SUSTAINED UTILIZATION OF THE IBERIAN PIG BREED

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SUMMARY

The Iberian pig is one of the scarce non-improved swine breeds which survives the modern techniques of pig production based on improved genotypes. This is attributed both to its perfect adaptation to the Mediterranean natural ecosystem and the high quality of its products. The production of meat products from Iberian pigs has very little in common with that of meat products obtained from selected pigs raised under intensive conditions, and it constitutes an example of the preparation of high quality meat products, comparable to the most exquisite food products in the world. The production of Iberian pig is deeply bound to the Mediterranean ecosystem. It is a rare example in the world swine production where the pig contributes so decisively to the preservation of the ecosystem. The aim of this review is to describe in detail the traditional feeding of the Iberian pigs in La Dehesa and to discuss some aspects of the use of alternatives to this production system. Some of the experience in the formulation of compounds feeds for Iberian pigs and in the processing of meat products could be useful in the feeding of other pig genotypes and in different meat processing strategies.

INTRODUCTION

The Iberian Pig is a native breed that has populated the Iberian peninsula from times immemorial on a Mediterranean forest territorial base: La Dehesa. With time, and particularly during the second half of this century, a group of factors linked to the urban development and intensification of animal production, made their numbers diminish. Nevertheless, their perfect adaptation to the environment and the high quality of its products has promoted the persistence of the breed and productive system, being one of the scarce non-improved swine breeds which has survived the modern techniques of pig production.

In recent years an increased demand for Iberian pig products has occurred, which is attributed to a higher standard of living and a revaluation of traditional products of top quality. At the moment, nearly 1.5 million Iberian pigs are slaughtered in Spain each year, and the figure have been increasing from year to year (Daza, 1996). Due to the high price of their products, Iberian pig production is again profitable, now based on a quality image for a select market, demanding high quality products for special occasions, and willing to pay a high price. It is therefore a production type that has little in common with that of meat products obtained from improved genotype pigs raised under intensive system (different genetics, feeding regimen, carcass fatness, slaughter weight, processing, etc) and it constitutes an example to the meat industry of the manufacture of products of high quality, with a production process comparable to the most exquisite food products.

The production of Iberian pig is deeply bound to the mediterranean ecosystem. It is a rare case in the world of swine production where the pig collaborates significantly in the preservation of the ecosystem.

LA DEHESA

In the first century B.C., the Graeco-Roman geographer Estrabon highlighted in his writings (Volume 2, 1.1) the extensive woodland mass that covered the Iberian peninsula, composed mainly of the 'Mediterranean forest', evergreen oaks (*Quercus ilex*), cork oaks (*Quercus suber*), gall oak (*Quercus lusitanica*), arbutus (*Arbutus*) and heath (*Ericeus*). Some estimates indicate that approximately 80% of the whole Iberian peninsula was occupied by the Mediterranean forest (Cabo, 1975). This forest type is very characteristic of this part of the world because it needs very specific climatic conditions. Other examples of evergreen quercus forest exist in places below the 40th parallel (Southern USA, Mexico) and in the equivalent part of the southern hemisphere. As in so many other parts of the planet, systematic destruction of the natural ecosystem has taken place by man's action in massive cutting and burning to obtain higher production from the land, for war, etc. The progressive decrease of the ecosystem of the Mediterranean forest has been aided by the slow growth of the trees of the *Quercus genus*, so that once the forest is eliminated, recovery of the original ecosystem is difficult. It is estimated that an evergreen oak does not give an appreciable production of acorns until it is 20-25 years old, and it does not reach its maximum productivity until it is approximately 100 years old (Daza, 1996). The total surface of evergreen oak and cork oak in Spain is at the moment about 3.0 and

0.3 million hectares respectively (less than 7% of the territory). A great quantity of this area of Quercus is not useful for pigs because is located in mountainous areas or in places of low productivity, this is particularly true for the cork oak forest. It is considered that less than 1.5 million hectares corresponds to fully developed trees. The preservation of the ecosystem through the centuries has been possible thanks to its multiple resources: grass, firewood, coal, cork, hunting, a variety of cultivation (cereals, melons, pumpkins, fruits, etc). However, the use of most of these resources has declined (progressive disappearance of the trashumance system, loss of importance of firewood, etc) and at the present time the persistence of the ecosystem is based economically on the production of the Iberian pig. Otherwise it is likely that La Dehesa would enter a continuous decline and could even disappear. Therefore, the Iberian pig and La Dehesa form an inseparable unit, so that the persistence of La Dehesa is possible due to the maintenance of the extensive exploitation of Iberian pigs and vice versa. More than 70% of Spanish evergreen oak forests are located in the south west of the country, where almost 100% of the Iberian pigs are produced and processed.

THE IBERIAN PIG

The term Iberian pig defines a racial grouping of native pigs from the Iberian peninsula originated from *Sus Mediterraneus* (Aparicio, 1960, Dieguez, 1992), and is characterized by its hardiness and fat producing ability (Aparicio, 1960). The production of Iberian pig dates from time immemorial. There are historical references from the time of the Romans dominance, where the meat products coming from Hispania were very much appreciated (Daza, 1996). A great amount of genetic heterogeneity exists, with black, red, blond and spotted varieties (Aparicio, 1960), the black and the red being the most abundant, and they can be either hair covered or hairless.

Although variation exists, the varieties of the Iberian pig have a short and jowled neck, medium length trunk and arched ribs (Aparicio, 1960). The extremities are very narrow and short, with pigmented hooves of uniform colour. In the final phases of fattening (140-160 kg) they can reach 60% carcass fat, 15 cm backfat thickness and 10-13% intramuscular fat content (unpublished data). The Black Iberian pigs are of smaller size and fatter than the Red, with a higher intramuscular fat content.

In spite of having a good maternal instinct (Rodríguez, 1994), the Iberian Pig has low prolificity (6-8 piglets per litter) and a small number of functional teats (Toro et al., 1986). With the purpose of improving these characteristics, the Iberian pig have been crossed with other breeds, although special attention has been paid not to lose one of the main characters of identification of great importance in the marketing of hams: the pigmentation of the hooves. Crosses have been carried out with Large Black, Berkshire, Wessex-Saddleback, Tamworth, Poland China, Jiaxing and mainly Duroc-Jersey. This crossing, besides increasing the prolificity by 2-3 pigs, improves the growth rate, the feed efficiency and the lean content (Dobao et al., 1986), particularly of hams and loins, without serious damage to the quality characteristics of the meat products (Antequera et al., 1994). In 1993, from a total number of 188,400 Iberian reproductive gilts,it was estimated that 58% were of the pure Iberian breed (Daza, 1996).

TRADITIONAL PRODUCTION OF IBERIAN PIG AND PRODUCTS

(a) The Iberian pig and La Dehesa

The Iberian pig has been raised for centuries to produce meat for dry-cured meat processing, which allowed storage and consumption of meat products for the whole year. This is still the main objective of production, although the quality of the meat products is now also emphasized. Consequently there is virtually no fresh meat marketed. The production of pigs for dry cured meat products has an important limitation that involves the main element of the productive system: if the meat does not stay in a cold environment during the first stages of processing (until the diffusion of salt within the product is enough to decrease the water activity to a point which prevents the proliferation of anaerobic microorganisms), deterioration is unavoidable. For this reason, the critical point in the production of Iberian pigs in the traditional system was that the slaughter should be carried out during the winter (Figure 1), and normally in mountainous areas. A good example of the perfect adaptation between the Iberian pig and La Dehesa is that the maturation of acorns takes place from early November to late February. The super-abundance of feeds from the acorn maturation is used by the Iberian pigs for the late fattening phase in what is called 'La Montanera' (Figure 1). Feeding Iberian pigs in Montanera produces meat products of high quality and with very specific properties (León Crespo, 1992).

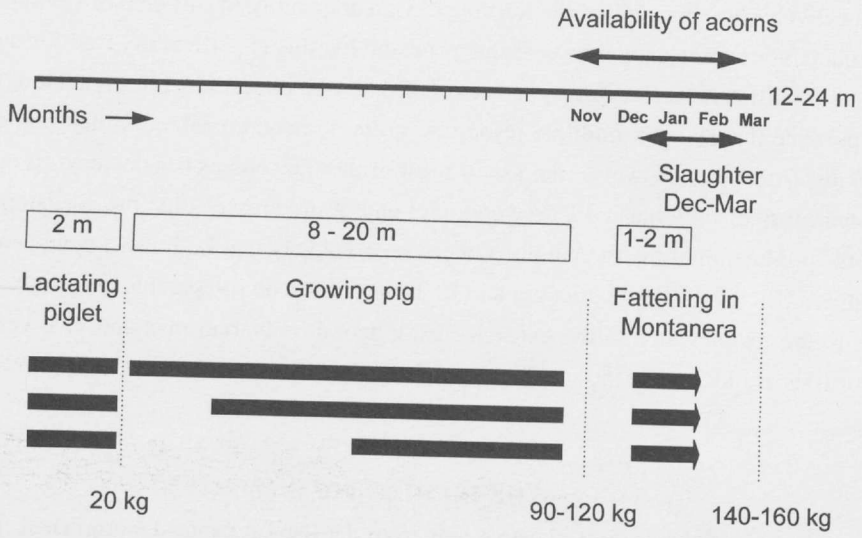

Figure 1.- Schematic representation of the production system of Iberian pigs

Consequently, the whole productive cycle of the animals is planned to get them physiologically capableof taking advantage of La Dehesa during the late fattening phase (minimum 8-10 months of age and 85-90 kg live weight at the beginning of la Montanera). Traditionally parturition occurred throughout the year, and the animals were weaned when over 2 months of age at approximately 20 kg live weight. The range of ages at the initial time of Montanera is therefore very wide (from 10 months to almost 2 years), and animals which are not in good enough physiological condition to benefit from la Montanera are kept for the next year to be finished (Figure 1). The feeding and handling previous to la Montanera take place in a various ways according availability of natural resources in each Dehesa: spring grasses, stubble in summer, products of the vegetable garden in autumn, pumpkins, melons, chestnuts, etc. Due to the scarce and diverse feed supply, average weight gain in this phase is very low. In times of low feed availability and in the nursing and final phase of gestation it is not uncommon to supplement with cereals or formulated feed.

A critical aspect in the feeding of the Iberian pig is to determine the number of pigs which can be supported by La Dehesa and their distribution during Montanera. If the number of pigs exceeds the productive capacity of la Dehesa, the resources can be used up before the pigs reach the optimal slaughter weight, and it becomes necessary to conclude fattening process by feeding with formulated feeds in what is known as 'recebo'. However, recebo diminishes an important part of the quality characteristics of la Montanera, and lead to a penalty in price. The estimate of the stocking capacity in la Dehesa is also hindered by differences in maturation rate (and fall) of acorns. These estimates can be made with enough reliability at the beginning of the summer, and according to that the feeding of the pigs should be planned to get the adequate state of development of the pigs at the beginning of the Montanera.

Pigs are slaughtered at high live weights (140-160 kg) because for quality characteristics of the meat products an extremely high carcass fat content is required. Traditionally animal fat was very much appreciated and one of the main sources of energy for humans during the whole year. Nowadays it is of limited commercial value, but it is still necessary to produce fat pigs with high intramuscular fat content. In non-minced dry-cured meat products (hams, loins, shoulders) it is only the intramuscular fat which is consumed, and a high concentration is generally considered essential because it is related to juiciness and flavour of the product (García et al., 1991, López et al., 1992). Moreover, fat distribution and composition regulate somehow the water migration during processing of dry cured meat products. With insufficient intramuscular fat concentration, the products would mature excessively quickly and the appropriate development of quality attributes would not take place. A group of complex chemical reactions have been described that take place during ripening of the products which are essential for the full development of the flavour (Ventanas et al., 1992). It is considered that a ham reaches the optimal characteristics for consumption after 18-24 months of processing, a critical factor being that hams remain two summers in the cellar.

The total fattening capacity in Montanera can be very variable. A reference value over the years has been 5-6 @ (i.e. 57.5-69 kg, 1@=11.5 kg), although the tendency is to reduce the weight put on while in Montanera in order to be able to increase the number of pigs produced by la Dehesa. The feeding in Montanera consists for the most part of acorns, and variable quantities

of grass. The pig does not utilise the entire acorn, but discards the dome and shell, which consist of fibrous material. Ruiz et al. (1993) estimated that the shell and dome represent 27% of the weight of the acorn approximately. The kernel in turn has a moisture content of around 40%. Expressed in dry matter, the kernel has a very low concentration of protein (around 4-6%) and a very high content of starch (more than 50%) and fat (6-9%)(Table 1)(Ruiz, 1993, Rey et al., 1997). The pig likes the acorn very much and can consume a great quantity per day (about 7-10 kg)(García, 1982, Benito, 1996), so that in the Montanera a very considerable dgree of fattening takes place. The accumulation of muscular, fat and bone tissues during the life cycle of the pig is shown in Figure 2, highlighting especially the accumulation of body lipid during Montanera (Mayoral, 1994). Under these conditions the pig grows between 750 and 1000 g a day, during the total time in Montanera which should not exceed 6-9 weeks. Due to the low protein level of acorns it is a frequent practice to feed pigs with 200-300 g/day of protein concentrate. This produces higher lean accumulation, particularly in loins and hams, and improved performance (Aparicio Macarro, 1992).

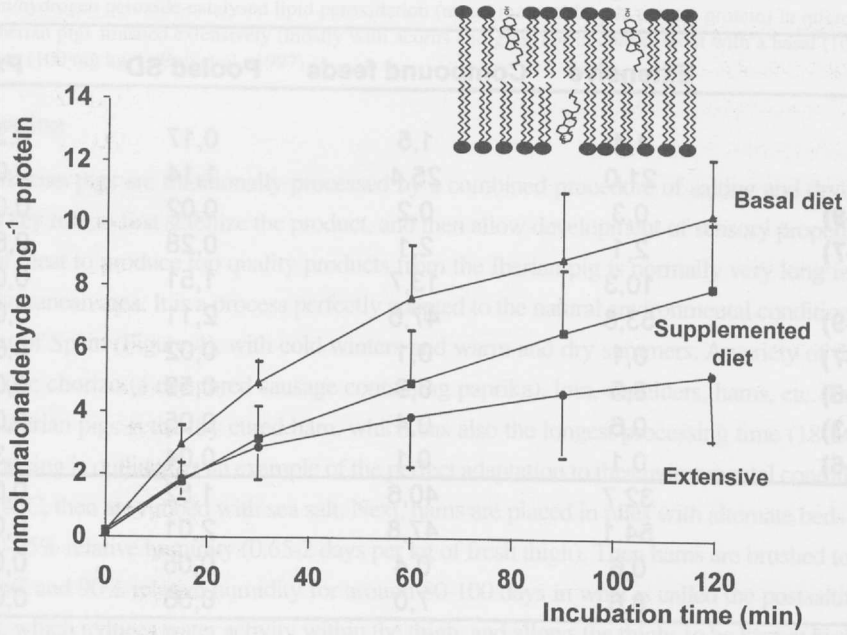

Figure 2.- Evolution of the average daily gain (g/d) of adipose, muscular and bone tissue from weaning to slaughter of Iberian pigs raised extensively (Mayoral, 1994)

Table 1. Chemical composition (g/100 g dry matter) and major fatty acid composition (g/100 g total fatty acids) of acorn and grass (Olea et al., 1990, Ruiz, 1993, Rey et al., 1997)

	Acorns	Grass
Dry matter	67	26
Crude protein	4-6	14-17
Fat	6-9	6
Crude fiber	3-6	22
Ash	2	7
α-tocopherol (mg/ kg DM)	20	171
Fatty acids		
C14:0	0.1	0.4
C16:0	12.9	15.6
C16:1 (n-7)	0.1	0.3
C17:0	0,1	0.2
C18:0	3.2	2.0
C18:1 (n-9)	66.1	9.4
C18:2 (n-6)	14.7	11.8
C18:3 (n-3)	1.0	44.9

The fat of the acorn has a very high concentration of oleic acid (more than 60% of fatty acids) and limited concentration of linoleic and saturated fatty acids (Rey et al., 1997)(Table 1). Since the pig is a monogastric animal, the fat of the Iberian pig raised in Montanera has a high concentration of oleic acid (around 55%), and a very low concentration of linoleic and palmitic acids (around 8 and 20% respectively)(Flores et al, 1988, Rey et al, 1997) (Table 2). Although it is an aspect which demands deeper investigation, the characteristic marbling of the Iberian breed and the high concentration of oleic acid that the acorn provides are considered essential for appropriate ripening and favour development of the products (Antequera et al., 1992; Cava et al., 1997, López et al.,1992)

Table 2. Fatty acid composition (g/ 100 g fatty acids) of the subcutaneus fat from Iberian pigs finished extensively or in confinement with compounds feeds

	Extensive	Compound feeds	Pooled SD	P>F
C14:0	1,4	1,5	0,17	0,250
C16:0	21,0	25,4	1,14	0,001
C16:1 (n-9)	0,3	0,2	0,02	0,001
C16:1 (n-7)	2,1	2,1	0,28	0,892
C18:0	10,3	13,7	1,51	0,008
C18:1 (n-9)	53,8	47,6	2,11	0,001
C18:1 (n-7)	0,1	0,1	0,02	0,639
C18:2 (n-6)	8,5	6,9	0,59	0,001
C18:3 (n-3)	0,6	0,4	0,05	0,001
C20:4 (n-6)	0,1	0,1	0,04	0,312
Σ sat	32,7	40,6	1,52	0,001
Σ (n-9)	54,1	47,8	2,01	0,001
Σ (n-3)	0,6	0,4	0,05	0,001
Σ (n-6)	8,6	7,0	0,56	0,001

La Dehesa also provides grass to the Iberian pig from September to May. These resources provide the base for ruminant feeding (mainly ovine), but they can also be ingested by the Iberian pig, although with some limitations. The production of grass depends very much on the climatic conditions. During the first phases of growth (autumn and winter grass) it has a high proportion of digestible nutrients and a very low concentration of lignin. In spring and mainly in summer the concentration of cell walls and lignin increases, which makes it much less digestible for the Iberian pig. The amount of grass ingested during the feeding of the Iberian pig has not been quantified, particularly in the late fattening phase in Montanera. Nevertheless it is clear that the pig takes advantage of (and likes) the grass, particularly the short and fine material of the first phase of vegetative development (autumn, winter). At the end of the fattening phase there is virtually no herbaceous coverage. Grass supply as a source of protein is needed to compensate for the low concentration of this nutrient in acorns (Table 1), and a source of (n-3) fatty acids (Table 1), which may be important for the development of flavor characteristics in the products (López-Bote et al., 1997, 1998). Moreover, it has been recently reported that (-tocopherol concentration in muscular tissue of Iberian pigs is significantly higher if feeding is carried out in Montanera than if it is done with formulated feeds containing a basal level of α-tocopheryl acetate (3.0 vs 2.2 ug (-tocopherol/g muscle). This was also found in sub-cellular membranes (Rey et al., 1997). This high concentration is attributed to the high content of α-tocopherol in the grass (171 ug/g of dry matter), since the acorn does not have a high concentration (20 ug/g dry matter)(Table 1). On the other hand, some data suggest that the presence of α-tocopherol in membrane extracts from Iberian pigs is not the only factor responsible for its resistance to oxidation (Figure 3), which suggests the possible role of other micronutrients present in the feeds which the Iberian pig ingests in its particular production system (Rey at al, 1997).

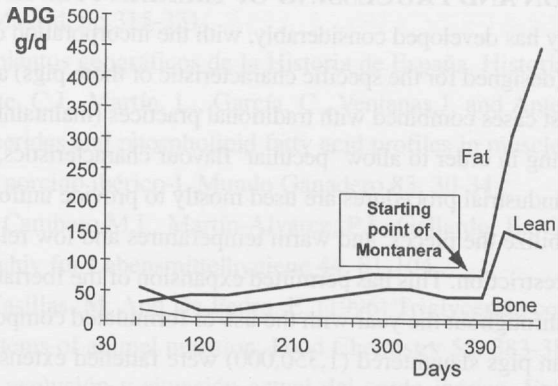

Figure 3.- Metmyoglobin/hydrogen peroxide-catalysed lipid peroxidation (mmol malonaldehyde per mg protein) in microsomes isolates from the longissimus dorsi muscle of Iberian pigs finished extensively (mostly with acorns and grass) or in confinement with a basal (10 mg kg-1) or supplemented level of α-tocopheryl acetate (100 mg kg-1)(Rey et al., 1997).

(b) Traditional processing

Meat products from Iberian pigs are traditionally processed by a combined procedure of salting and drying, where temperature and relative humidity play a key role to first stabilize the product, and then allow development of sensory properties. Although there may be variations, processing of meat to produce top quality products from the Iberian pig is normally very long in comparison to other meat products from the Mediterranean area. It is a process perfectly adapted to the natural environmental conditions of the mountainous areas located in the south west of Spain (Figure 4), with cold winters and warm and dry summers. A variety of dry cured meat products are obtained from Iberian pigs: chorizo (a dry cured sausage containing paprika), loin, shoulders, hams, etc. The most valuable meat product obtained from the Iberian pigs is the dry cured ham, which has also the longest processing time (18-24 months). A brief description of Iberian ham processing is outlined as an example of the perfect adaptation to the environmental conditions. After slaughter, thighs are held for 48 hours at 0oC, then are rubbed with sea salt. Next, hams are placed in piles with alternate beds of hams and sea salt for 7-20 days at 0-4oC and 90-95% relative humidity (0.65-2 days per kg of fresh thigh). Then hams are brushed to remove the salt left on the surface, and held at 0-4oC and 90% relative humidity for around 80-100 days in what is called the postsalting period. This is essential to allow salt distribution, which reduces water activity within the thigh, and allows the thighs to be kept at higher temperature (and lower relative humidity) without risk of spoilage. Next, drying starts by keeping the hams for approximately 90 days in a chamber were the temperature slowly increases and relative humidity decreases progressively, reaching 18-20oC and 80 % relative humidity. The hams are kept in the dryer an additional time which varies depending on the temperature. A typical value could be 1-1.5 months (until the temperature reachs up to 30oC and humidity 50% approximately). The process of drying ends with the arrival of the summer. Finally, hams are kept in a cellar for at least 12 additional months with a temperature ranging from 10 to 20oC and relative humidity from 65 to 82%. This step is where quality attributes fully develop. Microorganisms (probably specific from each cellar) seem to play a key role in this stage (Núñez et al., 1996).

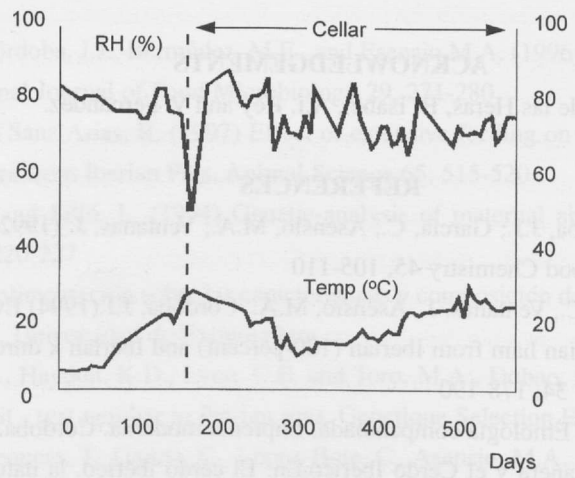

Figure 4.- Evolution of temperature and relative humidity (RH) recorded in the natural environment where Iberian pig hams are produced (see text)(Antequera et al., 1992).

PRESENT-DAY PRODUCTION AND PROCESSING OF IBERIAN PIGS AND PRODUCTS

In recent years, the Iberian pig meat industry has developed considerably, with the incorporation of modern production and processing techniques. Modern slaughter houses (designed for the specific characteristic of these pigs) and industrial chambers for dry cure processing are now in general use, in most cases combined with traditional practices (maintaining of meat products in a natural cellar or cave for the late phase of processing in order to allow 'peculiar' flavour characteristics, etc). Basically the processing has not been markedly modified and modern industrial procedures are used mostly to provide uniform and controlled conditions.

The need for cold during the winter, to stabilize the pieces, and warm temperatures and low relative humidity in summer, for the correct drying of products, is no longer a restriction. This has permitted expansion of the Iberian pig meat industry and simultaneously the ability to produce Iberian pigs throughout the year with the use of formulated compounds feeds. In 1993, it is estimated that 40% of the total number of Iberian pigs slaughtered (1,350,000) were fattened extensively in Montanera, while the remainder received formulated feeds (Daza, 1996). Of course quality characteristics of meat products are not comparable to those obtained from pigs raised extensively, probably due to the effect of feeding, exercise, temperature, etc, but they are still meat products of high quality. Quality control measures have been proposed and established to avoid fraud in the marketing of the three commercial types of meat products from Iberian pigs depending on the production background: Montanera, Recebo or Pienso (fed with mixed feeds)(Flores et al., 1988, De la Hoz, 1993, Díez et al. 1996).

Diet formulation for Iberian pig fattening has to take into account the characteristics demanded of the final product. In fact, in some cases these characteristics are opposite to those normally considered desirable for pigs of improved genotypes raised under intensive conditions. For instance, while in the Iberian pig softer fat is preferred, in improved genotypes it is necessary to limit the level of unsaturated fat to avoid floppy meat. If cereals (mainly wheat or barley) or compound feeds with a low concentration of fats are used for the feeding of the pigs, th e concentration of oleic acid in the carcass is much lower than in animals fed extensively and the concentration of saturated fatty acids is much higher (Table 2)(Flores et al., 1988), which is attributed to enhanced endogenous fat synthesis. This feeding practice is generally considered to markedly decrease the quality of the products. Alternatively fat-enriched diets (up to 7-9%) are now being used. However attention should be paid to the levels of linoleic acid in the diet, because excessive accumulation in tissues leads to a marked elongation of the processing period. It seems likely that if fat is melted during the initial steps of processing (linoleic acid melts below 0°C), the migration of water inside the pieces is limited. Moreover, a less favorable volatile profile has been reported in these products when compared to those from pigs raised extensively (García et al., 1991, López et al., 1992). An interesting possibility is the use of feeds enriched with monounsaturated fatty acids, similar in fatty acid composition to acorns (Table 1). Among possible sources of monounsaturated fatty acids that can be used are lard of Iberian pigs (50-55% oleic acid), by-products of the olive oil industry (oleins), oils from genetically modified seeds (sunflower oil or peanut oil rich in monounsaturated fatty acids), or even rapeseed oil. If 50-55% oleic acid is obtained in the pig fat, together with a concentration of saturated fatty acids lower than 35%, the correct processing time together with a high quality meat product can be achieved (López-Bote et al., 1998).

Some recent reports indicate the possible health benefit of consuming meat from pigs fed diets containing high levels of monounsaturated fatty acids instead of regular feeds (Flynn et al., 1992), which provide further reasons for the interest in the production of Iberian pigs.

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