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PRODUCTIVE PERFORMANCES OF TWO ITALIAN CROSSBRED PIGS FED HIGH ENERGY DIET

PERFORMANŢELE PRODUCTIVE A DOI HIBRIZI ITALIENI DE PORCINE HRANIŢI CU RAŢII AVÂND NIVELE RIDICATE ÎN ENERGIE

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The aim of the trial was to compare the average daily gain (ADG), the carcass characteristics, and the meat and fat quality of 18 Italian crossbred pigs fed high energy diets formulated for improved genotypes (digestible energy: DE >14 MJ/kg DM). Nine "Fumati" crossbreds (Large White x Mora Romagnola; average initial live weight: 84 kg) and nine "Borghigiana" (Large White x Nera di Parma; average initial live weight: 90 kg), reared under similar environmental and nutritional conditions, were slaughtered at the average final weight of 180 kg (285 days). Calculated dry matter intake (DMI) and feed conversion index (FCI) were similar; no significant differences were observed with respect to average daily gain (ADG: 679 vs. 658 g/d). At slaughtering, the dressing percentage of the Fumati was significantly lower than that of the Borghigiana (80.9 vs. 84.5). The Fumati seemed more prone to fattening than the Borghigiana, as confirmed by the statistically higher percentage of belly (14.9 vs.12.2), and fat (3.9 vs. 2.4) and marbling of M. longissimus dorsi (2.7 vs. 1.4). On colour analysis, the Fumati had statistically higher L and hue values, and lower a* of M. longissimus dorsi. The fatty acid composition of meat was similar between crossbreds; backfat fatty acid composition of the Fumati showed a significantly higher percentage of saturated fatty acids (SFA), and lower amounts of monounsaturated and polyunsaturated fatty acids (MUFA and PUFA) than in the Borghigiana. Results showed that performances and meat quality of local crossbreeds still bred in semi-intensive systems, like Fumati and Borghigiana, can be positively influenced when fed diets considered suitable for improved pig genotypes.*

Keywords: nutrition, pig crossbreds, performances, meat quality, fat quality

Introduction

It is commonly recognized that local pig breeds represent a valuable genetic reserve to utilise for typical products or for recovering some properties of meat. Crossbreeding can increase the commercial value of the carcass and produce

improvements in meat production, at this time lost because of severe selective programs, such as the dressing percentage and the meat and fat quality (Acciaioli *et al.*, 2002; Franci *et al.*, 2003). Italian crossbred pigs Fumati (Large White x Mora Romagnola) and Borghigiana (Large White x Nera di Parma) were fairly common until the mid '50s in the Southern Po plain and the Northern Appennine. Fumati originated in 1886 near Ravenna, and Borghigiana in 1873 near Parma; both were remarkable for their quick development and excellence as butcher's animals. They began to disappear as the English Middle White and the Large White took over their area and substituted the local Mora Romagnola and Nera di Parma (Vezzani, 1926; Tonini, 1953). It is generally recognized that Fumati and Borghigiana are well adapted to extensive or *plein-air* breeding systems. In these conditions, feeding is based on pasture grazing and/or domestic by-products, sometimes added with little amounts of cereals. Nowadays, due to the increasing number of consumers demanding for traditional meat products and heavily marbled meat, some animals are bred under intensive systems and fed diets formulated for hybrid pigs. However, no exact or recent information about nutritional requirements, growth rate and meat and fat quality are available. The aim of this study was to evaluate and compare the performances (average daily gain, ADG, and feed conversion index, FCI), the carcass characteristics, and the quality of meat and fat of a group of Fumati and Borghigiana reared indoors and fed high energy diets, formulated for commercial hybrid pigs and based on raw materials easily available from the market.

Materials and Methods

Animals and diets

Nine Fumati (5 castrated males and 4 females; average initial weight: 84±7.3 kg; average age: 131 days) and nine Borghigiana (6 castrated males and 3 females; average initial weight: 90±13.5 kg; average age: 129 days), obtained from a single LW boar and 2 Mora Romagnola and Nero di Parma sows, were reared indoors and assigned separately to 2 slatted floor pens. The animals were fed the same diets, previously formulated for hybrid pigs bred at the Experimental Station of theUniversity of Torino and prepared weekly. During the trial, diets changed twice according to the live weight of the animals (80 kg < LW < 120 kg, and 120 kg < LW < 180 kg). Digestible energy (DE) was always higher than 14 MJ/kg DM; crude protein (CP) decreased from 17.2% to 15.5%; lysine was maintained at 0.8% and methionine increased from 0.3% to 0.4% (Table 1).

Table 1.

Composition and characteristics of diets (% DM)

Feed	LW <120 kg	LW >120 kg
Corn	45	55
Barley	18	15.5
Soybean meal 44%	16	12
Lineseed meal	2.5	2.5
Wheat bran	13.5	11
Minerals and vitamins	3.55	3.50
Bentonite	1	-
NaCl	0.3	0.4
Lysine	0.1	0.05
Methionine	0.05	0.05
Characteristics		
DM %	87.6	87.2
CP %	17.2	15.5
DE MJ/kg	14.4	14.7
ME MJ/kg	13.8	14.1

Dry matter intake (DMI) was calculated as kg of feed supplied daily, divided by the number of animals in each pen. Animals were weighed every 15 days, and ADG and FCI were calculated from 80 to 120 kg LW, from 120 kg to 180 kg, and from 80 to 180 kg. Slaughtering occurred in winter time at the average age of 285 days (180 kg LW), corresponding to a trial period of 150 days for Fumati and 159 days for Borghigiana. Animals were transported to the abattoir on a single-deck lorry; the travel time was about 5 hours and the fasting period was 22 hours.

Carcass assessment, meat and fat quality

Data collected at slaughter were: live weight (LW); cold carcass dressing percentage; lean cut yield (shoulder, loin, collar, ham); fat cut yield (jowl, backfat, belly); head percentage; backfat thickness measured at the shoulder, last rib and *M. semimembranosus*; pH, 45 minutes after slaughtering (pH_{45}) of *M. longissimus dorsi* and *M. semimembranousus* (Knick 752 pHmeter with Crison 52-32 electrode). Data collected 24 hours *post mortem* were: pH (pH_{24}) of *M. longissimus dorsi* and *M. semimembranousus*; colour of *M. longissimus dorsi* using a Minolta Chromameter Reflectance II CR200/08 (CIE L*, a*, b*) (Boccard *et al.*, 1981); chroma ($C^* = \sqrt{(a^*)^2 + (b^*)^2}$) and hue angle ($H = \arctan b^*/a^*$); colour and marbling of *M. longissimus dorsi* by sensory analysis (colour score: 1 = very light; 5 = very dark; marbling score: 1 = no marbling; 5 = high marbling), both conducted on fresh meat by a sensory panel. Meat samples of *M. longissimus dorsi* (including 5th and 7th thoracic vertebra) and samples of the backfat layer were analysed for chemical composition and fatty acid composition (Shimadzu GC 17-A with a J&W DB-WAX capillary column, 60 m, 0.53 mm i.d., FID on FAMEs samples) (A.O.A.C., 2000).

Data were analysed in a full factorial design by ANOVA using the general linear model procedure of SAS (2000). The statistical model was:

$Y_{ijk} = \mu + \alpha_j + \beta_k + \gamma_{jk} + \varepsilon_{ijk}$

where Y_{ijk} is the single observation; μ is the overall mean; α_j is the breed effect; β_k is the sex effect; γ_{jk} is the interaction; ε_{ijk} is the error. Effects were considered to be significantly different at $P<0.05$. The effect of sex was not significant and was eliminated from the model.

Results and Discussion

The final weight of Fumati did not differ from that of Borghigiana (177±17.9 kg *vs.* 181±16.8 kg) (Table 2).

The two crossbreds consumed similar amounts of feeds (3195±103 g/d and 3292±79 g/d) to reach the final weights in about 285 days, and showed similar ADG (679±65 g/d and 658±101 g/d). No differences were observed in the average FCI of the trial (4.7±0.8 and 4.9±0.6 kg for Fumati and Borghigiana respectively).

Table 2.

Characteristics and performances of animals

	Fumati	**Borghigiana**
Animals	9	9
Days on test (d)	150	159
Initial age (d)	131	129
Final age (d)	281	288
Initial LW (kg)	84±7.3	90±13.5
Final LW (kg)	177±17.9	181±16.8
Total weight gain (kg)	90±14.2	88±17.7
DMI (80<kg≤120 LW) (g/d)	2790±85	3020±66
DMI (120<kg≤180 LW) (g/d)	3476±136	3696±108
DMI (trial) (g/d)	3195±103	3292±79
ADG (80<kg≤120 LW) (d/d)	808±82	779±98
ADG (120<kg≤180 LW) (g/d)	584±73	601±44
ADG (trial) (g/d)	679±65	658±101
FCI (80<kg≤120 LW)	3.4±0.4	3.7±0.3
FCI (120<kg≤180 LW)	6.0±0.5	6.0±0.6
FCI (trial)	4.7±0.8	4.9±0.6

Carcass characteristics are reported in Table 3. Fumati showed lower dressing and head percentage than Borghigiana, but a higher percentage of belly ($P<0.05$). Other results (total and single fat cuts, backfat thickness measured at the shoulder and last rib) did not reach a statistical difference.

Table 3.

Slaughtering results (P<0.05)

	Fumati	Borghigiana	P
Dressing percentage (%)	80.9±1.3	84.5±1.3	*
Shoulder (%)	10.8±1.1	11.8±1.2	
Loin (without collar) (%)	11.5±1.0	11.9±1.4	
Collar (%)	6.2±0.7	6.3±0.6	
Ham (%)	24.1±3.0	25.2±2.5	
Jowl (%)	7.9±0.9	7.6±0.9	
Backfat (%)	14.2±2.1	13.1±1.8	
Belly (%)	14.9±1.4	12.2±0.9	*
Lean cuts (%)	58.6±1.8	62.2±1.4	
Fat cuts (%)	41.4±1.3	37.8±1.1	
Head (%)	3.4±0.6	4.1±0.5	*
BT at shoulder (mm)	64.2±5.0	62.8±3.8	
BT at last rib (mm)	55.3±4.3	54.1±6.4	
BT at *M. s.* (mm)	49.9±6.1	50.8±13.0	

BT = Backfat Thickness
M.s. = *Musculus semimembranousus*

Table 4 shows meat characteristics. Values of pH at 45 minutes and 24 hours after slaughtering were similar, and did not indicate any uncommon reactivity to stress.

Table 4.

Meat characteristics (P<0.05)

	Fumati	Borghigiana	P
pH_{45} *M.l.d*	6.52±0.22	6.29±0.34	
pH_{24} *M.l.d.*	5.85±0.14	5.62±0.09	
pH_{45} *M.s.*	6.32±0.16	6.34±0.44	
pH_{24} *M.s.*	5.82±0.10	5.95±0.34	
L^* *M.l.d.*	46.71±1.82	42.14±1.73	*
a* *M.l.d.*	6.89±1.26	8.74±1.09	*
b* *M.l.d.*	2.94±0.60	2.24±0.52	
Chroma *M.l.d.*	7.51±1.29	9.00±1.15	
Hue *M.l.d.*	0.41±0.08	0.25±0.04	*
Sensory colour	3.3±0.3	2.8±0.6	
Marbling *M.l.d.* (24 h)	2.7±0.6	1.4±0.3	*

M.l.d. = M. longissimus dorsi
M.s.= M. semimembranousus

At colour analysis, the *M. longissimus dorsi* of Fumati showed higher L* values, and lower a* and hue values than Borghigiana. The meat of this crossbred

was less marbled than Fumati, as confirmed by the low percentage of fat at the chemical analysis (Table 5).

No statistical differences were observed in the fatty acid composition (FA) of *M. longissimus dorsi* (Table 6).

Table 5.

Chemical composition of *M. longissimus dorsi* (P<0.05)

	Fumati	Borghigiana	P
Water (%)	71.7±0.9	72.3±0.9	
Ash (%)	1.2±0.2	1.2±0.1	
Protein (%)	23.4±0.8	24.1±0.9	
Fat (%)	3.9±1.1	2.4±0.7	*

Table 6:

Fatty acids profile of *M. longissimus dorsi* and backfat (P<0.05)

	Fumati	Borghigiana	P	Fumati	Borghigiana	P
	Meat			Fat		
C14:0	1.4±0.,6	1.5±0.1		1.5±0.2	1.2±0.2	*
C16:0	26.2±0.5	25.7±0.6		25.4±0.8	22.9±0.9	*
C16:1	3.2±0.4	3.3±0.4		2.0±0.4	2.3±0.2	
C17:0	0.3±0.1	0.2±0.1		0.2±0.1	0.2±0.1	
C17:1	0.2±0.1	0.2±0.1		0.3±0.1	0.3±0.1	
C18:0	13.2±1.3	12.8±0.8		14.4±1.6	11.9±0.9	*
C18:1	47.6±2.7	49.1±1.8		42.5±1.9	46.0±1.6	*
C18:2 Ω6	4.9±0.6	5.6±0.9		10.3±1.2	12.7±1.3	*
C18:3 Ω3	0.2±0.1	0.2±0.1		0.1±0.1	0,3±0.2	*
Ω3/ Ω6	0,03±0,01	0,04±0,01		0.01±0.01	0.02±0.01	*
SFA	39.7±1.9	40.3±1.1		42.3±0.2	37.0±1.2	*
MUFA	53.5±1.0	53.8±0.9		46.0±2.1	49.6±1.6	*
PUFA	6.8±1.0	6.0±0.6		10.8±1.2	13.4±1.4	*
SFA/UFA	0.7±0.1	0,7±0.1		0.7±0.1	0.5±0.1	*

The Fumati backfat showed higher values of 3 saturated fatty acids (SFA) (C14:0 = 1.5 *vs.* 1.2; C16:0 = 25.4 *vs.* 22.9; C18:0 = 14.4 *vs.* 11.89), and lower values of oleic acid (C18:1 = 42.5 *vs.* 46.0), and 2 poly-unsaturated fatty acids (PUFA) (C18:2 Ω6 = 10.3 *vs.* 12.7; C18:3 Ω3 = 0.1 *vs.* 0.3). Consequently, the total amount of SFA was higher than in Borghigiana (42.3 *vs.* 37.0) (P<0.05), and the total percentage of MUFA and PUFA were lower (46.0 *vs.* 49.6, and 10.8 *vs.*13.4 respectively). The ratio SFA/UFA showed statistical differences between crossbreds, with higher values for Fumati (0.7 vs. 0.5).

According to historical data, Fumati and Borghigiana crossbreds were fed with domestic by-products, cereals and milk whey, and slaughtered at 180 – 200 kg LW (Tonini, 1953); the average FCI was 6-8. In our trial, both crossbreds reached an average final LW similar to those reported by hystorical data, but FCI were well below the data reported by Tonini. Weight gains were higher than those observed in recent trials on purebreds (Fortina et al., 2006; Zanon, 2006). Results show that these two crossbreds can perform better than purebreds and improve growth performances when fed diets formulated for commercial hybrid pigs.

Carcass characteristics were influenced by the maternal line. Both crossbreds were obtained from a single LW boar, therefore the high percentage of belly and marbling of Fumati was probably dependent by the Mora Romagnola, which is characterized by an uncommon high percentage of fat cuts and fat content of meat (Fortina et al., 2006).

Previous trials on this purebred showed an extraordinary high pH of the meat after transportation and fasting period (Fortina et al., 2006). Several Authors (Franci and Pugliese, 2004; Pugliese et al., 2003; Labroue et al., 2000) report higher pH_{24} values in some local breeds than in hybrids. Pre-slaughter handling, including mixing of unfamiliar animals, loading, transport and abattoir lairage, can induce stress either psychologically or physically, associated with that of DFD meat (Nanni Costa et al., 1999; 2001). In the present trial, animals were transported to the abattoir during winter at low temperature; the travel time was about 5 hours and the fasting period was 22 hours. Both crossbreds showed normal pH_{45} and pH_{24} values, suggesting a positive influence of Large White, especially on the meat pH of the Mora Romagnola.

Data from chromameter and sensory analysis showed that the colour of M. longissimus dorsi of both crossbreds can be considered "dark" when compared to the meat of modern hybrids. A possible residual enzyme activity and the removal of oxygen from the oxymyoglobin molecule can result in a dark meat colour, but no significant influence seemed due to the ultimate pH value of *M. longissimus dorsi.*

Slaughtering results and meat characteristics show that both crossbreds are prone to fattening, but the different marbling of *M. longissimus dorsi* indicate that they could follow different pathways in fat partitioning.

Like most animal production traits, fatty acid composition is influenced by both genetic and environmental factors (Boccard et al., 2004; Wood et al., 2004), including management, but mainly feeding. Oleic acid (C18:1) is the major component of pig adipose tissue but its concentration is poorly related to the firmness of the tissue. The highest correlation to subjective and objective measurements of fat firmness, which is inversely related to the thickness of the backfat, results from the concentration of linoleic acid (C18:2) (Eggert et al., 2001). Fumati showed a significant lower concentration of both fatty acids compared to the Borghigiana, probably due to the genetic influence of Mora Romagnola, which is characterized by an excellent firmness of the adipose tissue (Fortina et al., 2005).

Conclusions

In this study, two Italian crossbred pigs were fed high energy diets (DE>14 MJ/kg DM) and bred under conditions considered desirable for improved genotypes. Results showed good performances (ADG: 679 g/d and 658 g/d for Fumati and Borghigiana; FCI: 4,7 and 4,9, respectively) and valuable characteristic of some slaughtering parameters and technological characteristic of meat and fat. The dressing percentage (84,5%) and lean cuts percentage (62,2%) of Borghigiana were similar to those of modern hybrids. The Fumati seemed more influenced by the maternal line and prone to adipogenesis, as shown by the high marbling values at sensory analysis and total meat fat when compared to the Borghigiana (2,7 *vs.* 1,4 and 3,9% *vs.* 2,4% respectively). However, compared to recent experimental data on purebreds, both crossbreds showed a valuable improvement on some technological qualities of meat and fat, and on fatty acid composition, suggesting a positive influence of the Large White paternal line. Fatty acid composition of meat and fat has received considerable interest in view of its contribution to total fat intake from animal products in the diets, and its implications for human health. From this point of view, the Borghigiana showed a better quality of fatty acids than Fumati, whose subcutaneous adipose tissue is poor in MUFA (46,0 *vs.* 49,6) and PUFA (10,8 *vs.* 13,4), and has a low SFA/UFA ratio (0,5 *vs.* 0,7).

Most Fumati and Borghigiana are still bred in semi-intensive systems, therefore further studies are needed to better understand the role of these breeding techniques and nutrition - such as pasture grazing and supplementary feeding in the piggery - on performances of animals, and on meat and fat quality.

References

1. Acciaioli, A., C., Pugliese, R., Bozzi, G., Campodoni, O., Franci, G., Gandini, 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**, 171-180
2. A.O.A.C., 2000, Official methods of analysis, 17ª ed. Association of Analytical Chemists, Gaithersburg, Maryland, USA
3. Boccard, R., L., Butcher, E., Casteels, E., Cosentino, E., Dransfiel, D.E., Hood, R.L., Joseph, D.B., Mac Dougall, D.N., Rhodes, I., Schön, B.J., Tinbergen, C., Touraille, 1981, Procedures for measuring meat quality characteristics in beef production experiments. Report of a working group in the commission of the european communities (CEC). Beef production research programme, *Livestock. Production Science,* **8**, 385-397
4. Boccard, R., L., Butcher, E., Casteels, E., Cosentino, E., Dransfiel, D.E., Hood, R.L., Joseph, S., Mac De Smet, K., Raes, D., Demeyer, 2004, Meat fatty acid composition as affected by fatness and genetic factors: a review, *Animal Research,* **53**, 81-98
5. Eggert, J.M., M.A., Belury, A., Kempa-Steczko, S.E., Mills, A.P., Schinkel, 2001, Effects of conjugated linoleic acid on the belly firmness and fatty

acid composition of genetically lean pigs, *Journal of Animal Science*, **79**, 2866-2872

6. Fortina, R., S., Barbera, C., Lussiana, A., Mimosi, S., Tassone, A., Rossi, E., Zanardi, 2005, Performances and meat quality of two Italian pig breeds fed diets for commercial hybrids, *Meat Science,* **71,** 713-718

7. Fortina, R., S., Tassone, S., Barbera, A., Mimosi, 2006, Prova di alimentazione delle razze Mora Romagnola e Casertana. Performance produttive e qualità della carne. *Rivista di Suinicoltura.* **7**, 103-105

8. Franci, O., C., Pugliese, 2004, Issues and perspectives of Italian authocthonous pigs. Proc. 34 th Simp. Int. Zoot*., Meat Science and Research Science,* Roma, Italy, 143-158

9. Franci, O., G., Campodoni, R., Bozzi, C., Pugliese, A., Acciaioli, G., Gandini, 2003, Productivity of Cinta Senese and Large White x Cinta Senese pigs reared outdoors and indoors. 2. Slaughter and carcass traits, *Italian Journal of Animal Science* **2**, 59-65

10. Labroue, F., S., Goumy, J., Gruand, J., Mourot, V., Neelz, C., Legault, 2000, Comparison au Large White de quatre races locales porcines françaises pour les performances de croissance, de carcasse et de qualité de la viande. *Journées Recherche Porcine en France,* **32**, 403-411

11. Nanni Costa, L., D.P., Lo Fiego, S., Dall'Olio, R., Davoli, V., Russo, 1999, Influence of loading method and stocking density during transport on meat and dry-cured ham quality in pigs with different halotane genotypes, *Meat Science,* **51**, 391-399

12. Nanni Costa, L., D.P., Lo Fiego, S., Dall'Olio, R., Davoli, V., Russo, 2001, Combined effects of pre-slaughter treatments and lairage time on carcass and meat quality in pigs of different halotane genotype, *Meat Science,* **61**, 41-47

13. Pugliese, C., G., Campodoni, M., Badii, L., Pianaccioli, O., Franci, 2003, Cinta Senese and Large White x Cinta Senese raised on pasture in wood: sample join composition and meat quality, Proc. 15th Congr. A.S.P.A., Parma, Italy, 397-399

14. SAS, 2000, SAS/STAT User's guide (Release 8.02). SAS Institute Inc, Cary, NC, USA

15. Tonini, G., 1949, I suini di Faenza. *L'Italia Agricola,* **5**, 3-19.

16. Tonini, G., 1953, La razza suina mora e i suoi derivati di incrocio, Stabilimento Grafico F. Lega, Faenza

17. Vezzani, V., 1926, L'opera di miglioramento delle razze suine italiane, *L'Italia Agricola,* **9**, 402- 405

18. Wood, J.D., G.R., Nute, R.I., Richardson, F.M., Whittington, O., Southwood, G., Plastow, Mansbridge, R., Mansbridge, N., Da Costa, K.C., Chang, 2004, Effects of breed, diet and muscle on fat deposition and eating quality in pigs, *Meat Science,* **67**, 651-667

19. Zanon, A., 2006, Passato, presente e futuro della Nera Parmigiana. *Rivista di Suinicoltura,* **1**, 60-63.