

## SWINE PRODUCTION IN ITALY AND RESEARCH PERSPECTIVES FOR THE LOCAL BREEDS

G. MAIORANO

University of Molise, Campobasso, Italy

---

### ABSTRACT

Autochthonous pig breeds represent a valuable genetic reserve to utilise for typical products linked to the gastronomic traditions of Italy, or for recovering some organoleptic proprieties of pork actually lost because of severe selective programmes. These extreme phenotypes can be used to emphasize the loci involved in the productive traits by crossing with selected pigs or as a model to understand the physiological process of fat deposition. Moreover, the importance of recovering the primitive germoplasm is suggested also by the fact that, generally, the Mediterranean pig breeds seems to be free from the halothane gene. The survival of these breeds is strictly connected to a good assessment and exploitation of their performances, considering that the latter may involve both rearing environments and interactions between feeding plan adopted and breed characteristics. Even if the free range system worsened growth performance, studies had documented that the semi- extensive (*plein air*) condition brings about better performances for unimproved pigs. The link with the semi extensive rearing could be suitable to increase the commercial value of products of local pigs, because of both effective characterization and consumer preferences. Considering that the information on the research on the Italian local pigs is limited, it is necessary to increase a suitable activity of research to exploit these breeds and to increase the knowledge of their rearing system. A valid example is the Iberian pig. In fact, it is evident that the productive system of the Iberian pig is maintained by an adequate research activity, that produced in the last twelve years about 100 articles in scientific journal. In conclusion, it is required to elucidate the optimal management that improves the growth and meat quality traits of Italian local breeds and, in addition, to conduct research regarding the genetic traceability, feeding traceability and sustainable exploitation of natural resources.

### Key words:

---

### INTRODUCTION

Swine production in Italy is characteristically oriented towards typical meat products. In 2007, the Italian pig population was more than 9 million head (Italian Pig Breeders Association - ANAS, 2008).

Pig farms numbered around 101,000 in 2007 and over 80% were concentrated in the four northern Italian regions of Lombardia, Emilia-Romagna, Piemonte and Veneto (ISTAT, 2008). This is why the dairy producers and cereal cultivations are located in these areas. In Italy, pig farming developed in the 1960s in the Po valley, where all pig farms were annexed to dairy factories to utilize the whey produced from milk processing (to obtain typical Italian cheese, e.g. the renowned Parmesan) for feeding

purpose. Successively, the closeness of pig markets to the big urban centres and to better transport systems changed the frame and the dimensions of Italian pig farming. Gradually these farms evolved to the closed cycle, self-sufficient in terms of piglet supply, and organized in larger and better specialized units. So, local breeds were gradually eliminated and replaced with more efficient genotypes coming from northern European countries. Today, the national production covers the requirements for about 60% and the per capita yearly consumption is approximately 37.13 kg (ISTAT-ISMEA, 2008) of fresh and processed pork. The sector employs approximately 60,000 workers, of whom 47% work on livestock farms and the rest are employed in the pork processing industry.

## PIG PRODUCTION

Compared to that of other countries, Italian pig production differs in the high live weight at slaughter. Pigs are slaughtered at 10-12 months of age when they reach a live weight of 150-170 kg and provide carcasses of 125-140 kg maintaining proper adiposity (e.g. backfat thickness in the lumbar and dorsal area averaging between 36 and 41 mm but varies greatly from carcass to carcass). This higher weight may be surprising for foreign breeders and experts as it is well-known that it involves an increase in the quantity of carcass fat and a decrease in the feed efficiency; however, these negative aspects are offset not only by the possibility of amortizing the cost of the weaned piglet more effectively and of utilizing some dairy by-products, such as whey from milk, but mostly market driven. This kind of production is determined by the meat processing industry which requires heavy cuts, mature, firm and not watery meat for the production of processed products: dry-cured and cooked ham (ham and shoulder), "mortadella" (hashed heat-cured pork sausage with lard pieces), speck (smoked spiced ham), "coppa" (salted and rolled up neck joint), "pancetta" (salted, spiced, dried and rolled up belly), and other prestigious types of salami, such as "Felino". About 9 million heads are destined for the production of typical dry-cured hams having protected origin denomination, such as Parma and San Daniele (*Istituto Parma Qualità*, 2008). To obtain high quality processed pig products, heavy pig production in Italy is subjected to rules fixed by several Consortia, on the basis of the experience of producers and the results from scientific research. For the production of the Italian heavy pig, Consortia for the protection of Parma and San Daniele hams admit only some purebred subjects, or hybrids obtained from some breeds. Pure breeds are limited to Italian Large White and Italian Landrace, selected for specific parameters such as loss at 1<sup>st</sup> salting of the ham, and their crosses. In addition, the crosses with the Italian Duroc breed are permitted. Individuals of the same breed coming from other countries or pigs of other breeds, can be used for the production of cross pigs if obtained from selection and crossing schemes that fit the objectives of Italian selection. The pigs utilized, excluding boars and sows, to produce Parma and San Daniele hams must be at least 9 months of age and  $160 \pm 10$  kg of live weight. Furthermore, the characteristics of heavy pigs are particularly important for Parma ham, the production of which requires an initial weight of 13-15 kg ham, which is then reduced to 11-13 kg after trimming, so that after at least 12 months of seasoning with limited quantities of salt only, a sweet end-product of 8-10 kg is obtained.

Over the last 25 years, the production of light pigs (100-110 kg of live weight) has also developed in Italy. It accounts for 20% of the national production and is mostly used for fresh meat consumption.

## ITALIAN AUTOCHTHONOUS PIGS: DEMOGRAPHIC SITUATION, MORPHOLOGICAL TRAITS, PERFORMANCES AND MEAT QUALITY

The evolution of improved pig populations has brought some aspects of performance close to their biological maximum or economic optimum. Furthermore, consumers' concerns about animal welfare, ecological production, sensorial meat quality and specificity of the meat products led to an increasing demand for foodstuffs obtained from local breeds reared under natural/extensive conditions.

Among the numerous pig breeds and ecotypes reared in Italy at the beginning of the last century, there were twenty-one local pig breeds (Mascheroni, 1927), five of them survived the post-war industrialisation process of pig production and are still reared today: *Apulo-Calabrese*, *Casertana*, *Cinta Senese*, *Mora Romagnola* and *Nero Siciliano*. In addition, one more breed, named *Sarda* recently (2006) received recognition as autochthonous breed and is listed in the National Pedigree Register. The demographic situation of six breeds is reported in table 1 which considers only animals and herds recorded in the National Pedigree Register that was recently set up (D.M. 20871; 6/3/2001) by the ANAS at the request of the Italian Ministry for Agricultural Politics. However, for some breeds (*Nero Siciliano*, for instance) the population size is greater since it makes it difficult to identify and register standard animals in the free-range system (Franci and Pugliese, 2007).

The *Apulo-Calabrese* pig is a local endangered breed from the Calabria region (Southern Italy). The pig is medium-small sized, the coat is black with a long head, front lop ears and strong fore legs. It shows no excessively developed muscles but strong skeleton.

The *Casertana* pig originates from the Campania region (Southern Italy); there were about 200,000 heads in the early 1950s but the breed declined almost to extinction in a few years. The *Casertana* pig is medium-small sized, the coat is bright black and mostly hairless (*pelatella*); the standard type exhibits wattles.

The *Cinta Senese* is a pig breed which originates in the Siena hills of Montemaggio and Chianti in the Tuscan region (Central Italy). In contrast to the other local breeds that are mainly reared in the original area, the *Cinta Senese* is spread out of Tuscany. Probably, it is due to the more precocious recover of this breed, which has been registered in the national herd-book for the first time from 1936 to 1966 and again in a regional herd-book since 1976 (Franci and Pugliese, 2007). This breed is featured by a dark grey colour and a white band around the thorax, withers, and shoulders. Known for

its robust constitution the Cinta easily adapted itself to living in a wild state. The *Cinta Senese* is well-known because of its typical and renowned “*lardo di colonnata*”. The Colonnata lard (a salted, ripened and spice/herb seasoned salami product, with a homogeneous and soft consistency) has recently been included in the Italian ‘Register of protected designations of origin and protected geographical indications’ (Commission Regulation EC No. 1856/2004).

The *Mora Romagnola* was fairly common until the mid-1950s in Emilia Romagna (North-East Italy): in 1953 there were more than 22,000 animals (Tonini, 1953). This breed began to disappear as the Large White took over its area; in 1998 only 12 animals survived (Fortina et al., 2005). The pig has a very dark brown colouring with a coppery hue. Sows have a thicker ridge of longer bristles along the back and dark grey skin with a rosy coloured underside and a typical long body. The head is long with a straight profile and forward-growing ears covering a long, tapering snout.

The *Nero Siciliano*, also called black swine of Nebrodi, is an autochthonous Sicilian breed of very ancient origin (Southern Italy). This pig is reared under extensive or semi-extensive management mainly in the Nebrodi mountains of the Messina province in the island of Sicily (Italy). This pig has a homogeneous black colour and medium-small in size. The pigs show a long snout and long limbs; very hard clogs allow them to move easily on different kinds of ground and have a kind of mane on the back which is raised when the animal is nervous. This pig is particularly appreciated for its mothering ability.

The *Sarda*, a heterogeneous local pig population,

is native to Sardinia. Very little demographic information is available in the National Pedigree Register, because of their recent recognition, but a survey from the mountain regions of Sardinia estimated in several thousands of pigs attributable to the *Sarda* breed (Franci and Pugliese, 2007).

The evolution of the size of six breeds over the four years shows (Table 1) a moderate increase for the smallest populations and a general decrease for the largest ones (e.g. *Cinta Senese*) which probably suffers the search for equilibrium with the niche market of its products. It is noticeable the low sows/boars ration increases the rearing cost in this system, but, on the other hand, it assures the maintenance of the genetic variability and can limit the increase of the inbreeding level, inevitable in small population. The natural mating, moreover, imposes the presence of at least one boar per herd, irrespective of the size. However, except the *Nero Siciliano* and *Sarda* breeds which maintained high genetic variability owing to effective population size (1500-2000 pigs for *Nero Siciliano* breed by Chiofalo and Liotta, 2003), for the other breeds there is urgent necessity to adopt mating management programmes with the aim to increase the genetic variability and to reduce the inbreeding; while for the *Nero Siciliano* in the near future there is the need to establish a sustainable breeding strategy with optimised selection programmes, including information from complete genetic characterization of its genetic pool (D’Alessandro et al., 2007); the individualization of morphological standard and the recovery of appropriate genotypes to fix the typical traits (Franci and Pugliese, 2007).

**Table 1. Demographic situation of Italian pig breeds according to National Register**

	Year	Apulo-Calabrese	Casertana	Cinta Senese	Mora Romagnola	Nero Siciliano	Sarda
Boars <sup>(1)</sup>	2004	20	12	258	41	29	-
	2005	18	11	231	60	34	-
	2006	20	21	189	54	30	-
	2007	15	29	222	77	49	6
Sows <sup>(2)</sup>	2004	53	26	1137	112	175	-
	2005	57	30	1031	128	148	-
	2006	71	68	916	144	173	-
	2007	78	87	998	178	286	6
Herds <sup>(3)</sup>	2004	7	4	220	33	21	-
	2005	7	9	195	36	24	-
	2006	13	16	161	37	23	-
	2007	9	13	158	37	21	2
Sows/boars	2004	2.65	2.17	4.41	2.73	6.03	-
	2005	3.17	2.73	4.46	2.13	4.35	-
	2006	3.55	3.24	4.85	2.67	5.77	-
	2007	5.2	3.0	4.49	2.31	5.84	1.0

<sup>(1)</sup>Males which mated at least once in the year; <sup>(2)</sup>Females which farrowed at least once in the year; <sup>(3)</sup>Herds with reproductive activity in the year.

**Table 2: Reproductive traits in the Italian pig breeds recorded by ANAS in 2007**

	Litter size at birth		Litter size at weaning	
	no.	$\mu \pm \text{s.d.}$	no.	$\mu \pm \text{s.d.}$
Cinta Senese	1278	7.04 $\pm$ 2.17	1218	6.25 $\pm$ 2.11
Casertana	120	7.55 $\pm$ 2.58	96	5.59 $\pm$ 2.40
Apulo-Calabrese	90	6.41 $\pm$ 2.88	76	4.99 $\pm$ 2.39
Mora Romagnola	220	7.21 $\pm$ 2.62	206	5.47 $\pm$ 2.53
Nero Siciliano	300	5.92 $\pm$ 2.25	143	6.45 $\pm$ 2.09
Sarda	6	8.83 $\pm$ 1.17	2	6.00 $\pm$ 2.83
Large White	9700	11.36 $\pm$ 2.66	7927	9.66 $\pm$ 1.83

Data on reproductive performances (litter size at birth and litter size at weaning) of the Italian autochthonous pigs is shown in table 2, as obtained by ANAS through the functional records of the National Register in the 2007. For comparison, the comparable data achieved for Large White is reported in the table. Compared to improved breeds such as Large White, Italian local pigs had lower reproductive traits probably due to both inbreeding depression and to poor management, besides the additive genetic effect. Similar results of reproductive performances were obtained from other Mediterranean pig breeds, i.e. the Iberian pig produces, on average, 6.45 and 6.07 piglets to birth and weaning, respectively (Barba *et al.*, 2001).

These breeds are adapted to poor breeding management, which is often linked to outdoor system, showing a great ability to utilise poor foods such as roots, tubers, acorns and spontaneous fruits which abound in mountains area. The autochthonous pigs are characterised by a strong resistance to illness, a zoo-technical adaptability to very different climatic conditions as well as the ability to procure food thanks to their strong inclination to grazing, high rusticity and energetic temperament.

In the past, the autochthonous breeds were highly valued mainly because of their high fat deposit as well as their productive performance, but the widespread introduction of cosmopolite breeds in Italy has dramatically reduced the number of these pigs which were not suited to the intensive, quantity-oriented and lean-type pig production system. Concerns over the preservation of genetic resources and the increasing number of consumers demanding typical meat products, linked to the local gastronomic tradition, suggest a new way of maintaining local breeds.

Unfortunately, information on productive performances of Italian local breeds and their meat characteristics is limited. This situation has encouraged some researchers to extend their knowledge on these breeds, reared also in intensive management, and to

compare their performances with commercial breeds.

It is commonly recognized that local pig breeds show slow growth and lower feed conversion, as well as high fat deposition than pigs of modern breeds (Serra *et al.*, 1998; Alfonso *et al.*, 2005). In accordance with reports, Acciaioli *et al.* (2002) and Franci *et al.* (2003) found an average daily gain gap of 30% between the *Cinta Senese* and Italian Large White pigs, and Pietrolà *et al.* (2006) reported a similar gap between the *Casertana* and the Large White pig. Furthermore, both *Cinta Senese* and *Casertana* showed a worse feed conversion for 1-2 kg of feed per kg of gain. However, we have recently noted (Maiorano *et al.*, 2006a, 2006b) in *Casertana* pigs fed with concentrates and reared in semi extensive environment (*plein air*), and slaughtered at 140 kg of live weight (about 11 months of age), a good level of growth (478 g/d) and good quality meat also from a technological point of view. A comparable growth was obtained on *Casertana* pigs (415 g/d) fed with diets formulated for the commercial pigs, reared indoors and slaughtered at 200 kg of live weight (500 days of age); however, it was fat and also showed a rapid decrease of average daily gain after 160 kg of live weight (Fortina *et al.*, 2005). Comparable average daily gain findings among *Mora Romagnola*, *Cinta Senese* and *Casertana* pigs were cited by Franci and Pugliese (2007); authors have also reported that *Calabrese* and *Nero Siciliano* pigs are characterized by lower growth rate, though the rearing system might have influenced their performance. Rearing and feeding systems have strong influence on growth performance. In fact, the *Cinta Senese*, *Apulo-Calabrese* and *Nero Siciliano* pigs show worsened growth performance when reared outdoors in comparison to indoors (Franci *et al.*, 2003; Cosentino *et al.*, 2003a; Pugliese *et al.*, 2003). This difference has been related to the discontinuous availability of feed (Acciaioli *et al.*, 2002) as well as the higher energy requirements necessary for physical exercise and thermoregulation in outdoor pigs (Enfält *et al.*, 1997).

As a consequence of slower growth rate, local

breeds reach a commercial slaughter weight (about 150 kg) at a considerably greater age than improved pigs and, of course, their rearing is very expensive. For example, studies comparing Large White and *Cinta Senese* pigs documented that the breeds reached the weight of 140 Kg in 225 and 325 days, respectively (Acciaioli *et al.*, 2002; Franci *et al.*, 2003; 2005). However, data (Colatruglio *et al.*, 2000) on dressing percentage involving local breeds did not highlight differences among *Apulo-Calabrese*, *Cinta Senese* and *Nero Siciliano* breeds, which was 80.90% on average. Similar values of dressing out were found for *Mora Romagnola* and *Casertana* pigs slaughtered at 200 kg of live weight (Fortina *et al.*, 2005). These results are comparable with findings of Pietrolà *et al.* (2006) as they recorded a dressing of 81.40% in *Casertana*, compared to 79.80% for Italian Large White pigs. The higher dressing percentage in unimproved breeds confirms the findings on European autochthonous breeds, suggesting that dressing percentage is positively influenced by fatness (Serra *et al.*, 1998; Labroue *et al.*, 2000).

We investigated skeletal development, which plays a significant role in carcass and meat quality (Field *et al.*, 1990), in *Cinta Senese* (Filetti *et al.*, 2003) and *Casertana* (Maiorano *et al.*, 2006a) breeds. We found that these breeds possess smaller and lighter metacarpal bones than that of improved pigs and that the *Cinta Senese* have a wider growth plate (the site of the longitudinal bone growth) than that of Large White pigs (0.45 versus 0.33 mm, respectively), indicating slower bone ossification. These substantial differences in skeletal development condition muscle growth and fat deposition (Maiorano *et al.*, 2002).

Literature documents the aptitude for strong adipogenic ability of the unimproved breeds (Serra *et al.*, 1998; Labroue *et al.*, 2000; Fortina *et al.*, 2005; Maiorano *et al.*, 2007). It is well known that in some muscles of local breeds the fat content can reach values significantly higher than those reported for improved breeds (Franci and Pugliese, 2007). Several works, comparing Italian improved and unimproved pig breeds (Franci *et al.*, 2003, 2005; Pugliese *et al.*, 2003; Maiorano *et al.*, 2006a; Pietrolà *et al.*, 2006), reported that the latter, slaughtered at different ages and weights, produce greater fat deposition (e.g.: *Casertana* 4.5÷5.1 cm of backfat thickness; *Nero Siciliano* 5.0 cm of backfat thickness) as well as greater incidence of separable fat cuts (e.g. 39.0 and 31.4% for *Cinta Senese* and *Casertana*, respectively). This considerable difference is likely to be due to the fact that the local breeds had never been selected using modern instruments and with the modern goals of fast growth rate and lean meat production.

Very few studies on the lipid profile of Italian pigs meat have been published, and available data generally are not directly comparable because they refer to animals

of different age/weight at slaughter, fed different diets and reared with different systems, or because they are determined on different muscles, or using different analytical methods. However, in agreement with Gandemer *et al.* (1990), local breeds should have higher predisposition to depot oleic acid whereas improved breeds deposit higher quantities of saturated fatty acids or, in the case of extreme leanness, of linoleic acid. These results are validated in the comparison between *Cinta Senese* and Large White reared in the similar rearing conditions (Franci *et al.*, 2005). In fact, it is interesting to note that *Cinta Senese* fat, compared to Large White fat, is characterized by greater predisposition to deposit oleic acid and less saturated and polyunsaturated fatty acids; it could be due to differences in *de novo* lipid synthesis and turnover between the two breeds (Franci *et al.*, 2005). As a consequence, *Cinta Senese* fat had a low index of thrombogenicity (TI) and atherogenicity (AI), which respectively indicate the risk of increase of serum lipid and an excess of platelet activity (Ulbricht and Southgate, 1991). Comparisons among European autochthonous breeds and selected breeds are in accordance with these results (Serra *et al.*, 1998; Labroue *et al.*, 2000). The capacity of unimproved breeds to deposit monounsaturated acids increases with age, as opposed to improved breeds which tend to deposit more saturated fatty acids (Edwards, 2005). In our recent report (Salvatori *et al.*, 2008) on *Casertana* pig and its crossbreed (*Casertana* x Large White), reared under semi-extensive conditions and slaughtered at two different live weights, we observed that backfat from *Casertana* cross displayed a better fatty acid profile than that of pure *Casertana*, showing higher PUFA/SFA ratio. In addition, we have also observed that meat from heavy pigs (150 kg of live weight) presents a better fatty acid profile with respect to light pigs (130 kg of live weight), because of the higher PUFA to SFA ratio, as well as the lowest AI, TI and SFA/UFA ratio, and a lower cholesterol muscle concentration. These findings confirm that both the profile of fatty acid deposition and cholesterol content of the meat changes during growth (Kloareg *et al.*, 2007; Maiorano *et al.*, 2007). It is well-known that the extensive rearing system improves the dietetic property of fat, without lowering its technological properties (Lopez-Bote, 1998). In fact, the adipose tissue of *Nero Siciliano* and *Cinta Senese* pigs reared in woods is characterized by a high content unsaturated fatty acids (Cosentino *et al.*, 2003b; Pugliese *et al.*, 2004, 2005).

Compared to improved breeds, Italian local pigs are characterized by meat with higher dry matter (24.5÷26.8%) and overall lipid (9.5÷11.9% on DM) contents, higher energy values (4.3 kcal/g of DM) and lower proteins (84.6÷85.7% on DM) (Zullo *et al.*, 2003; Franci *et al.*, 2005).

In regards to meat quality traits there are little

available findings but some considerations are possible. The Italian local pig breeds seem to be free from the halothane gene, as reported by Matassino *et al.* (2000). However, in *Nero Siciliano* and in *Cinta Senese* Russo *et al.* (2004) and Croveti *et al.* (2007), respectively, found a very low frequency of 1843T allele at RYR1 locus. These investigations indicate the possibility of some introgression of the HAL gene from the commercial breeds (Landrace or Pietrain) into several local breeds and suggest the importance of recovering the primitive germoplasm and of monitoring the local populations to avoid the use of indiscriminate crossbreeding, as it happened during the period of severe reduction of their size (Franci and Pugliese, 2007). Regarding other candidate genes for meat quality traits, the condition of the Italian local pigs in comparison with the improved breeds is less detailed (Davoli *et al.*, 2006; Croveti *et al.*, 2007), however, Croveti *et al.* (2007) reported that all the *Cinta Senese* animals checked were homozygous for the R200 allele of the PRKAG3 gene confirming the absence of the acid meat defect (RN-) in the breed.

As regards the technological parameters of meat, in accordance with the greater part of the literature, Franci *et al.* (2005) found the parameter  $pH_{24}$  values higher in *Cinta Senese* pigs than in Large White, suggesting that local breeds have slower rates of post-mortem pH decline. Furthermore, they observed that the local pigs had lower cooking loss than selected pigs, determining lower loss during salting and seasoning of ham. In this trial, however, no animals exceeded the threshold of 6.2 for  $pH_{24}$ , over which the meat is classified DFD.

Colour of pork is strongly associated with expected meat quality (Bredahl *et al.*, 1998). In accordance with literature, Franci *et al.* (2005) and Maiorano *et al.* (2006b) found the meat of *Cinta Senese* and *Casertana* pigs, respectively, more intensively coloured than Large White and cross Large White x *Cinta Senese* meat, because of the greater red contribution. They also observed the lower hue value for unimproved pigs that made their meat more acceptable than that of the other genotypes. In another study on *Nero Siciliano*, comparing the outdoor and indoor systems, Pugliese *et al.* (2004) reported that outdoor-pigs produced lighter and more yellow meat, probably due to their higher intramuscular fat content.

Meat from local pigs is tougher than that of improved pigs, as indicated by a Warner-Bratzler shear force measure (Franci *et al.*, 2005) that appears to be directly related to collagen content (De Smet *et al.*, 1998) and crosslinking (Maiorano *et al.*, 2003). Hydroxylslypyridinoline (HLP) concentration, the principal non-reducible crosslink of muscle collagen (McCormick, 1999), indicating the degree of collagen maturation, plays an import role on yield from a technological point of view on the pork (Boutten *et al.*, 2000).

In our recent study (Maiorano *et al.*, 2006b), we observed that *Casertana* pig, compared to Italian Large White breed, exhibits a more mature intramuscular collagen (0.187 *versus* 0.081, mol HLP/mol of intramuscular collagen), meat with more HLP crosslink (5.30 *versus* 2.60  $\mu$ g HLP/mg of muscle) and less collagen content (19.88 *versus* 24.90,  $\mu$ g of intramuscular collagen/mg of lyophilized tissue). Differences in collagen properties between local and improved pigs are due to genetic effect (Lebret *et al.*, 2001) and could be due to different growth rate too (McCormick, 1994; Harper, 1999; Maiorano *et al.*, 2001). We suggested that *Casertana* pigs produced meat that could be tougher than that of the improved breed, but more acceptable from the technological point of view.

#### REFERENCES

- ACCIAIOLI, A. – PUGLIESE, C. – BOZZI, R. – CAMPODONI, G. – FRANCI, O. – GANDINI, G. 2002. Productivity of *Cinta Senese* and Large White x *Cinta Senese* pigs reared outdoor on woodlands and indoor. 1. Growth and somatic development. *Italian Journal of Animal Science*, 1, 2002, p. 171-180.
- ALFONSO, L. – MOUROT, J. – INSAUSTI, K. – MENDIZABAL, J. A. – ARANA, A. 2005. Comparative description of growth, fat deposition, carcass and meat quality characteristics of Basque and Large White pigs. *Animal Research*, vol. 54, 2005, p. 33-42.
- ANAS. 2008. Home page address: <http://www.anas.it/>, access data: 12-12-2008.
- BARBA, C. – DELGADO, J. V. – SERENO, J. R. B. – DIEGUEZ, E. – FORERO, J. – JAUME, J. – PEINADO, B. 2001. Performances of the Iberian and other local breeds of Spain. In: Ollivier L., Labroue F., Glodek P., Gandini G., Delgado J. V. editors. Pig genetic resources in Europe. Wageningen Pers., 2001, p. 77-83.
- BOUTTEN, B. – BRAZIER, M. – MORCHE, N. – MOREL, A. – VENDEUVRE, J. L. 2000. Effects of animal and muscle characteristics on collagen and consequences for ham production. *Meat Science*, vol. 55, 2000, p. 233-238.
- BREDAHL, L. – GRUNERT, K. G. – FERTIN, C. 1998. Relating consumer perceptions of pork quality to physical product characteristics. *Food Quality and Preference*, vol. 9, 1998, p. 273-281.
- CHIOFALO, L. – LIOTTA, L. 2003. Suino nero, una perla in terra siciliana. *Suinicoltura*, vol. 44(10), 1998, p. 79-86.
- COLATRUGLIO, P. – ESPOSITO, D. F. – FORNATARO, D. – CAPONE, A. – ZULLO, A. – MATASSINO, D. 2000. Some aspects of meat production in pig autochthonous genetic types. 1. Data at slaughtering, jointing of carcass and tissue separation. In Afonso de Almeida J. A. (ed.), Tirapicos Nunes J. L. (ed.). *Tradition and innovation in Mediterranean pig production*. Zaragoza : CIHEAM-IAMZ, 2000, p. 275-278.
- COSENTINO, E. – MORANO, F. – CAPPUCCIO, A. – FRESCHI, P. 2003a. Zootechnical performances of Calabrese pigs reared in free range management. *Italian Journal of Animal Science*, 2, 2003, p. 403-405.
- COSENTINO, E. – POIANA, M. – IULA, C. – PERNA, A.

- 2003b. Acidic composition in Italian local pigs backfat: comparison between indoor and outdoor rearing. *Italian Journal of Animal Science*, 2, 2003, p. 406-408.
- CROVETTI, A. – BOZZI, R. – NARDI, L. – FRANCI, O. – FONTANESI, L. 2007. Assessment of variability of genes associated with meat quality traits in Cinta Senese pigs. *Italian Journal Animal Science*, 6 (Suppl. 1), 2007, p. 101 – 101.
- DAVOLI, R. – FONTANESI, L. – BRAGLIA, S. – NISI, I. – SCOTTI, E. – BUTTAZZONI, L. – RUSSO, V. 2006. Investigation of SNPs in the ATP1A2, CA3 and DECR1 genes mapped to porcine chromosome 4: analysis in groups of pig divergent for meat production and quality traits. *Italian Journal Animal Science*, 5, 2006, p. 249-263.
- D’ALESSANDRO, E. – FONTANESI, L. – LIOTTA, L. – DAVOLI, R. – CHIOFALO, V. – RUSSO V. 2007. Analysis of the MC1R gene in the Nero Siciliano pig breed and usefulness of this locus for breed traceability. *Veterinary Research Communications*, vol. 31 (Suppl. 1), 2007, p. 389-392.
- DE SMET, S. – CLAEYS, E. – BUYASSE, G. – LENAERTS, C. – DEMEYER, D. 1998. Tenderness measurements in four muscles of Belgian Blue normal and double-muscle bulls. Proceedings of the 44th international congress of meat science and technology. Barcelona, Spain, 30 August-4 September 1998, 288-298.
- EDWARDS, S. A. 2005. Product quality attributes associated with outdoor pig production. *Livestock Production Science*, vol. 94, 2005, p. 5-14.
- ENFÄLT, A. C. – LUNDSTRÖM, K. – HANSSON, I. – LUNDEHEIM, N. – NYSTRÖM, P. 1997. Effects of outdoor rearing and sire breed (Duroc or Yorkshire) on carcass composition and sensory and technological meat quality. *Meat Science*, vol. 45, 1997, p. 1-15.
- FIELD, R. A. – MAIORANO, G. – MCCORMICK, R. J. – RILEY, M. L. – RUSSEL, W. C. – WILLIAMS, jr. F. L. – CROUSE, J. D. 1990. Effect of plane of nutrition and age on carcass maturity of sheep. *Journal of Animal Science*, vol. 68, 1990, p. 1616-1623.
- FILETTI, F. – MAIORANO, G. – GAMBACORTA, E. – PALAZZO, M. – MANCHISI, A. 2003. Effects of rearing system and genotype on skeletal growth and carcass traits of pigs. *Italian Journal of Animal Science*, 2 (Suppl. 1), 2003, p. 382-384.
- FORTINA, R. – BARBERA, S. – LUSSIANA, C. – MIMOSI, A. – TASSONE, S. – ROSSI, A. – ZANARDI, E. 2005. Performance and meat quality of two Italian pig breeds fed diets for commercial hybrids. *Meat Science*, vol. 71, 2005, p. 713-718.
- FRANCI, O. – CAMPODONI, G. – BOZZI, R. – PUGLIESE, C. – ACCIAIOLI, A. – GANDINI, G. 2003. Productivity of Cinta Senese and Large White x Cinta Senese pigs reared outdoors in woodlands and indoors. 2. Slaughter and carcass traits. *Italian Journal of Animal Science*, 2, 2003, p. 59-65.
- FRANCI, O. – BOZZI, R. – PUGLIESE, C. – ACCIAIOLI, A. – CAMPODONI, G. – GANDINI, G. 2005. Performance of Cinta Senese pigs and their crosses with Large White. 1. Muscle and subcutaneous fat characteristics. *Meat Science*, vol. 69, 2005, p. 545-550.
- FRANCI, O. – PUGLIESE, C. 2007. Italian autochthonous pigs: progress report and research perspectives. *Italian Journal Animal Science*, 6 (Suppl. 1), 2007, p. 663-671.
- GANDEMER, G. – PICHOU, D. – BOUGUENNEC, B. – CARITZ, J. C. – BERGE, P. – BRIANT, E. – LEGAULT, C. 1990. Influence du system d’evilage et du genotype sur la composition chimique et les qualites organoleptiques du muscle long dorsal chez le porc. *Journées Recherche Porcine en France*, vol. 22, 1990, p. 101-110.
- HARPER, G. S. 1999. Trends in skeletal muscle biology and the understanding of toughness in beef. *Australian Journal of Agricultural Research*, vol. 50, 1999, p. 1105-1129.
- KLOAREG, M. – NOBLET, J. – van MILGEN, J. 2007. Deposition of dietary fatty acids, de novo synthesis and anatomical partitioning of fatty acids in finishing pigs. *British Journal of Nutrition*, vol. 97, 2007, p. 35-44.
- ISTAT. 2008. Home page address: <http://www.istat.it/>, access data: 12-12-2008.
- ISTAT-ISMEDIA. 2008. Home page address: <http://www.istat.it/agricoltura/datiagri/consistenza/elecns.html>, access data: 12-12-2008.
- ISTITUTO PARMA QUALITÀ 2008. <http://www.ineq-ipq.it>, access data: 2-12-2008.
- LABROUE, F. – GOUMY, S. – GRUAND, J. – MOUROT, J. – NEELZ, V. – LEGAULT, C. 2000. Comparison au Large White de quatre races locales porcine françaises pour les performance de croissance, de carcasse et de qualité de la viande. *Journées Recherche Porcine en France*, vol. 32, 2000, p. 403-411.
- LEBRET, B. – JUIN, H. – NOBLET, J. – BONNEAU, M. 2001. The effects of two methods of increasing age at slaughter on carcass and muscle traits and meat sensory quality in pigs. *Animal Science*, vol. 72, 2001, p. 87-94.
- LOPEZ-BOTE, C. J. 1998. Sustained utilization of the Iberian pig breed. *Meat Science*, vol. 49, 1998, S17-S27.
- MAIORANO, G. – FILETTI, F. – SALVATORI, G. – GAMBACORTA, M. – BELLETTI, A. – ORIANI, G. 2001. Growth, slaughter and intra-muscular collagen characteristics in Garganica kids. *Small Ruminant Research*, vol. 39, 2001, p. 289-294.
- MAIORANO, G. – FILETTI, F. – GAMBACORTA, M. – CENTODUCATI, P. – PRISCIANTELLI, A. – CIARLARIELLO, A. 2002. Influence of genotype on lamb meat quality. 1. Carcass and meat qualitative traits. Proceedings 48th International Congress of Meat Science and Technology (Vol. 1) Roma, Italy, August 2002, 342-343.
- MAIORANO, G. – FILETTI, F. – GAMBACORTA, M. – CIARLARIELLO, A. – CAVONE, C. 2003. Effects of rearing system and genotype on intramuscular collagen properties of pigs. *Italian Journal of Animal Science*, 2(Suppl. 1), 2003, p. 385-387.
- MAIORANO, G. – PAOLONE, K. – CAVONE, C. – PIETROLÁ, E. – D’ANDREA, M. – STEFANON, B. 2006a. Growth and slaughter performance of Casertana, Italian Large White and Duroc x Italian Large White-Landrace pigs reared outdoors. IIIrd International Conference on application of scientific achievements in the field of genetics, reproduction, nutrition, carcass and meat quality in modern pigs production. Ciechocinek, Poland, June 2006.
- MAIORANO, G. – COSTANZA, L. – CAVONE, C. – PILLA, F. – GAMBACORTA, M. – MANCHISI, A. 2006b. Meat quality of Casertana, Italian Large White

- and Duroc x Italian Large White-Landrace pigs reared outdoors. IIIrd International Conference on application of scientific achievements in the field of genetics, reproduction, nutrition, carcass and meat quality in modern pigs production. Ciechocinek, Poland, June 2006, p. 32-36.
- MAIORANO, G. – CAVONE, C. – PAOLONE, K. – PILLA, F. – GAMBACORTA, M. – MANCHISI, A. 2007. Effects of slaughter weight and sex on carcass traits and meat quality of Casertana pigs reared outdoors. *Italian Journal Animal Science*, 6 (Suppl. 1), 2007, p. 698-700.
- MATASSINO, D. – DAVOLI, R. – OCCIDENTE, M. – MILE, J. – CAIOLA, G. – ROCCO, M. – RUSSO, V. 2000. Identificazione del genotipo per la sensibilità all'alotano in alcuni tipi genetici autoctoni. In: Alfonso De Almeida J. A., Tirapicos Nunes J. L. editors. *TYradition and innovation in Mediterranean pig production*. Option Méditerranéennes, 2000, A41, 265 p.
- McCORMICK, R. J. 1994. The flexibility of the collagen compartment of muscle. *Meat Science*, vol. 36, 1994, p. 79-91.
- McCORMICK, R. J. 1999. Extracellular modifications to muscle collagen: implications for meat quality. *Poultry Science*, vol. 78, 1999, p. 785-791.
- PIETROLÁ, E. – PILLA, F. – MAIORANO, G. – MATASSINO, D. 2006. Morphological traits, reproductive and productive performances of Casertana pigs reared outdoors. *Italian Journal of Animal Science*, vol. 5, 2006, p. 55-62.
- PUGLIESE, C. – MADONIA, G. – CHIOFALO, V. – MARGIOTTA, S. – ACCIAIOLI, A. – GANDINI, G. 2003. Comparison of the performances of Nero Siciliano pigs reared indoors and outdoors. 1. Growth and carcass composition. *Meat Science*, vol. 65, 2003, p. 825-831.
- PUGLIESE, C. – CALAGNA, G. – CHIOFALO, V. – MORETTI, V. M. – MARGIOTTA, S. – FRANCI, O. – GANDINI, G. 2004. Comparison of the performances of Nero Siciliano pigs reared indoors and outdoors. 2. Joints composition, meat and fat traits. *Meat Science*, vol. 68, 2004, p. 523-528.
- PUGLIESE, C. – BOZZI, R. – CAMPODONI, G. – ACCIAIOLI, A. – FRANCI, O. – GANDINI, G. 2005. Performance of Cinta Senese pigs reared outdoors and indoors. 1. Meat and subcutaneous fat characteristics. *Meat Science*, vol. 69, no.3, 2005, p. 459-464.
- RUSSO, V. – FONTANESI, L. – DAVOLI, R. – CHIOFALO, L. – LIOTTA, L. – ZUMBO, A. 2004. Analysis of single nucleotide polymorphisms in major and candidate genes for production traits in Nero Siciliano pig breed. *Italian Journal Animal Science*, 3, 2004, p. 19-29.
- SALVATORI, G. – FILETTI, F. – DICESARE, C. – MAIORANO, G. – PILLA, F. – ORIANI, G. 2008. Lipid composition of meat and backfat from Casertana purebred and crossbred pigs. 2008. *Meat Science*, vol. 80, 2008, p. 623-631.
- SERRA, X. – GIL, F. – PEREZ-ENCISO, M. – OLIVER, M. A. – VAZQUEZ, J. M. – GISPERT, M. – D'YAZ, I. – MORENO, F. – LATORRE, R. – NOGUERA, J. L. 1998. A comparison of carcass, meat quality and histochemical characteristics of Iberian (Guadyrbas line) and Landrace pigs. *Livestock Production Science*, vol. 56, 1998, p. 215-223.
- TONINI, G. 1953. La razza suina mora e i suoi derivati di incrocio. Stabilimento Grafico F. Lega, Faenza. very old
- ULBRICHT, T. L. V. – SOUTHGATE, D. A. T. 1991. Coronary heart disease: seven dietary factors. *The Lancet*, 338, 1991, p. 985-995.
- ZULLO, A. – BARONE, C. M. A. – COLATRUGLIO, P. – GIROLAMI, A. – MATASSINO, D. 2003. Chemical composition of pig meat from the genetic type 'Casertana' and its crossbreeds. *Meat Science*, vol. 63, 2003, p. 89-100.