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Basque Pig

*Marie-José Mercat, Bénédicte Lebret, Herveline Lenoir
and Nina Batorek-Lukač*

Abstract

Local pig breeds are adapted to the specific local environment and fed with various locally available feedstuffs. Besides their genetic merit for agro-biodiversity, they represent the basis for sustainable local pork chains. The present chapter aims to present history and current status of the Basque pig breed, its exterior phenotypic characteristics, geographical location, production system and main products. This French autochthonous breed of pigs, which almost disappeared few decades ago, seems now consolidated, thanks to a chain organization and recognised high-quality products (Protected Designation of Origin). Reproductive performance data reviewed from the literature and estimated from the LIGERAL database (herdbook) are presented. Available data on production traits including growth (early, middle, late and overall growth), feed intake, body composition and carcass traits are also summarized. Meat quality traits (pH, colour, intramuscular fat content and fatty acid composition) and back fat tissue characteristics (fatty acid profile) are also described. Studies on the Basque pig breed are scarce. Different production systems, feeding regimes and feed composition used among studies can explain differences observed between studies, especially for productive traits. However, the current review gives insight into the reproduction, production and carcass and meat quality traits of this local pig breed.

Keywords: traditional European breed, TREASURE, productive traits, phenotype, France

1. History and the current status of the breed (census)

The Basque pig (French, Pie Noir du Pays Basque) is a breed of pig native of the Basque Country (South-West of France). What is today called the Basque pig comes from the two historical breeds kept by Basque people. It was consolidated under the name only in the 1920s. With livestock sector modernisation, production of Basque pigs sharply declined in the 1960s. The breed was considered in the way of extinction in 1981 further to an inventory requested by the French Ministry of Agriculture. By this time, ITP (former IFIP name) and INRA counted only 50 sows and 5 boars left. Then, few pig breeders gathered by a dry-cured ham artisan producer, Pierre Oteiza, decided to revive the Basque breed and developed a local chain organisation. Their objective was to maintain peasant and butcher-processor artisan activities in Les Aldudes valley in the Basque Country. Afterwards, a specific farm for the preservation of Basque breed and genetic resources was developed, assisted by ITP. In 2001, the Basque chain association was created, and the instruction for further registration as protected designation of origin (PDO)

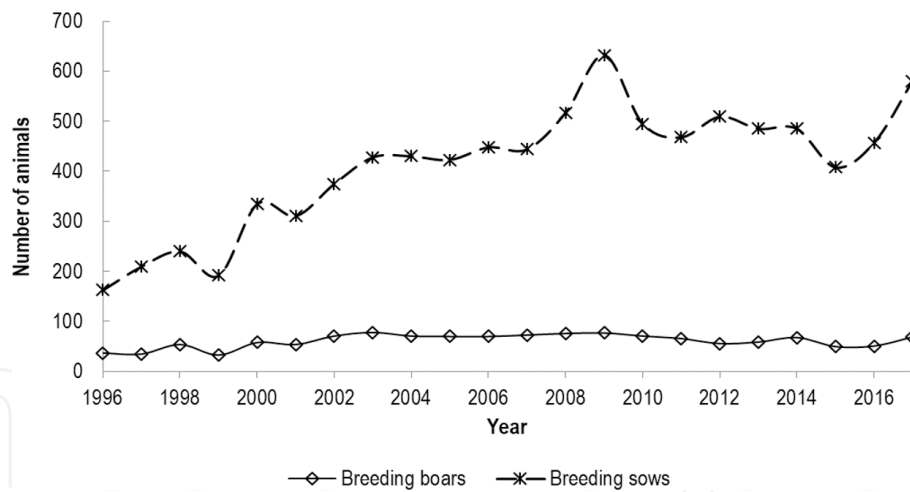


Figure 1. Census of Basque pig breed, presenting the evolution of the number of sows and boars per year, starting with the year of heard book establishment.

was initiated. The Basque pork sector has progressively developed, based on the production of traditional and high-quality pork products. In 2016 the “Kintoa” fresh pork and Kintoa dry-cured ham (Jambon du Kintoa), produced from Basque pigs, obtained the French AOC (Appellation d’Origine Contrôlée) label. In October 2017, this national recognition was further translated at European level into the “Kintoa” PDO registration.

Presently the Basque pork chain gathers 80 members including 57 breeders or fatteners, 16 of them being also processors, 1 slaughterhouse, 4 butcher-processor artisans, and 2 processing plants for dry-cured products. The census of Basque pig breed is presented in **Figure 1**. Currently, there are 28 farms of Basque breeders registered in the LIGERAL herd book, with 580 breeding sows (01/01/2017).

2. Exterior phenotypic characteristics

The Basque pig breed morphology information is summarised in **Table 1**. As suggested by its name in French, pigs are piebald, black and white (**Figures 2 and 3**): black head and rump. The breed standard describes animals with a slightly convex back, some of them with large black areas and a sloping croup. Limbs are large and strong well suited for outdoor rearing in extensive hilly zones. The chest is large, ribs are round, and hams have an elongated shape. Pigs have large horizontal ears, tilted over the eyes, representing two thirds of the head length. Bristles are rare and fine with a circular aspect above the rump.

Measurement (average)	Adult male	Adult female
Body weight (kg)	250	200
Body length (cm) ¹	140	140
Height at withers (cm)	78	75
Number of teats	≥10	≥10

¹Measured from the tip of the nose to the starting point of the tail.

Table 1. Summary of morphology information on Basque pig breed.



Figure 2.
Sow of Basque breed with piglets (photo credit B. Lebret).



Figure 3.
Boar of Basque breed (photo credit Kintoa).

3. Geographical location and production system

The Basque pig is originated from the Basque Country, a region located in the South-West of France and across Spain border. Nowadays farms producing Basque pigs are still located in this historical region of production. The geographical area and rearing conditions for Basque pigs dedicated to PDO Kintoa pork and dry-cured hams are detailed in specifications for AOC, the national label required before PDO registration [1]. Briefly, this region has a mild and humid climate under the influence of the Atlantic Ocean and warm winds from the South that are essential for the ripening process of the dry-cured hams. Located close to the Pyrénées mountains, this area exhibits a hilly landscape and includes grasslands and forests. To benefit from AOC/PDO registration, the pigs must be born, reared and slaughtered in the specified geographical area. Pigs (either castrated males or females before any lactation) are generally born and kept indoors with possible access to an outdoor area, up to a maximum of 5 months of age. They are then placed until slaughter in an extensive plot land that provides natural feeding resources (grass or herbaceous vegetation, roots, chestnuts or acorns) with a maximal animal density of 35 pigs/ha grassland

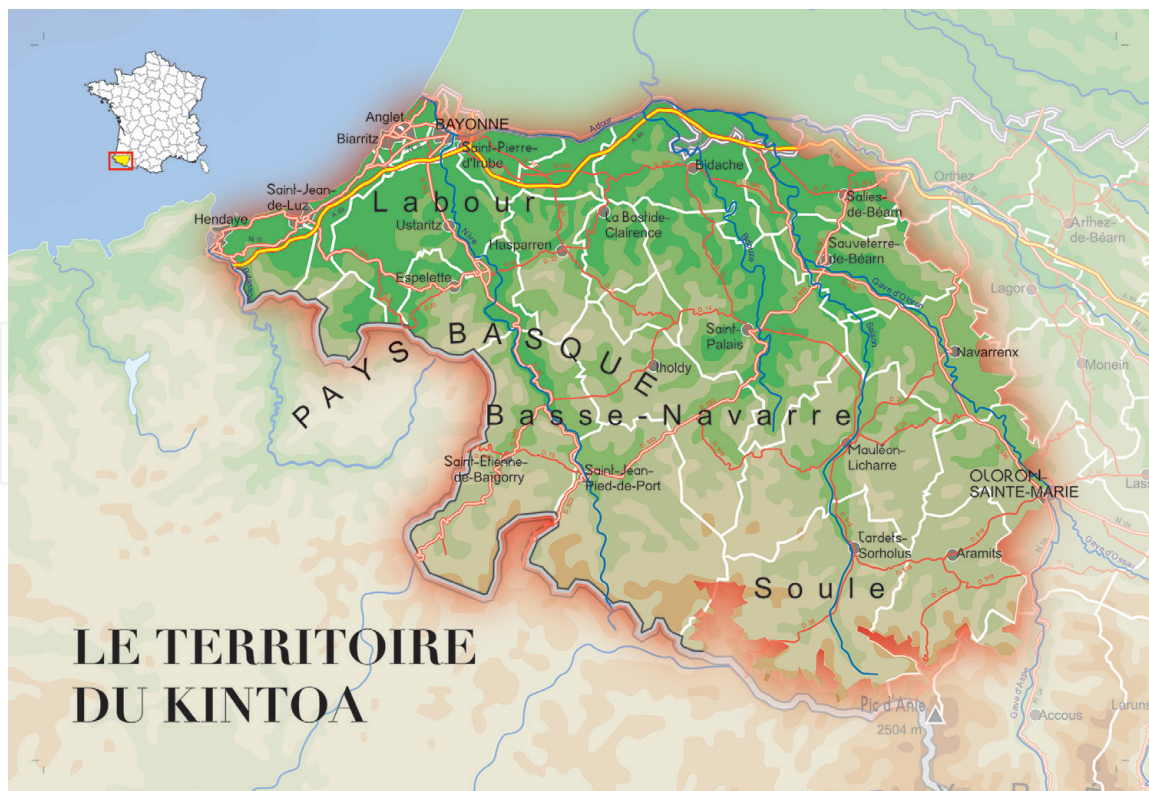


Figure 4.
 Geographical localisation of the production of Basque pigs for the Kintoa protected designation of origin in France (BDCARTO-IGN, MAPINFO, INAO, 2014).

and 25 pigs/ha forest. Plot lands must be approved by the authorities responsible for quality sign management and control. Plots include a shed, water access and a feeding area. In addition to natural feeding resources that correspond to around 50% volume of feed intake, pigs are fed with complementary (without GMO) food up to a maximum of 3.2 kg per pig and per day between 3 and 8 months of age and 2.7 kg afterwards. From weaning, the allowed foodstuffs include wheat, corn, barley, rye, triticale, sorghum, oats, peas, faba beans, lupine, vetch, flax (as seeds or derived products), soybean, sunflower and rapeseed (as seeds, meal or oil), cane or beet molasses, alfalfa, beet pulp and whey only up to 2 months before slaughter.

Pigs are slaughtered at minimum 12 and maximum 24 months of age. Specifications for carcasses are minimum 100 kg hot weight and 25 mm back fat thickness (fourth/fifth lumbar vertebra level). Whole traceability is a guarantee for pigs and carcasses. A minimum green ham weight of 10 kg and minimum ripening duration of 16 months including 10 months in natural conditions are required for Kintoa hams (**Figure 4**).

4. Organisations for breeding, monitoring and conservation

All animals, boars, sows and piglets are individually identified and recorded in the LIGERAL herd book. A committee, composed of an expert and the technician in charge of following up the breed, validates each potential breeder considering the breed standard, the teats' number (minimum 10 functioning teats) and the inbreeding coefficient. Only pure breed reproduction is performed: natural mating usually. Also, for few years, few artificial insemination boars are available but just for slaughter pig production purposes. Usually, farms self-renew their sows and buy boars. Replacement breeding policy is based on relationship coefficients estimated by IFIP and the number of live animals per family (sows) or line (boars). One farm, dedicated to sow and boar rearing, has recently been created for the production of

replacement animals and to facilitate the establishment of new farms. The number of breeders per family and line, reproductive performances and inbreeding are reviewed at least once a year. More complete analyses of the genetic variability based on probabilities of gene origin studies are occasionally performed [2]. In addition, Basque semen doses are preserved in the French National Cryobank which contains semen collected explicitly in the 1990s and the beginning of the 2000s. This heritage material is only dedicated to breed preservation (**Table 2**).

Name of organisation	Address	Web address
Filière Porc Basque Kintoa	64430 Les Aldudes, France	https://www.kintoa.fr/
LIGERAL—c/o IFIP	La Motte au Vicomte, BP 35104, 35651 Le Rheu Cedex, France	http://www.asp.asso.fr/

Table 2.

Contact details of breeding organisation for Basque pig breed.

5. Productive performance

5.1 Reproductive traits

Basic data obtained on reproductive traits in this review are presented in **Table 3**. Averages are calculated from data recorded in the LIGERAL database. For the last available 5-year period (2012–2016), the average age of sows at the first parturition is 16.6 months. On average, sows of Basque pig breed have 1.6 litters per year with 7.5 piglets born alive [9]. The death rate of piglets until weaning in the considered study (last 5 years available period) of Basque pig breed averages 18.9%. Published data are also synthesised in **Table 3**. Without selection on reproductive performances, a progressive decline in litter size (born alive and weaned piglets) had been seen until 2003. Then, a slight improvement was observed [3]. Most recent

Reference	Sow age at the first parturition (mth)	Litters per sow per year ¹	No. of piglets alive per litter	Mortality at weaning (%)	Duration of lactation (d)	Farrowing interval (d)	Sow age at culling (mth)
[3]	—	1.5	7.2	20.8	—	243	—
[4] ²	—	—	8.3	25	—	—	—
[5]	—	—	7.4	23	—	—	—
[6]	—	1.4	7.4	16.2	—	261	—
[7]	16.4	1.6	7.7	18.6	33	228	38
[8]	—	1.4	7.6	21	—	261	—
[9] ³	16.6	1.6	7.5	18.9	38.5	228	44

No. = number, mth = month, d = days.

¹Litters per sow per year calculated as the average number of litters per sow having at least one litter in the year.

²Least squares mean with a GLM model including breed (five local breeds), parity season as a fixed effect, breed*parity interaction, the age of the sow and birth year as a covariate.

³Five-year average value from the herd book data (LIGERAL database between 2012 and 2016).

Table 3.

Summary of collected literature data on reproduction traits in Basque pig breed.

TREASURE data confirm this tendency with +0.5 born alive and +0.6 weaned piglets in the last 10 years. Technical improvement of farming can explain this. Duration of lactation is prolonged in comparison to modern intensive systems to 38.5 days, which is also reflected in the prolonged farrowing interval (228 days on average). Thus, it can be concluded that Basque pig breed has moderate fertility compared to the most prevalent breeds.

5.2 Growth performance

Basic data on growth performance obtained in this review are presented in **Tables 4** and **5**. Due to big differences between studies with regard to the live weight range covered, we defined the stages for growth performance as lactation (regardless of how long it was), growing stage (from weaning to approximately 30 kg live body weight) and early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively. Sometimes the source provided only the overall growth rate for the whole fattening stage (defined as overall). It should also be noted that a big part of the collected studies tries to simulate to some extent practical conditions of the production systems used and that only a smaller part of the studies actually aimed at evaluating the breed potential for growth. In the considered studies, the weight gain in the growing stage (around 320 g/day in the three studies) is lower than observed for modern breeds denoting lesser intensity of rearing and lower growth potential. It also reflects the fact that no selection is undertaken on growth in the Basque breed, unlike modern breeds. Also the early, middle, late and overall fattening stages are characterised by much slower growth than in “modern” selected breeds and big heterogeneity (358–640, 452–560, 236–499 and 335–544 g/day in early, middle, late and overall growing stage, respectively), related to the fact that this review comprises studies where different systems and feeding levels were practised. In the context of the evaluation of growth performance, it is also of interest to observe the extreme values,

Reference	Feeding	No. of animals	ADG growing ¹	ADG fattening ²				ADG birth to slaughter ³
				Early	Middle	Late	Overall	
[10, 11]	Ad lib	28	—	560	560	—	—	—
	Semi	16	—	—	—	316	443	—
[12]	—	309	—	—	—	—	539	—
[13]	Ad lib	18	—	—	—	—	488	—
[14–16]	Ad lib	20	316	599	481	429	498	437
	Ad lib	20	321	640	508	499	544	467
	Semi	20	325	358	452	236	335	333

No. = number, ADG = average daily gain in g, Ad lib = ad libitum feeding regime; Semi = semi ad libitum feeding regime.

¹ADG in growing period estimated from weaning to approximately 30 kg live body weight.

²ADG in period of fattening is reported for early, middle and late fattening stages estimated between approximately 30 and 60 kg, 60 and 100 kg and above 100 kg live body weight, respectively, in studies 1–2 and between approximately 30 and 75 kg, 75 and 110 kg and above 110 kg live body weight, respectively, in study 4. Sometimes the source provided only the overall growth rate for the whole studied period (in that case defined as overall); in study 3 this is between 26 and 86 kg LW.

³ADG from birth to slaughter was calculated from the individual data, considering the birth weight as 1.00 kg.

Table 4.

Summary of collected literature data on growth performance in Basque pig breed.

Reference	Feeding	NE content of feed ¹ (MJ/kg)	CP content of feed ¹ (%)	No. of animals	ADFI fattening ²			
					Early	Middle	Late	Overall
[11, 15]	Semi	10.3	15.5	20	—	—	—	2.1
[12]	—	—	—	—	—	—	—	3.70
[13]	—	—	17.7	—	—	—	—	2.30
[14–16]	Ad lib	10.3	14.7	20	2.23	2.51	2.41	2.39
	Ad lib	10.3	14.7	20	2.43	2.64	2.85	2.67

No. = number, ADFI = average daily feed intake in kg/day, Ad lib = ad libitum feeding regime, Semi = semi ad libitum feeding regime, NE = net energy, CP = crude protein.
¹NE and CP content of the feed is reported for the finishing diet distributed from 75 up to 145 kg.
²ADFI in a period of fattening is reported for early, middle and late fattening stages estimated between approximately 30 and 75 kg, 75 and 110 kg and above 110 kg live body weight, respectively. Sometimes the source provided only the overall daily feed intake for the whole studied period (in that case defined as overall).

Table 5.
 Summary of collected literature data on average daily feed intake (in kg/day) in Basque pig breed.

because it can be assumed that the maximum figures exhibit the growth potential of Basque pigs in ad libitum conditions of feeding (≈ 544 g/day in overall fattening stage).

In considered studies, the information on feed intake and feed nutritional value were scarce (max five available values), which limits the evaluation of growth potential. Average daily feed intake increased from 2.3 kg/day in the early growing stage up to max 2.9 kg/day in the late fattening stage when ad libitum feeding regime was applied.

5.3 Body composition and carcass traits

Basic data obtained in this review with some of the most commonly encountered carcass traits that could be compared are presented in **Table 6**.

Reference	No. of animals	Final age (d)	Final BW (kg)	Hot CW (kg)	Dressing yield (%)	Back fat thickness ¹ (mm)	Loin eye area (cm ²)
[8]	—	458	130	114	—	39	—
[10, 11]	12	—	105	77	72.9	41	—
	16	—	154	113	73.2	48	—
[13]	18	202	86	65	75.4	26	18.1
[14–16]	20	320	140	118	81.8	47	—
	20	312	146	117	81.3	51	—
	20	423	142	116	80.4	39	—
[17]	10	—	145	—	—	45	—

No. = number, BW = body weight, CW = carcass weight.
¹Backfat thickness was either measured at the level of the last rib, reported as the average of measurements taken along the carcass, or between the fourth and fifth lumbar vertebra level (in agreement with specifications for AOC Kintoa studies [14–16]).

Table 6.
 Summary of collected literature data on body composition and carcass traits in Basque pig breed.

Reference	No. of animals	pH 45	pH 24	CIE ¹			IMF (%)	FA composition of IMF (%)				FA composition of BFT (%)			
				L*	a*	b*		SFA	MUFA	PUFA	n6/n3	SFA	MUFA	PUFA	n6/n3
[10, 11]	16	6.27	5.76	47	11	—	—	—	—	—	—	—	—	—	—
	12	—	—	—	—	—	3.9	—	—	—	—	43.1	45.2	11.7	—
[13]	18	—	—	43	6.0	8.0	5.7	42.9	43.4	13.8	—	—	—	—	—
[14–16, 18]	20	6.48	5.59	51	9.6	6.6	3.8	38.2	54.0	7.6	9.3	38.9	48.6	12.4	9.5
	20	6.52	5.54	52	9.7	6.9	4.1	38.5	53.6	7.6	9.3	37.5	49.8	12.5	9.1
	20	6.63	5.67	48	9.3	4.9	3.3	35.7	54.0	10.0	11.0	35.7	49.0	15.0	10.0
[19]	12	—	—	—	—	—	3.4	34.6	56.1	9.3	15.9	—	—	—	—

No. = number, pH 45 = pH measured approximately 45 minutes post-mortem, pH 24 = pH measured approximately 24 h post-mortem, IMF = intramuscular fat, BFT = back fat tissue, SFA = saturated fatty acids, MUFA = monounsaturated fatty acids, PUFA = polyunsaturated fatty acids, n6/n3 = the proportion between n-6 and n-3 polyunsaturated fatty acids.

¹CIE, objective colour defined by the Commission Internationale de l'Eclairage; L* greater value indicates a lighter colour; a* greater value indicates a redder colour; b* greater value indicates a more yellow colour.

Table 7.
Summary of collected literature data on meat and fat quality in Basque pig breed.

In considered studies, pigs of Basque breed were slaughtered between 202 and 458 days of age ($n = 5$ studies) and between 86 and 154 kg live weight (over 130 kg in 6 out of the 8 references). In the six listed references, dressing yield was in the 72.9–81.8% interval. The back fat thickness value measured at the level of the last rib, reported as the average of measurements taken along the carcass or between the fourth and fifth lumbar vertebra level (according to AOC specifications), spanned from 26 to 51 mm ($n = 8$ studies), whereas muscularity measured as loin eye area was 18.1 cm² [13]. These values indicate lower muscular development and greater carcass fatness compared to modern breeds which can be explained by the absence of selection on fatness and muscle in the Basque breed. This variation in back fat and muscle thickness is also a consequence of the wide range of final live weight of pigs and different feeding regimes applied in considered studies.

5.4 Meat and fat quality

Basic data obtained in this review with some of the most commonly encountered meat and fat quality traits measured in *longissimus* muscle and subcutaneous back fat tissue that could be compared are presented in **Table 7**. In the studies reporting meat quality of Basque pigs, pH measured in *longissimus* muscle at 45 minutes and 24 h *post-mortem* was between 6.27 and 6.63 and between 5.54 and 5.76, respectively ($n = 4$ studies). Loin meat from Basque pigs also exhibited high intramuscular fat content (over 3.3% and with a maximum of 5.7%; $n = 6$) and a dark colour (high Minolta a* value over 9.3 in four out of five studies and moderate lightness with L* value within the 43–52 interval). Big differences in the SFA, MUFA and PUFA content of intramuscular fat in *longissimus* muscle were observed between the considered studies ($n = 5$ studies). These are due to differences concerning the feeding regime, feed composition, final body weight/age and fatness, which are all important factors influencing the fatty acid composition of meat.

6. Use of breed and main products

The Basque pig breed is intended for the production of traditional high-quality pork and processed products that have been now protected at national (AOC) and European (PDO) levels. The main products are listed in **Table 8**. The low growth rate of animals, low lean growth potential and high fatness, associated with the extensive production system including natural feeding resources, strongly interact and lead to muscle and meat phenotypic traits that are favourable for the high sensory and technological quality of pork and pork products [20]. Notably, the meat of Basque pigs exhibits a red colour, very low drip loss, low rate and moderate amplitude of *post-mortem* pH decline and high intramuscular fat content, all these traits playing an important and positive role on the appearance, tenderness and juiciness of pork products [18]. The high intramuscular fat associated with the high content of monounsaturated fatty acids of ham muscles is also of great interest for sensory (tenderness, flavour) and nutritional quality of dry-cured hams [15]. The very high sensory quality of pork and products from Basque pigs is recognised at both national and international levels, with the export of dry-cured hams to Japan and Hong Kong. The recent AOC/PDO official label certification will be helpful to improve consumer awareness and knowledge about these specific products and production systems and thereby should enhance the sustainability of the local Basque pork chain (**Figure 5**).

Product name	Type of the product	Status of the product	Label
Jambon du Kintoa	Dry-cured ham	AOC (French label) and PDO Kintoa	<i>AOC Kintoa, PDO in progress</i>
Viande fraîche Kintoa	Carcass and meat	AOC (French label) and PDO Kintoa	<i>AOC Kintoa and PDO</i>
Saucisson sec	Dry sausage	No specific status; “from Basque pork”	
Pâté	Pâté	No specific status; “from Basque pork”	
Boudin noir	Black blood pudding	No specific status; “from Basque pork”	
Chichons	Kind of rillettes	No specific status; “from Basque pork”	

Table 8.
Main products from Basque pig breed.



Figure 5.
New logo (2018) of Kintoa pork produced from Basque pigs: On the left, French logo for AOC label on dry-cured ham (AOC, French label mandatory before PDO registration at EU level) and on the right AOP on fresh pork (AOP, French translation for PDO).

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Author details

Marie-José Mercat^{1*}, Bénédicte Lebret², Herveline Lenoir¹ and Nina Batorek-Lukač³


1 IFIP—Institut du porc—French Institute for Pig and Pork Industry, Le Rheu, France

2 PEGASE, INRA, Agrocampus Ouest, Rennes, France

3 Agricultural Institute of Slovenia, Ljubljana, Slovenia

*Address all correspondence to: marie-jose.mercat@ifip.asso.fr

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References

- [1] Bulletin officiel du Ministère de l'agriculture, de l'agroalimentaire, et de la forêt, no. 2016-34; 2016
- [2] Lenoir H. Analyse de la variabilité génétique des six races locales porcines. *Les Cahiers de l'IFIP*. 2015;2(1):19-26
- [3] Lenoir H, Mercat M-J. Bilan des effectifs, des performances de reproduction et de la variabilité génétique des 6 races locales. *Techni porc*. 2008;31:15-22
- [4] Labroue F, Goumy S, Gruand J, Mourot J, Neelz V, Legault C. Comparaison au large white de quatre races locales porcines françaises pour les performances de croissance, de carcasse et de qualité de la viande. *Journées de la Recherche Porcine en France*. 2000;32:403-411
- [5] Leenhouders JI, Merks JWM. Suitability of traditional and conventional pig breeds in organic and low-input production systems in Europe: Survey results and a review of literature. *Animal Genetic Resources/ Recursos Genéticas Animales/ Recursos Genéticos Animales*. 2013;53:169-184. DOI: 10.1017/S2078633612000446
- [6] Lenoir H. Races locales: La progression des effectifs est conditionnée par la valorisation. *Techni Porc*. 2014;20:32-35
- [7] Mercat M-J. Treasure Survey WP 1.3, Personal Communication; 2017
- [8] La Filière Porc Basque. Le porc Basque [Internet]. Available from: <http://porcbasque.fr/spip.php?article31> [Accessed: 19 July 2017]
- [9] Mercat M-J, Lenoir H. Average Data from LIGERAL Database between 2012 and 2016; 2017
- [10] Labroue F, Guillouet P, Marsac H, Boisseau C, Luquet M, Arrayet J, et al. Etude des performances de reproduction de 5 races locales porcines françaises. *Journées de la Recherche Porcine en France*. 2000;32:413-418
- [11] Gueblez R, Labroue F, Mercat M-J. Performances de croissance, carcasse et qualité de viande de 4 races locales. *Techni Porc*. 2002;25:5-15
- [12] IFIP. Le porc Pie noir du pays Basque [Internet]. 2009. Available from: http://www.ifip.asso.fr/sites/default/files/pdf-documentations/races_basque.pdf [Accessed: 23 November 2017]
- [13] Alfonso L, Mourot J, Insausti K, Mendizabal JA, Arana A. Comparative description of growth, fat deposition, carcass and meat quality characteristics of Basque and large white pigs. *Animal Research*. 2005;54:33-42
- [14] Lebret B, Damon M, Gondret F, Lefaucheur L, Louveau I, Prunier A, et al. Variation de la qualité de la viande de porc selon la race: Basque ou large white et le système d'élevage: Conventuel, alternatif ou extensif. *Journées de la Recherche Porcine en France*. 2011;43:39-46
- [15] Lebret B, Ecolan P, Bonhomme N, Pollet P-Y, Dourmad J-Y. Quality of fresh pork and dry-cured ham: Interactive effects of pig breed (Basque or large white) and production system (conventional, alternative or extensive). *Acta Agriculturae Slovenica*. 2013;4(Suppl):77-80
- [16] Lebret B, Dourmad J-Y, Mourot J, Pollet P-Y, Gondret F. Production performance, carcass composition, and adipose tissue traits of heavy pigs: Influence of breed and production system. *Journal of Animal Science*. 2014;92:3543-3556

[17] Vincent A, Louveau I, Gondret F, Lebret B, Damon M. Mitochondrial function, fatty acid metabolism, and immune system are relevant features of pig adipose tissue development. *Physiological Genomics*. 2012;**44**(22):1116-1124

[18] Lebret B, Ecolan P, Bonhomme N, Méteau K, Prunier A. Influence of production system in local and conventional pig breeds on stress indicators at slaughter, muscle and meat traits and pork eating quality. *Animal*. 2015;**9**:1404-1413

[19] Lebret B. Rapport d'étude: Influences du type génétique (Basque ou large White) et du système d'élevage: Conventionnel, alternatif ou extensif, sur la croissance des animaux et la qualité de la viande et des produits. Identification de biomarqueurs de la qualité de la viande. In: Programme de recherches européen Q-Porkchairs 2007-2012. 2012. 15 p

[20] Lebret B. Effects of feeding and rearing systems on growth, carcass composition and meat quality in pigs. *Animal*. 2008;**2**:1548-1558