but most pig production is carried out as a source of income. Most farmers resort to large-scale crossbreeding of local breeds with exotic breeds in order to improve the productivity of local pig breeds. However, the authors note that this leads to inbreeding and thus to poor production, reproduction, and health, as well as impairment of the adaptive traits needed for sustainable local pig production. The authors also report that most pig farmers (66%) feed their pigs with kitchen scraps (cooked cassava, fish, yams, and soup), while a small percentage (11%) feed them concentrates, and some (23%) feed them agricultural by-product feeds. Xayalath et al. (2020) report that in Laos, food security and malnutrition in rural or mountainous areas are considered a major problem, which both the national government and several international organizations are struggling to overcome. The authors point out that over 50% of households in rural areas of the country consume chicken or pork at least once a week. Native pigs play an important role in the meat supply there (more than 90% of meat products come from native breeds of pigs reared using traditional methods). They also account for approximately 9–14% of annual household incomes in rural areas. In the European Union, pork ranks first among the most important meat types, producing 22.1 million metric tons per year (Kasprzyk and Walenia, 2023). This meat is primarily derived from selected pigs with optimal feed conversion rates, efficient weight gain, and high meat content. Unfortunately, these animals' rapid weight gain and high percentage of lean meat are not always accompanied by good meat quality and flavor. In many European countries, a large group of consumers are guided by health, ethical and animal welfare considerations when purchasing meat and meat products (Kasprzyk and Walenia, 2023; Milković et al., 2023; Szulc et al., 2012). This is leading to a "renaissance" among many native breeds in terms of their significance for the production of high-quality foods, which are often protected by the European quality protection system for agricultural products and foodstuffs (Barłowska, 2023). These include Iberian pig breeds (Entrepelado, Lampino and Porc Negre Mallorque (Majorcan Black), Retinto, Manchado de Jabugo, Torbiscal, Chato Murciano, Euskal Txerria, Gochu Asturcelta and Porco Celta), Italian breeds (Apulo-Calabrese, Casertana, Cinta Senese, Mora Romagnola, Nero Siciliano, Nero di Lomellina, Nero di Lomellina and Sarda), French breeds (Blanc de l'Ouest, Cul Noir Limousin, Porc de Bayeux, Gasconne and Nustrale), and others (Kasprzyk and Walenia, 2023).

A discussion of the importance of local breeds of different livestock species in ensuring food security should also include horses. Even before they were domesticated, horses were used by humans as a source of food (Belaunzaran et al., 2015). Horse breeding is currently carried out mainly for recreational and medical purposes (Stanciu, 2015); the Food and Drug Administration (FDA) considers horses to be companion animals rather than food-producing animals (FAO, 2024). However, in many parts of the world, they are still a source of food. Horse meat is part of the traditional diet in Central Asia and is considered a delicacy in some regions of Europe and Africa (Kurmangaliyev et al., 2013). Milk is also obtained from horses. They are traditionally milked in Central Asia and Eastern Europe, where their milk is used to produce kumis and other fermented products claimed to have health-promoting properties (Salimei and Fantuz, 2012; Barłowska et al., 2023 a, b). In most cases, both meat and milk are sourced from horses of local cold-blooded breeds (Cittadini et al., 2021; Insausti et al., 2021; Miraglia et al., 2020; Barłowska et al., 2023 a, b; Kabylbekova et al., 2024; Pieszka et al., 2011; Pietrzak-Fiećko et al., 2013). One of the oldest autochthonous breeds, the Mongolian horse, is maintained in parts of Mongolia. From time immemorial, Mongolian people have been using these horses as a source of food and benefitting from their great ability to move around. Although Mongolian people can farm other species (sheep and cattle), horses are preferred due to their ability to exploit low-quality pastures, which is well suited to Mongolians' nomadic lifestyle (Langlois, 2011).

It should be noted that local animal breeds are also finding a niche in food production in Europe. For about a quarter of a century, the European Union has been placing strong emphasis on sustainable development of rural areas, environmental protection, and the preservation of biodiversity and animal welfare. Animals of local breeds are commonly kept on grassland, where pastoral and small-scale mixed crop and livestock farming systems are used (Hoffmann 2010; Moreno-Indiasa et al., 2011). These animals provide a wide range of products and services to the local community, with low-to-medium use of external inputs (Hoffmann, 2010). Cattle are generally dual-purpose animals. An analysis conducted by Hiemstra et al. (2010) on 108 local cattle breeds found in Europe concluded that only 17 are used exclusively for dairy purposes, and over 50% are used for both dairy and meat. Gandini et al. (2012) analyzed 335 farms keeping local cattle breeds in different European countries, taking into account economic, technical and social aspects. They demonstrated wide variation between farms in terms of farm area, herd size, and income from cattle farming, including from local cattle breeds (Table 8). The authors noted major differences between countries in this respect, due in part (according to the farmers) to the value attributed to local animal breeds by society. The likelihood of the breed's survival and greater profitability of these farms was largely due (according to the farmers) to cooperation between farmers and the public's appreciation of the cultural, environmental and social role of local cattle breeds.

Table 8. Characteristics of farms (335) keeping local cattle breeds (Gandini et al., 2012)

	Farmer's age (years)	Farm area (ha)	Farmer's own land (%)	Herd size (number of cows)	Local breeds (%)	Income from cattle farming (%)	Income from local breeds (%)	Local market (%)
Range	25–83	1.3–2740	0–100	1–500	6–100	0–100	0–100	0–100
Average	48.84	145.09	47.70	56.90	68.97	80.79	59.32	42.67

In the case of pigs, a good example of the use of local breeds for the production of high-quality pork and pork products is the Iberian pig (an autochthonous breed of fat pigs, traditionally produced in the *dehesa* area of the south-western Iberian Peninsula). It accounts for 6% of total pork production in Spain (Garbayo, 2016). Iberian pork products are gaining acceptance, not only in domestic markets but also internationally (in Europe, Japan, Russia and the USA) (Lorido et al., 2016). Horrillo et al. (2023) report that of the 3,754,704 pigs of the Iberian breed that were commercialized in Spain during the 2019–2020 campaign, 60% were reared in intensive systems ("cebo indoor"), 20% were reared in free-range extensive systems ("cebo de campo"), and the remaining 20% were acorn-fed ("bellota") animals, or animals finished in free-range and acorn-fed in the *dehesa* areas.

It should be noted that products sourced from local animal breeds (meat, meat products, cheese, and other dairy products) are often sold under designation of origin or other quality labels (Barłowska, 2023; Moreno-Indiasa et al., 2011). The labeling of these foods with certificates of origin helps consumers to make the decision to purchase high-quality, safe foods (Knežević et al., 2019). According to Di Gregorio et al. (2022), manufacturing products from local animal breeds is of vital importance for the survival of agriculture and animal husbandry in a given area. This, in turn, helps to increase consumer demand for local products, which are more sustainable (less transportation and pollution) and manufactured according to long-standing tradition.

Summary

The rapid increase in the world's human population, especially in underdeveloped regions, mainly in Africa and Southeast Asia, necessitates numerous measures to ensure global food security. It is estimated that the human population will grow to approximately 9 billion by 2050, requiring a 50–70% increase in food production. Landless, intensive production systems, in which international breeds are generally kept, are currently estimated to account for more than half of global pork production and 70% of global poultry meat production, in both developed and developing countries. These breeds have been selected for many years for high performance in the production of a particular product (meat, milk, or eggs). These breeds, as well as industrial food production systems, will continue to be a major factor in ensuring the world's food security. Unfortunately, they put major pressure on the environment. In developing countries, however, extensive, low-input production systems in which local breeds of animals are kept also play an important role in food production. In these countries, the livestock sector represents almost 1 billion small producers, for whom the maintenance of local breeds contributes directly to the provision of food, mainly protein (meat, blood, and milk), as well as indirectly, through the sale of live animals, products and/or by-products, generating income to support poor families. Local breeds are less productive, but having lived for decades in a given region, they have acquired numerous adaptive traits, i.e. better utilization of poorer quality fodder, adaptation to unfavorable climatic conditions (high/low temperatures or drought), and resistance to parasites or diseases. Moreover, they are a reservoir of many genes that have been lost due to many years of selection for high productivity. As a result, they protect biodiversity and exhibit resilience to sudden climate change. Therefore, local breeds are often used for crossbreeding with imported high-yielding exotic breeds in order to increase productivity while retaining the adaptive traits of the local breed. In areas with abundant grassy areas, ruminants (cattle, sheep, and goats) perform well, providing food for the inhabitants in the form of milk, meat and blood. Local pigs and poultry are a source of daily food in the least developed countries, as well as a source of income for farms. Pig production has high potential for increased productivity due to the animals' fast growth rate, shorter generation interval, good feed conversion efficiency, and large litters, as compared to cattle. Local breeds have also found a niche in food production in developed countries. This is because emphasis is currently placed on sustainable development of rural areas, environmental protection, and the preservation of biodiversity and animal welfare, particularly in the European Union. In keeping with these strategic EU objectives, animals of native breeds are generally raised under extensive or semi-intensive rearing systems, where they enjoy the benefits of free-range conditions and grassland. This, in addition to genetic determinants, largely contributes to the acquisition of higher-quality products (improved palatability, higher content of biologically active substances, and more favorable parameters for processing). These products (meat, meat products, cheese, and other dairy products) are increasingly reaching consumers bearing quality labels, including certificates of origin. This reassures them that they are consuming food that is tasty, safe, of high quality, and produced traditionally. In summary, local animal breeds make an important contribution to ensuring food security worldwide.

Conflicts of interest

The authors declare no conflict of interest.

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