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Abstract. Meat quality characteristics of Mediterranean pigs as affected by genetic and environmental effect are summarised and discussed. From the recent literature it is evident that the Mediterranean local breeds have interesting quality of meat and fat respect to the improves one. The link with free-range rearing increases the commercial value of products of local pigs, because of both effective characterization and consumer suggestion, research is helpful to increase the knowledge of their rearing system.

Keywords. Mediterranean autochthonous pigs – Meat quality – Free range – Dry-cured products.

Qualité de la viande des produits secs des porcs autochtones méditerranéens

Résumé. *Les effets du type génétique et du système d'élevage sur les caractéristiques de la qualité de la viande et des produits secs des races porcines autochtones méditerranéennes ont été examinés. La littérature récente montre que les races porcines ont des paramètres qualitatifs de la viande et de la graisse qui sont souvent supérieurs à ceux des porcs améliorés. Le lien avec le troupeau sauvage augmente la valeur commerciale des produits du porc local, en raison de la forte caractérisation et de la suggestion du consommateur qui en résulte.*

Mots-clés. *Races porcines indigènes méditerranéennes – Qualité de la viande et des produits secs – En plein-air.*

I – Introduction

In the countries of the Mediterranean area there is a increasing interest for autochthonous pig as the numerous scientific trials reviewed in this paper demonstrate. In the web site of FAO (http://dad.fao.org/), is shown the list of local breeds in the main Mediterranean countries.

1. The main local pigs in the Mediterranean area

In Croatia the main local breed is the Black Slavonian created in the second half of the 19th century. Until the 1950s it was the most widespread breed in the Slavonia, mainly used for the production of fat and meat products. Recently, the population was drastically reduced and in 1990s the survival of the breed was endangered. Due to current protection measures the effective population rather increased; in 2006 there were 46 boars and 604 sows. The breed is well adopted for outdoor keeping (Karolyi *et al*., 2007). In France, at the present, the main local breeds of interest are: the Porc Blanc de l'Ouest, the Porc Limousin, the Porc Gascon, the Porc de Bayeaux, the Porc Basque and the Porc Nustrale (ex Porc Corse).

The conservation of these breeds is intended, as in other European countries, to maintain genetic variation within-breeds and to obtain economics advantages through the obtainment of high quality products. As regard Greek pig, it is one of the oldest Mediterranean pig breeds. Currently its rearing is expanding, due also to public subsidies to the farmers. In the years 70-90s it faced the extinction because of the strong competition of improved genotypes and crossbreeding with wild boars. Although the extinction risk is still considerable, at present the

statistics report the presence of approximately 350 sows and a total population of 2000 black pigs. In Italy, among the several local pigs listed by FAO (Table1), only six autochthonous swine breeds are, at the present, well survived to the well-known problems linked to the social-economical transformations of the agricultural world happened in the last century; they are: Apulo-Calabrese, Casertana, Cinta Senese, Mora Romagnola, Nero Siciliano and Sarda.

Table 1. Local breeds of some Mediterranean countries listed by FAO(http://dad.fao.org/).

France	Italy	Spain
Bayeux	Apulo-Calabrese	Celta
Blanc del'Ouest	Bergamasca nera	Chato Murciano
Carélie	Casertana	Gochu Asturcelta
Corse	Cinta Senese	Iberico
Creole	Macchiaiola Maremmana	Ibérico (Dorado Gaditano)
Gallia	Mora Romagnola	Ibérico (Mamellado)
Gasconne	Napoletana Fulva	Ibérico (Negro Entrepelado)
Pie Noir du Pays Basque	Nero dei Lepini	Ibérico (Negro Lampiño)
Porc de Saint Yriex	Nero dei Monti Dauni Meridionali	Iberico (Retinto)
	Nero Reatino	Ibérico (Torbiscal)
	Nero Siciliano	Manchada de Jabugo
	Parmigiana Nera	Negra Canaria
	Pugliese	Negra Mallorquina
	Sarda	
	Siciliano	
	Suino dei Nebrodi e Madonie	

Greece: Greek; **Portugal:** Alentejana and Bisaro; **Slovenia:** Krskopolje; **Croatia:** Black Slavonian and Turopolje

These breeds have been recognised with the establishment of the Anagraphic Register. The recovery of genetic variability represent an indubitable vantage for breeders; through the valorisation and characterization of autochthonous breeds they can offers at consumers products with high added value. Moreover Italian consumers have an increasing interest toward "niche products". Besides those reported by FAO (Table 1), in Portugal are officially reared three breeds of local pigs: Bisara, Malhado de Alcobaça and Alentejano. In recent years there has been a consolidation and expansion of Portuguese local pig and many changes in production, processing and marketing are taking place. In Slovenia the only autochthonous breed of pig is the Krskopolje, or "blackbelted", who's origin is the south-eastern part of the Slovene region of Dolenjska. This is an extensive breed, whose characteristics are resistance, good adaptability to poor rearing and feeding conditions and excellent meat quality. In Spain, besides some local breeds are at present reared, the Iberian breed is certainly the most famous pig and it can be considered the best example of the strong cooperation among public institutions, producers and scientific world.

In recent years productive performances of Mediterranean autochthonous breeds have been investigated by several Authors, that take into account many affecting factors. This paper will discuss only the trials that consider the effect of genotype and rearing system being the latter the main factors that affect quality of products of local breeds.

II – Quality of meat and cured products

The Mediterranean pig breeds are reared with different modalities that go from systems that, even if outdoor, foreseen the total food supply with concentrate, to more extensive systems up to the rearing where the fattening phase is carried out using only the spontaneous resources of the wood. The latter is the typical example of the "Montanera" system where the Iberian pig are reared in the "Dehesa" (López-Bote, 1998) and of the "Montados" for local Portuguese pigs (Tirapicos-Nunes, 2007). In the extensive pig production of the Mediterranean area the genotype-environment interactions result in measurable effects on pig meat quality (Edwards and Casabianca, 1996).

1. Effect on quality of lipids

As previously pointed out, the outdoor rearing of local pigs is carried out almost on pasture in forest, so it is very different from the classic outdoor system used for improved pig where feeding is based on commercial feed. Consequently, the effect of food source, especially on the quality of lipids, is very strong (Table 2). As reported by various Authors (Dìaz *et al.*,1996; Coutron-Gambotti *et al.*, 1998; Andrés *et al.*, 2001; Cava *et al.*, 1999a-2000a), the adipose tissue of outdoor-pigs reared in woods is characterised by a high content of unsaturated fatty acids. Coutron-Gambotti *et al*. (1998) found higher percentage of polyunsaturated and monounsaturated fatty acids in Corsican pigs fed chestnuts than commercial diet. In the Iberian pigs fed acorn higher MUFA (primarily oleic acid) and lower SFA contents (primarily palmitic and stearic acid) were found both in intramuscular fat (Cava *et al*., 1999a; Cava *et al*., 2000a; Andrés *et al*., 2001) and in backfat (Díaz *et al*., 1996). This result is consistent with the data on Italian breeds Nero Siciliano (Chiofalo *et al*., 2007) and Cinta Senese (Pugliese *et al*., 2005).

Table 2. Effect of pasture on fatty acid composition

Author	Rearing system	C18:1	C18:2	C18:3
Díaz *et al*., 1996, on Iberico (fresh fat)	Acorn + grass	57.1	9.4	
	Concentrate	47.4	8.3	
Andrés *et al*., 2001, on Iberico (TG of fresh BF)	Acorn + grass	53.4	5.6	0.3
	Concentrate	50.7	6.4	0.3
Cava *et al*., 2000, on Iberico (TG of fresh BF)	Acorn + grass	55.1	5.66	0.68
	Concentrate	51.9	5.02	0.64
Pugliese *et al*., 2005, on Cinta Senese (fresh fat)	Pasture on wood (chestnut + acorn + grass)	52.8	11.6	0.87
	Concentrate	50.3	9.5	0.32
Pugliese *et al*., 2009, on Cinta Senese (dry-cured ham)	Acorn	50.8	12.2	0.8
	Chestnut	48.4	13.6	1.0
	Concentrate	46.2	14.6	0.84
Pérez-Palacios *et al*., 2010, on Iberico (dry-cured ham)	Acorn + grass	53.2	6.96	0.64
	High Oleic Concentrate	48.8	5.75	0.27
		MUFA	**PUFA-n3**	**PUFA -6**
Chiofalo *et al*., 2007, on Nero Siciliano (fresh fat)	Traditional diet	49.1	0.94	9.08
	Concentrate	47.6	0.77	10.62

The latter, in addition, showed an higher PUFA content in outdoor, probably because of the contemporary pasture on chestnuts and acorn during fattening. It is well known that chestnuts have higher contents of polyunsaturated fatty acids in comparison to acorns (Coutron-Gambotti *et al*., 1998; López-Bote, 1998). Also Sirtori *et al.*, (2008) found that the substituting concentrate for chestnut affects significantly the fat quality. Chestnut supply led to more unsaturation level of adipose tissue due to the highest PUFA and MUFA content. Another source of PUFA in free range conditions is the grass that, as reported by Muriel *et al*. (2002), is characterized by high levels of linolenic acid. These authors concluded that free-range leads to increasing levels of total n-3 PUFA in neutral and polar lipids and of individual n-3 PUFA, including EPA and DHA.

The effect of pasture on acorn-wood is not the same of the administration of acorn in confinement rearing system. In fact, Zumbo *et al*. (2007a), on *Longissimus lomborum* of Nero Siciliano pigs, found an higher content of MUFA an lower of PUFA in animals fed acorn respect to pigs fed barley. As regard α- and γ-tocopherols they are provided by the free range system and contribute as antioxidants to prevent lipid oxidation even if it seems that the tocopherol accumulation is not modified by the rearing system but by the type of feeding (Rey *et al*., 2006). On Alentejano pigs Neves *et al*. (2007) found a higher level α-tocopherols in pigs reared extensively respect to those reared in intensive condition.

The effect of the extensive rearing system on fatty acid composition of lipids remain also on seasoned products, as confirmed by a wide literature on several autochthonous breeds. Antequera *et al*. (1992) and Cava *et al*. (2000b) reported, in Iberian ham, high concentration of oleic acid supported by acorn pastures that, together with the typical marbling of the meat, is considered essential for appropriate ripening and flavour development of dry-cured products. In some cases the effect of pasture in wood on fatty acid profile was more strong on dry-cured product than on fresh meat. So, Pérez-Palacios *et al*. (2010) found that feeding acorn respect feedstuff with high oleic determined higher MUFA and PUFA content on intramuscular fat of Iberian dry-cured ham, but no effect on fresh meat of the same animals (Pérez-Palacios, 2009). Similar effect of pasture on wood was found on the fatty acid profile of dry-cured product of Cinta Senese pigs (Pugliese *et al*., 2009) where a higher content of MUFA (primarily oleic acid) in seasoned fat of pastured animals were found. The strong genotype X rearing interaction, and the consequent differences in lipids fatty acid composition, is well exploited for Iberian pig products which are classified according to their fatty acid composition to discriminate the commercial value in three commercial types: Montanera, Recebo and Cebo (López-Bote, 1998).

In this regard, to ensure the consumer against fraud, inspection controls are carried out. They are based upon "on farm" inspector visits and fatty acid analysis done in one fat sample taken from a group of animals from the same producer. That system is very time consuming and expensive, and not objective enough to fulfil the increasing consumer demands from regional, national, and international markets (Garrido and De Pedro-Sanz, 2007). For these reason many researches are carried out to try to found new innovative methods of traceability, such as NIRS technology (Pérez-Marín *et al*., 2009), electronic nose (Garcia *et al*., 2003) and neophytadiene content (Tejeda *et al*., 2001).

2. Effect on volatile compounds and sensorial traits

Many researches were carried out on the effect of rearing system effect on volatile compounds of dry-cured products identified by gas chromatography-mass spectrometry analysis (GC-MS) procedures. The effect of rearing system on Iberian ham volatile compounds has been studied (Carrapiso *et al*., 2003; Cava *et al*., 1999; López *et al*., 1992; Jurado *et al*., 2007; Jurado *et al*., 2009) but contradictory results have been reported. As shown by Jurado *et al*. (2007), there are a lot of factors that could influence volatile compounds in relation to rearing system, such as the concentrate composition and the Montanera feeding period length. They could cause a great heterogeneity in the results.

Up to now a great effect of rearing system on volatile compounds has been found when feeding composition is clearly different. In fresh and in seasoned lard of Nero Siciliano pigs fed acorn (Zumbo *et al*., 2007b) and in salami (Zumbo *et al.*, 2007c) and dry-cured ham (Pugliese *et al.*, 2009) of Cinta Senese pigs fed acorn, a significant effect of feeding regime on volatile compound was found. In the last years further analytical techniques of detection of volatile compounds has been developed. Some powerful odorants found in meat systems exist at concentrations too low to allow their identification by the usual gas chromatography-mass spectrometry (GC-MS) procedures while gas chromatography associated with olfactometry (GC-O) could be a useful tool to identify and characterize the odour-active compounds. GC-O may be used to research aroma differences, because samples with different sensory profiles show differences in their odour-active compounds; in addition, odours detected during GC-O could be related to sensory attributes (Carrapiso *et al*., 2002).

In Iberian ham significant differences in the olfactometric profile between pigs fed acorn or commercial feedstuff were found, even if there was not a single contributor to the two feeding systems odours; odour and aroma differences seem to be caused by differences in the concentration of some odour-active compounds (Carrapiso *et al*., 2002). Garcìa-Gonzales *et al*. (2009) carried out a study on the relationship between odours, flavour sensory attributes and volatile compounds in Iberian hams from diverse geographical origins. Also in other Mediterranean products the olfactometric profile was defined, such as in Serrano ham in Spain (Flores *et al*., 1997).

In order to explain how some chemical characteristics, affected by rearing system, can influence the sensorial traits of dry-cured products, many researches are recently focused on the study of relationships between sensorial traits and lipids composition. Carrapiso *et al*. (2003), with regard to the relationships between sensory profile and subcutaneous fatty acid composition, found that palmitic and oleic acid were the most significantly correlated to the largest number of sensory traits. Moreover, large correlations appeared between stearic and oleic acids and brightness, oiliness, juiciness, sweetness, fat hardness and cured aroma of Iberian dry-cured ham. The effect of rearing system on volatile compounds, above stressed, is reflecting also on sensorial traits being a significant correlations between these traits. As reviewed by Gandemer (2009), positive aroma notes, such as "cured ham", or "aged" aroma notes, have been correlated to either branched aldehydes arising from aminoacids degradation or methylketones arising from lipid oxidation; rancid aroma is correlated to oxidation products, mainly to aldehydes such as nonanal and 2-hexanal which exhibit a strong rancid odour.

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