

## Use of Iberian Pigs for Production of Iberian Ham ((jamón ibérico))

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An important element in the production process of Iberian ham is the appropriate selection of animals and the way they are bred. Ibérico ham is obtained from Iberian pigs and their hybrids. These animals are maintained in the traditional way under special conditions without major human involvement in the final fattening stage. The intensive and often months-long pig movements combined with a specific diet are a key to the success of the breeder, manufacturer, and processor and to the consumer satisfaction.

According to the data of the Spanish Ministry of Agriculture, in 2016, the Iberian pig population in this country was 3,152,720 items with different blood share of this breed in the genotype (which accounted for 10.8% of the total pig population in the country). The majority of the Iberian pigs and hybrids population are kept in the provinces of Extremadura (43%), Andalusia (27.8%) and Castile and León (24.8%) (MAPAMA, 2016).

It is considered that the ancestor of Iberian pigs is *Sus scrofa ferus* (Fig. 1 and 2), and the first references to their appearance in the Iberian Peninsula come from the times before the Romans. In Tarraco (Tarragona), a fossilized ham from 2000 years ago has been found. Thanks to the dispersion of the population, the Iberian breed includes many genetically diversified varieties depending on the region they originate from. Therefore, the areas from which the pigs of this breed originate are the current borders of Portugal and Spain.



Fig. 1. One of the interpretations concerning the origin of Iberian pigs (cerdo ibérico)  
(Moran Palacios et al., 2014)



Fig. 2. Drawing depicting *Sus scrofa ferus* (1812)  
Źródło/Source: Atticus Bookstore, <https://www.atticus.pl/?pag=poz&id=42459> (7.11.2018)

Iberian pigs are characterised by medium size, harmonious body posture and, most frequently, dark colour. Males reach 79 cm of height at the withers and the average body weight of 143 kg; females - 77 cm at the withers and 128 kg of body weight. The average growth during the fattening period is 360 g/day. The average body weight before slaughter is 128 kg, which translates into a yield of 83% (Barba et al., 2002, MAPAMA, 2016). Animals of this breed are resistant to many diseases, they tolerate difficult environmental conditions and easily adapt to the changing climate.

#### Varieties of Iberian pigs.

Within the Iberian pigs breed, there are many varieties divided into black and coloured ones. Among the black ones, the most popular are Lampiño and Entrepelado varieties and the coloured ones include Retinto, Manchado de Jabugo and Torbiscal. The Mamelado, Portugués and Silvela varieties are of minor breeding importance as they are not too popular. Both breeders and producers are primarily concerned with preserving pure Iberian breed of the most productive black varieties at the expense of those which are less popular or even threatened with extinction (Delgado et al., 2000).

**Retinto** (photo 1) it is a dark/black variety although there are also dark-red and even blond varieties, which occur less frequently. These pigs have an elongated snout and drooping, forward-facing ears. Occurrence: all of Extremadura, the western part of Castilla La Mancha, almost entire Andalusia (except for several eastern provinces) and the south-western region of Castile and León. The body weight of piglets at birth is approximately 1.50 kg, and increases up to 60 days of age 246.1 g/day (Barba et al., 2002).



Photo 1. Retinto variety

Source: Retinto: <https://www.mapa.gob.es/es/ganaderia/temas/zootecnia/razas-ganaderas/razas/catalogo/autoctona-fomento/porcino/iberico-retinto/default.aspx> (7.11.2018)



Photo 2. Entrepelado variety

Entrepelado: <https://www.mapa.gob.es/es/ganaderia/temas/zootecnia/razas-ganaderas/razas/catalogo/autoctona-fomento/porcino/iberico-entrepelado/default.aspx> (7.11.2018)

**Entrepelado** (photo 2) is the effect of cross-breeding of Retinto and Lampiño varieties. Their carcasses are characterised by a lower fat content than Lampiño, but not as high as in Retinto. They have poor hair, the skin is dark at young specimen, and in the mature ones it becomes matt. This variety occurs in the region of the entire province of Extremadura, north-western Andalusia and south-western Castile and León. The body weight of piglets at birth is approximately 1.40 kg, and increases up to 60 days of age are 192.5 g/day (Barba et al., 2002).

**Manchado de Jabugo** (photo 3) is a variety that appeared in the region of Andalusia in the mid-nineteenth century. It is characterised by a blonde colour with black, grey or coloured patches on the whole body and thick hair. It is recognised as a variety threatened with extinction; it occurs only in the province of Huelva in the west of Andalusia. The body weight of piglets at birth is approximately 1.60 kg, and increases up to 60 days of age are 206 g/day (Forero et al., 2001).



*Photo 3. Manchado de Jabugo variety*



*Phot. 4. Torbiscal variety*

Source: Manchago de Jabugo: <https://www.mapa.gob.es/es/ganaderia/temas/zootecnia/razas-ganaderas/razas/catalogo/peligro-extincion/porcino/iberico-manchado-jabugo/default.aspx> (7.11.2018)  
Torbiscal: <https://www.mapa.gob.es/es/ganaderia/temas/zootecnia/razas-ganaderas/razas/catalogo/peligro-extincion/porcino/iberico-torbiscal/default.aspx> (7.11.2018)



*Photo 5. Lampiño variety*

<https://www.mapa.gob.es/es/ganaderia/temas/zootecnia/razas-ganaderas/razas/catalogo/peligro-extincion/porcino/iberico-lampino/default.aspx> (7.11.2018)

**Torbiscal** (photo 4) is the newest variety of the Iberian breed. It was created as a result of breeding work carried out in the 1940s of the 20<sup>th</sup> century, consisting of the cross-breeding of 4 breeds: two from Extremadura (Campanario, Puebla) and two from Portugal (Ervideira, Caldeira). It has an elongated snout, dangling ears and light or dark skin. This variety is extremely resistant to diseases and harsh environmental conditions. It is recognised as a breed threatened with extinction. It occurs in the entire area of Extremadura, western Andalusia, north-western Castilla La Mancha and south-western regions of Castile and León. The body weight of piglets at birth is approximately 1.53 kg (Garrido de la Osa i in., 2017) and the increases up to 60 days of age are 253 g/day (Benítez Ortiz and Sánchez, 2001).



**Lampião** (photo 5) are endangered hairless (or almost hairless) pigs with high increments during fattening (especially with fat), short limbs and characteristic skin folds concentrated mostly in the front parts of the body. They are found in the entire area of Extremadura, north-western Andalusia and Castilla La Mancha and the south-western region of Castile and León. The body weight of piglets at birth is approximately 1.32 kg, and increases up to 60 days of age are 229.3 g/day (Barba et al., 2002).

For the production of ham, apart from pure-bred animals, also hybrids of the Iberian breed with the Duroc breed are used. The breeding of hybrids means lower profits from the sale of Iberian ham, the organoleptic and technological quality of meat is also deteriorating, but they are characterised by other qualities that are not achieved in pure-bred animals. These include more numerous litters, larger increments, lower piglet mortality or higher meat/fat ratio.

### Maintenance and Feeding System

The areas where Iberian pigs are grazed from October to January are called *dehesa* (Fig. 3 and 4). They are characterised by various types of soil with the majority of not sandy ones, which results in a rich flora resulting from better hydration. These are areas covered with specific vegetation, mainly consisting of cork, holm and Portuguese oaks and, to a much lower extent, beech or pine. Numerous grass and herbs species are also characteristic for such areas. The most frequent vegetation are species belonging to the family of paniculate (*Aira cupaina*, *Poa bulbosa* and *Dactylis glomerata*), fabaceae (*Anthyllis cornicina*, *Lathyrus sphaericus*, *L. inconspicuus* and *L. maxima*, *Trifolium charlei*, *T. bocconei*, *T. glomeratum* and *T. hirtum*), plantain (*Plantago gellardi*), clove (*Paronychia cymosa* and *Silene gallica*) and asteraceae (*Tolpis barbata*) (Observatorio local de empleo, 2002).

The efficiency of pastures is extremely important for breeding pigs. The annual average production of acorn of one holm oak is from 250 to 800 kg, and cork oak - 100-600 kg, although in poor environmental conditions these values rarely exceed 100 kg (Ruíz, 1994; Muñoz Vázquez, 1994). According to Muñoz Vázquez (1994), the potential weight of obtained green forage ranges from 3500 to even 12,000 kg of dry matter per hectare. It is just from oaks that the main ingredient of the pig food comes from, in order to obtain a high quality product marked as *ibérico*.



Photo 6. *Dehesa* and grazing Iberian pigs

(autor/author: Manuel Pizarro V., źródło/source: <http://ciudad-dormida.blogspot.com/2014/10/dehesas-de-extremadura-es-tiempo-de.html>) (7.11.2018)



Fig. 3, 4. Comparison of the area known as *dehesa* in the Iberian Peninsula (left) and the territorial range of Iberian pigs in Spain (right)

Source: <http://www.anvepi.com/index.php?noticia=643>, i FEAGAS (7.11.2018)  
<http://feagas.com/razas/porcino/iberico-general/> (7.11.2018)

Montanera is the period during which pigs are fed in the *dehesa* area, based on the pastures present there (grass, herbs) and acorns. This has a huge impact on the later organoleptic properties of the obtained meat. The season of *montanera* covers, on average, the period from October (or more often November) to January (according to the Standard of 2014, the beginning of grazing has to begin between October 1 and December 15). The exact dates depend on both local climatic conditions and the weather which can be variable - it can change from year to year (and even from month to month) and in this way shape the market of Iberian hams in the country. Intense winds combined with meagre, late rainfall clearly reduce the availability of food for pigs (EFEAGRO).

The knowledge of these concepts will facilitate the presentation of individual Iberian pigs' maintenance and feeding systems, which has a direct impact on the subsequent marking and price of the final product. It is worth emphasising that the maintenance system for most groups of animals is similar to the beginning of the fattening. It is based on dry fodder, grains or ready industrial mixtures. The differences result mainly from the methods of fattening and feeding base available for animals at that time.

The first potential type of animal maintenance is the so-called "*bellota*" (acorn). The basis for such maintenance is grazing in *dehesa* areas during autumn and winter (*montanera*). Animals have access only to naturally found water reservoirs, herbs and grass growing on the pasture as well as many acorns found on the ground (depending on the abundance). Pigs are maintained almost as wild, with the ability to express their natural behaviour as well as satisfy the need for movement. Fat contained in the acorns is rich in oleic acid which gives an olive flavour to the meat, which is an aspect highly appreciated by consumers.

Another maintenance system is called "*cebo de campo*" or "*recebo*". It may be carried out intentionally or it may result from poor climatic conditions that force the breeders to supplement the feed doses with grain-based feedstuff (barley, corn, oats) and beans (soybeans). As a result, the meat is of poorer quality (this is especially true for organoleptic properties), which means that it will later qualify as the "*recebo*" category (Flores et al., 1988, De la Hoz et al., 1996).

"*Cebo*" is pig fattening based exclusively on fodder of farm or industrial origin, i.e. green fodder and grains of high energy value (maize, barley) or ready-mixed industrial mixtures. Such a maintenance system does not require access to pastures at all. Animals are fattened indoors, which affects their well-being, and the way of feeding on the quality of meat (and the content of fat, which is valuable from the consumer's point of view). An exemplary feed ration derived from industrial feeds for this maintenance and feeding system is presented in Table 1.

Table 1. Components (%) and chemical composition of the diet for animals under the “cebo” feeding system (Criado, 2009)

Component (%)	Stage I: growth (35–50 kg/b.w.) (14–18 tyg. wks of age)	Stage II: before fattening (50–100 kg/ b.w.) (18–30 tyg. wks of age)	Stage III: fattening (>100 kg /b.w. for slaugh- ter) (30–37 wks of age)
Barley	29,71	30,00	31,00
Maize	31,52	24,68	10,00
Wheat	10,00	10,00	30,00
Cereal bran	–	7,00	4,83
Beet pulp	3,00	–	–
Maize gluten meal	–	–	7,00
Sunflower cake 32–34*	–	4,00	–
Soybean 44*	18,00	18,47	10,34
Fish meal 60–65*	3,01	–	–
Lard	2,06	2,78	4,00
Calcium carbonate	0,78	0,98	1,10
Dicalcium phosphate	1,04	1,32	1,02
Salt	0,30	0,36	0,31
DL-methionine	0,005	0,003	–
L-lysine	0,17	0,004	–
Mineral-vitamin supplement	0,40	0,40	0,40
<b>Chemical composition (% in fresh product)</b>			
Water	10,88	10,84	10,21
Crude protein	16,96	16,70	14,16
Ash	5,37	5,68	5,20
Crude fat	4,51	5,06	6,07
Crude fibre	4,00	4,84	4,00
Starch	42,03	–	42,85
Lysine	1,00	0,80	0,60
Methionine	0,30	0,28	0,23
cystine	0,59	0,59	0,51
Threonine	0,64	0,62	0,50
Tryptophan	0,19	–	0,16
Calcium	0,85	0,85	0,80
Available phosphorus	0,34	0,35	0,30
Sodium	0,16	0,15	0,15
Oleic acid	1,19	1,45	1,88
Linoleic acid	1,20	1,31	1,32

\*protein percentage.

Tables 2 and 3 present the average nutritional values of acorns and grass growing on dehesa in autumn and winter grazing.

Table 2. Chemical composition and fatty acids – comparison of acorns and grasses on dehesa pastures in the “bellota” feeding system (López Bote et al., 2000)

Component	Grasses in DM (%) (Ruíz, 1993)	Acorns (%) (FEDNA, 1999)
Dry matter (DM)	26,0	60,0
Ash	7,0	1,1
Crude protein (CP)	15,5	3,0
Crude fibre (CF)	22,0	6,5
Crude fat (CFa)	6,0	4,7
Content in CFa*:		
C16:0	15,6	15,0
C16:1	0,3	–
C18:0	2,0	3,0
C18:1	9,4	62,0
C18:2	11,8	16,0
C18:3	44,9	1,1
Content in CFa*:		
C16:0	15,6	15,0
C16:1	0,3	–
C18:0	2,0	3,0
C18:1	9,4	62,0
C18:2	11,8	16,0
C18:3	44,9	1,1

\*CF = crude fat

Table 3. Content of macro- and microelements, energy and amino acids in acorns – “bellota” feeding system (López Bote et al., 2000)

Component	Content in acorns (%) (FEDNA, 1999)
Ca	0,07
P	0,08
Na	0,01
Cl	–
Mg	0,04
K	0,60
S	–
Cu	3 mg/kg
Fe	120 mg/kg
ME (metabolizable energy)	1 730 kcal/kg
DE (digestible energy)	1 820 kcal/kg
Content in crude protein:	
Lysine	7,0
Methionine	2,1
Met + cys	4,9
Threonine	8,8
Tryptophan	–
Isoleucine	–

## **Production and Reproduction Cycle**

The breeding process begins at selection stations, where the animals are evaluated for their reproductive and production features such as the number of piglets born alive, the number of weaned piglets, the feed consumption, the feed conversion index (kg of feed/kg of growth) or the penetration of fat into the muscular tissue (marbled meat). In the case of the Iberian breed of boars, the so-called "finura", i.e. their "slenderness" is evaluated because for the production of regional products it is disadvantageous to transfer the features responsible for excessive limb growth. When assessing the posture characteristics, the scoring is one of the criteria for registering an animal in the Breeding Book of the Iberian Breed. For females the score is at least 70 points, and for boars 75 points. 7 features are evaluated (each with its assigned coefficient): general body posture (2.25), head and neck (1.25), shoulder (1.75), ham (2.00), trunk and back (1, 50) and limbs (1.25). Each of the features is scored from 0 to 10 (in any case a value lower than 4 is equivalent to the disqualification of the animal for reproduction), then the values are multiplied by the corresponding factors for each feature so that the maximum score the animal can get is 100 points. Additionally, the minimum age at which an animal can be entered into the books is six months (Orden APA / 3376, 2007). The prediction equation (BLUP) is used to assess the genetic value and to determine the breeding indices. The best reproducers are made available to breeders in insemination stations and, therefore, the most valuable genotypes in the population are distributed. Reproductive data of the Iberian breed are collected in the BDporc database (Base de Datos del Porcino Español), and exemplary average values (as of 2014) include, as follows: the number of piglets in the litter 8.06, number of live piglets 7.68, and the number of weaned piglets 6.88.

The first mating of the sows (most often of the Retinta or Entrepelada varieties) is carried out in the 8<sup>th</sup>-10<sup>th</sup> month of life. During this time, their body weight reaches a value oscillating between 140 and 160 kg (condition assessed at 3-3.5 points). Within a year, sows give birth to two litters, on average there are from 4 to 8 litters per one sow in the entire production cycle. The sows from the first mating are used for breeding for the next 2-4 years, reaching the maximum age of 5 years. After this time, they are sterilised and then fed on pastures together with other animals during the montanera.

Boars are used for the reproduction from the age of 10 months. After 3-4 years of breeding use, they are castrated (immuno-castration) and fattened in the pasture as well as sows. As the paternal material in the breeding there are used almost all the varieties of the Iberian breed, hybrids of these varieties, as well as pure-bred Duroc males entered into the breeding books or their hybrids with the Iberian breed (the production characteristics beneficial due to the heterosis effect) (Sánchez, 2015).

Piglets born in March are called "March piglets", and those born at the turn of May/June are referred to as "September piglets" because this month is the time of their weaning. The piglets born in September are called "montaneros". The fattening period for them is the time of the montanera. These are the most valuable litters in terms of the quality of the final product. "Lechones" piglets (0-23 kg) are fed with mother's milk and, if necessary, the addition of softened protein-rich fodder, and their weaning is carried at the age of 3 months. "Marranos" piglets (23-57.5 kg) after reaching the weight of 57.5 kg are called "primales". Both groups are fed with dry fodder, rich in fibre, but low in energy, with a small addition of grains. The purpose of this breeding period is primarily the development of the musculature and the skeletal system without gaining excessive body fat. The next group are "gordo" fattening pigs (> 103.5 kg), whose nutrition during the fattening period determines what the final product is labelled like.

To obtain 1 kg of body weight gain, the animal must be fed with about 8-10 kg of acorns. Their daily intake for animals with a body weight of 70-80 kg is 5-6 kg, approximately 7 kg - for animals weighing 90-100 kg and 8 kg per day for fattening pigs (Mayoral, 1994). In practice, this means 500 to 700 kg of acorns consumed during 90-100 days of fattening (as long as the montanera lasts), which is equivalent to an increase in body weight of 60-70 kg. Due to the risk of competition in gaining food, Iberian pigs should be the only farm animals present in the dehesa pastures.

Currently, special emphasis is placed on the sow feeding system. It is based mainly on the administration of low-energy feed and protein throughout almost the entire pregnancy and a gradual increa-



se in the share of both components during lactation or drying. The composition of the feeding ration should be adjusted individually taking into account the weight of the sows, their fertility or productivity. This applies primarily to the period of the first 10 days of lactation and the last 20 days of pregnancy, especially due to the intensive foetal growth that goes on at that time, as well as the development of mammary gland and production of colostrum, which translates into a high demand for nutrients (Bueno and Sarmiento, 2015).

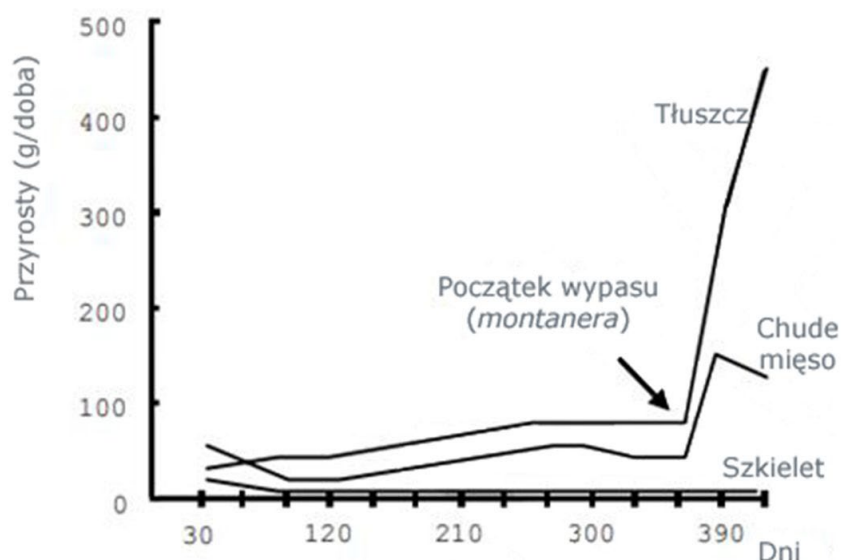


Fig. 5. Values of gains and their variation in time with regard to the onset of grazing (Mayoral, 1994)

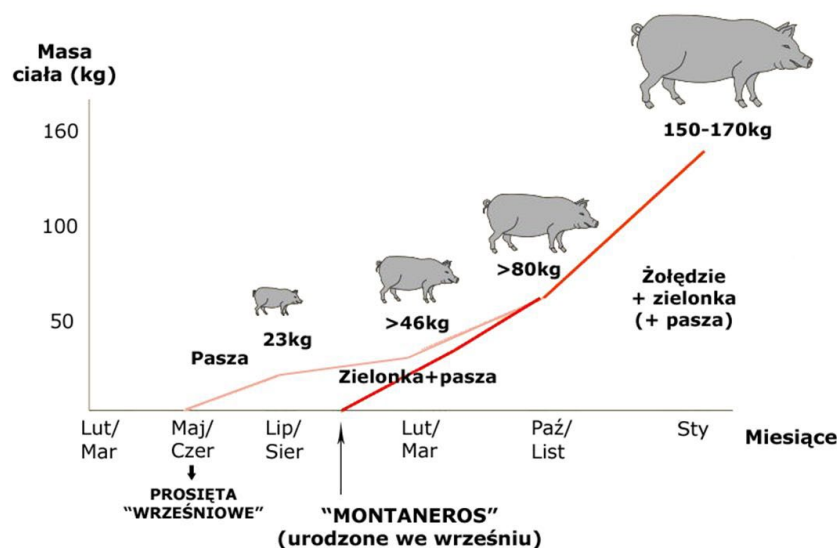


Fig. 6. Effect of farrowing date and diet on fattening performance of pigs

Source: Universidad Politécnica de Madrid, modified by normative data on the quality of Iberian pigs of 2014; [http://www2.montes.upm.es/Dptos/Dsrn/SanMiguel/APUNTES\\_PRESENTACIONES/GESTION%20ESPECIES%20PROTEGIDAS/GEP\\_Tema%205.6%20Razas%20ganaderas%20aut%C3%B3ctonas.pdf](http://www2.montes.upm.es/Dptos/Dsrn/SanMiguel/APUNTES_PRESENTACIONES/GESTION%20ESPECIES%20PROTEGIDAS/GEP_Tema%205.6%20Razas%20ganaderas%20aut%C3%B3ctonas.pdf) (7.11.2018)

At the final stage of montanera fattening, the average fat gain per day according to Mayoral (1994) is 400-600 g, and muscle tissue 150 g. This means that for optimal production and economic results, the increments of  $0.87 \pm 0.02 \pm 0.02$  kg according to Rodríguez-Estévez et al. (2007), require grazing that lasts from 6 to 9 weeks. Feeding with acorns, which is a high-energy and low-protein feed, directly impacts the intensive deposition of adipose tissue (Lavado Contador et al., 2000, Gea-Izquierdo et al., 2009). Intense fat gain (Fig. 5) just after the start of grazing is possible in animals that have developed a strong skeleton, strongly developed musculature and low fat.

As can be seen from Figure 6, the moment of delivery has a significant impact on the daily weight gains of animals. In the case of animals born at the turn of May and June, the slaughter mass gain takes 20-21 months, and in the case of animals born in September, this is already after 17 months of life. The relatively short period of use of the sows requires very precise reproduction planning, so that at least half of the births are in September. The slaughter for animals whose nutrition is based solely on grazing during the montanera period, according to the 2014 Standard, has to be carried out immediately after grazing (officially between December 15 and March 31). Therefore, a good planning of reproduction is important (Fig. 7), so that at the beginning of January animals for slaughter have reached optimal body mass.

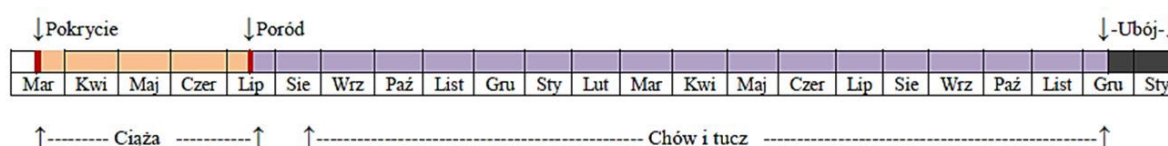


Fig. 7. Reproductive and production cycles (authors' own elaboration)

Table 4 presents the requirements for fattening and slaughter specified in the 2014 Quality Standard, which has to be met in order to be able to apply for the appropriate meat reference. In the case of the "de bellota" class, slaughter must be carried out by March 31 at the latest and preferably immediately after grazing.

Table 4. Requirements for grazing, slaughter and carcass weight  
Source: Quality Standard of 2014 and Council Regulation (EC) No 510/2006

Meat signature		
„de bellota”	„de cebo de campo”	„de cebo”
92–115 kg body weight before grazing, min. gain during grazing: 46 kg	minimal pasture grazing duration (not necessarily with acorns): 60 days	livestock housing
Stocking rate: 1 animal/ha at most	stocking rate: 12 animals/ha at most	min. area per animal: 2 m <sup>2</sup>
Min. age at slaughter: 14 months	min. age at slaughter: 12 months	min. age at slaughter: 10 months
Minimal carcass weight: 115 kg (108 kg for 100% Iberian breed)		

### Summary

The paper presents the characteristics of Iberian pigs' varieties, the system of production and reproduction, animal feeding and maintenance in accordance with Spanish and European standards allowing for the qualification of products as ibérico. Furthermore, there are described examples of dietary doses, factors determining optimal weight gains of animals as well as the relationship between the planning of breeding and the quality of carcasses. The study focuses on the impact of the most important genetic and environmental factors that determine the size and quality of the final product.

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## USE OF IBERIAN PIGS FOR PRODUCTION OF IBERIAN HAM (JAMÓN IBÉRICO)

### Summary

The farming and breeding of Iberian pigs has from the beginning been closely connected with the Mediterranean region. During the period of intensive gains, the fatteners are turned out to pasture, where holm oak acorns form the basis of their feed. Fattening results are strongly related to the environmental conditions in a given season, which translate into both pasture and oak yield. The resulting feeding system during the fattening period is known as “bellota”, “recebo” or “cebo” depending on the proportion of feeds other than acorn in the ration. The feeding system is one of the criteria which determines subsequent classification of the meat and products obtained from it. Of great importance is breeding work with the Iberian breed, which concerns conformation, reproduction and production traits, which are used as the basis for calculating indices that determine registration in the herdbook. Despite the intensification and ongoing changes in animal production technology, the tradition of Iberian pig breeding and grazing, which is culturally rooted in Spain, has been maintained until today, and the raw material obtained allows for traditional production of internationally recognized products.

**Key words:** Iberian pigs, grazing, Iberian ham