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The effects of pressed sugar beet pulp silage (PBPS) and dairy whey on heavy pig production

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ABSTRACT

The effects of pressed beet pulp silage (PBPS) replacing barley for 10% and 20% (DM basis) were studied on heavy pigs fed dairy whey-diluted diets.

60 Hypor pigs (average initial weight of 28 kg), 30 barrows and 30 gilts, were homogeneously allocated to three experimental groups: T1 (control) in which pigs were fed a traditional sweet whey- diluted diet (the ratio between whey and dry matter was 4.5/1); T2 in which PBPS replaced barley for 10% (DM basis) during a first period (from the beginning to the 133rd day of trial) and thereafter for 20% (DM basis); T3 in which PBPS replaced barley for 20% (DM basis) throughout the experimental period. In diets T2 and T3 feed was dairy whey-diluted as in group T1.

No significant ($P > 0.05$) differences were observed concerning growth parameters (ADG and FCR). Pigs on diets containing PBPS showed significantly higher ($P < 0.05$) percentages of lean cuts and lower percentages of fat cuts. On the whole, ham weight losses during seasoning were moderate but significantly ($P < 0.05$) more marked for PBPS-fed pigs as a probable consequence of their lower adiposity degree. Fatty acid composition of ham fat was unaffected by diets. With regard to m. *Semimembranosus* colour, pigs receiving PBPS showed lower ($P < 0.05$) "L", "a" and "Chroma" values.

From an economical point of view it can be concluded that the use of PBPS (partially replacing barley) and dairy whey in heavy pig production could be of particular interest in areas where both these by products are readily available.

Key words: Heavy pig, Pressed beet pulp silage, Dairy whey, Growing performance, Meat quality.

RIASSUNTO

EFFETTI DI POLPE DI BIETOLA INSILATE E PRESSATE (PBPS) E DI SIERO DI LATTE NELLA PRODUZIONE DEL SUINO PESANTE

Numerose sperimentazioni hanno evidenziato la possibilità di somministrare polpe di bietola surpressate ed insilate (PBPS), anche in quantità significative ed in sostituzione di pari percentuali di orzo, ai suini pesanti (vedasi la recente rassegna di Scipioni e Martelli, 2001). Con la presente ricerca si sono voluti saggiare gli effetti della somministrazione di tale sottoprodotto ad animali che ricevevano l'alimento in forma liquida e diluito con siero di latte. 60 suini ibridi (Hypor), metà maschi castrati e metà femmine intere, sono stati seguiti dal peso vivo di 28 kg sino a quello di macellazione (160 kg, circa).

Gli animali sono stati assegnati a tre gruppi sperimentali: T1 (controllo) nell'ambito del quale gli animali ricevevano diete "tradizionali" diluite con siero di latte dolce secondo un rapporto fra siero e sostanza secca di 4,5 a 1; T2 in cui in una prima fase, compresa fra l'inizio ed il 133° giorno di sperimentazione, il 10% della sostanza secca dell'orzo era sostituito con PBPS mentre nel periodo successivo la sostituzione avveniva in ragione del 20%; T3 costituito da suini che ricevevano costantemente, ed in sostituzione di pari percentuale di orzo, PBPS in ragione del 20% della sostanza secca. Anche nell'ambito delle tesi T2 e T3 l'alimento era diluito con siero di latte in proporzioni analoghe a quanto effettuato per il gruppo T1. L'allevamento è stato suddiviso in due fasi comprese fra il primo ed il 133° e fra il 134° ed il 216° giorno di sperimentazione, cui corrispondevano differenti formulazioni del mangime, atte a soddisfare i fabbisogni

degli animali. Le diete sono state rese equivalenti in termini di energia digeribile, proteina, minerali ed amminoacidi essenziali.

Il trattamento alimentare non ha modificato le prestazioni di accrescimento dei suini e le caratteristiche qualitative delle carcasse. Gli animali appartenenti alle tesi T2 e T3, entrambe contenenti PBPS, hanno evidenziato una significativa ($P < 0.05$) maggior incidenza di tagli magri e minore di tagli adiposi. I suini alimentati con PBPS hanno mostrato valori più bassi per quanto attiene ai parametri "L", "a" e "Chroma" rilevati a livello di *m. Semimembranosus*. Nessuna differenza è stata riscontrata a carico della composizione acidica del grasso di copertura del prosciutto. I suini che avevano ricevuto PBPS hanno infine presentato, seppur entro margini di normalità nell'ambito della produzione del suino pesante, cali di stagionatura dei prosciutti più marcati ($P < 0.05$).

Sulla base dei risultati della presente esperienza l'impiego di PBPS, quali parziali sostitute dell'orzo, in diete diluite con siero di latte si è dimostrato globalmente positivo; l'eventuale beneficio di ordine economico sulla riduzione del costo alimentare è da considerarsi subordinato alla disponibilità in loco di tali sottoprodotti.

Parole chiave: Suino pesante, Polpe bietola surpressate insilate, Siero latte, Accrescimento, Qualità carne.

Introduction

Many studies have demonstrated that pressed beet pulp silage (PBPS) can be usefully included in the diets of heavy pigs as recently reviewed by Scipioni and Martelli (2001). At the inclusion rate of 17% (DM basis) PBPS had no adverse effect on either growth performance or on slaughtering parameters (Parisini *et al.*, 1991). Plain and molassed PBPS can replace barley at 15% resulting in an improvement in growth rhythm of heavy pigs (Martelli *et al.*, 1999). Furthermore PBPS can improve Nitrogen balance in pigs, significantly reducing the excretion of this element via urine (Scipioni *et al.*, 1993; Canh *et al.*, 1997). Data obtained by using vinasse-added PBPS as a partial substitute for barley demonstrated that this type of by-product could be used at 10-20% even though at the highest level (20%) a slight worsening of growth was observed (Martelli *et al.*, 2000).

With the exception of the digestibility trial (Scipioni *et al.*, 1993) in the above-mentioned experiments, feed was offered wet (water-diluted). Liquid feeding represents, in fact, the most common way in which feed is provided to heavy pigs. The historical reason for this choice lies in the widespread availability of dairy whey in Northern Italy, as a result of the presence of cheese-making industries (e.g. Parmigiano Reggiano and Grana Padano). Despite its low dry matter content (less than 7%), dairy whey can be considered a valuable source of nutrients (aminoacids and vitamins) for pigs. For this by-product the suggested percentage

of incorporation is of about 25% on a dry matter basis (Fevrier and Chauvel, 1977). From a practical standpoint, it is well known that 13-15 litres of dairy whey can replace one kilogram of dry meal in pig formulations.

The relatively poor knowledge of the combined effect of PBPS and dairy whey in the feeding of heavy pigs prompted this trial, which aims to investigate the effect of the partial substitution of barley with PBPS (10% and 20% DM basis) in dairy whey-diluted diets.

Material and methods

Animals, housing and feeding

Sixty hybrid (Hypor) pigs, with a starting live weight of about 28 kg, 30 castrated males and 30 females, were used.

The pigs were homogeneously (according to age, body weight and litter) allocated into three groups, each containing four replications of five animals of the same sex. The growing period was divided into two phases, which corresponded to different nutrient supplies: phase I was from the beginning of the trial to the 133rd day, and phase II from the 133rd day to the end of the trial (216th day).

A control group (T1) was fed a traditional diet based on cereals and soybean meal, a second group (T2) received a diet in which PBPS replaced barley for 10% on a DM basis during the first phase and thereafter PBPS replaced barley for 20% (DM

basis); a third group (T3) was fed PBPS at 20% (DM basis) replacing barley throughout the trial. In all groups dairy whey-diluted feed (whey/dry matter = 4.5/1) was used. Sweet whey was stocked in a fibreglass container refilled three times a week. Pigs were fed at the rate of 8% of their metabolic live weight up to a maximum of 3.3 kg DM (including whey) per pig, per day. Whey was supplied at 20% DM. The diets were formulated to get the same amounts of Calcium, total Phosphorus, essential aminoacids and digestible energy by using feed reference values of INRA (1989). Feed composition is shown in table 1; a complete diets analysis is displayed in table 2. Diets analyses were performed according to the official methods of the ASPA - the Italian Scientific Association of Animal Production (Martillotti *et al.*, 1987).

The pigs were kept in environmentally controlled rooms and housed in group pens, each containing five pigs of the same sex.

Parameters measured and statistical analysis

The pigs were individually weighed at the beginning of each phase and at the end of the trial to determine the average daily weight gain (ADG). Feed intakes of each pen were recorded daily to

calculate the feed conversion rate (FCR). The collection of the growing parameters stopped on the 216th day of the trial, when one half of the pigs attained the required slaughtering BW of 160 kg. The remaining pigs were fed the experimental diets up to the day in which these pigs in turn attained the final BW of about 160 kg.

Pigs were slaughtered after a 12 h fast. Dressing out and lean percentages of carcasses were determined, the latter by Fat-o-Meater (FOM-SFK, Copenhagen, DK). The pH value of *Semimembranosus* and *L. dorsi* muscles was determined at 45' post mortem by means of a portable pH-meter. Thereafter, each carcass was dissected into the main commercial cuts (ham, loin, shoulder, neck and fat cuts). At 24 h post mortem a second pH value of m. *Semimembranosus* was taken and colour of the *Semimembranosus* and *L. dorsi* muscles was determined according to the L*a*b* System (McLaren, 1980) using a Minolta Chroma meter CR200. Samples of subcutaneous fat were taken from 20 hams per group to determine the fatty acid composition by gas-chromatograph. Unsaturation index was calculated according to Micossi *et al.* (1996) and obtained multiplying fatty acids percents by the number of double bound in each fatty acid.

Table 1. Percent composition of dry feeds (without dairy whey).

Groups		First period			Second period	
		(1 - 133 rd day of trial)			(from 134 th day of trial to slaughtering)	
		T1	T2	T3	T1	T2-T3
Maize meal	% DM	37.30	37.71	38.12	50.00	50.72
Barley meal	"	35.00	25.00	15.00	30.00	10.00
Soyabean meal	"	24.00	24.00	24.00	16.70	16.70
PBPS ⁽¹⁾	"	-	10.00	20.00	-	20.00
Dicalcium phosphate	"	1.50	1.58	1.60	1.20	1.45
Limestone	"	1.40	0.95	0.55	1.40	0.50
Trace mineral-vitamin premix	"	0.60	0.60	0.60	0.50	0.50
Sodium chloride	"	0.20	0.13	0.08	0.20	0.08
Methionine	"	-	0.03	0.05	-	0.05

⁽¹⁾ PBPS: pressed beet pulp silage; pH 3.75; dry matter (DM) 23.60%. Chemical composition (% DM): crude protein 9.44; crude fibre 22.77; NDF 50.99; ADF 31.12; ether extract 0.44; ash 6.01; Calcium 1.60; Phosphorus 0.09.

Table 2. Chemical composition and nutritive value of the diets.⁽¹⁾

Groups		First period			Second period	
		(1 - 133 rd day of trial)			(from 134 th day of trial to slaughtering)	
		T1	T2	T3	T1	T2-T3
Crude protein	% DM	16.49	16.41	16.32	14.25	14.06
Crude fibre	"	3.79	5.16	6.53	3.40	6.14
Ether extract	"	2.46	2.38	2.30	2.63	2.45
Ash	"	7.12	6.91	6.69	6.51	6.18
<i>Calculated values⁽²⁾:</i>						
Calcium	% DM	0.98	0.98	0.96	0.92	0.92
Total phosphorus	"	0.46	0.45	0.45	0.38	0.38
Lysine	"	0.99	1.01	1.03	0.80	0.85
Met. + Cys.	"	0.62	0.62	0.63	0.56	0.57
Threonine	"	0.74	0.75	0.76	0.65	0.66
Tryptophan	"	0.22	0.22	0.22	0.18	0.18
Digestible energy	kcal/kg DM	3550	3549	3546	3585	3576

⁽¹⁾ Sweet dairy whey pH 5.5; dry matter (DM) 5.80%. Chemical composition (% DM): crude protein 8.41; ether extract 1.72; ash 8.04; Calcium 0.59; Phosphorus 0.71.

⁽²⁾ According to INRA (1989)

Twenty hams per group, deriving from the right side, were controlled during a 12-month seasoning period and weight losses recorded after trimming, salting, resting and final seasoning periods.

The experimental data obtained were analysed by ANOVA (SPSS/PC+, 1988) according to the following model:

$$Y_{ijk} = \mu + \alpha_i + \beta_j + \varepsilon_{ijk}$$

where: μ is the general mean, α is the diet ($i = 1, 3$), β is the sex ($j = 1, 2$) and ε is the error contribution.

The trimmed weight of ham was used as covariable on hams' weight losses during seasoning.

The interaction between the diet and the sex was excluded because non significant.

The T Student's test was used to determine significant differences in mean values.

Results

The experimental conditions did not appear to influence the pigs' health.

Growth parameters of pigs are shown in table 3. No significant differences among groups were observed as attributable to dietary treatments. From the comparison between the two sexes a lower ($P < 0.05$) daily weight gain and a worsening ($P < 0.05$) of FCR were detectable for gilts in the second phase.

Slaughtering performances are displayed in table 4. Dietary treatment did not significantly influence carcass qualitative traits (dressing out and lean percentages). After carcass dissection, pigs on diets containing PBPS (T2 and T3) showed a significant improvement in shoulder ($P < 0.01$) and loin ($P < 0.05$) percentages when compared to control animals. These differences resulted in a higher ($P < 0.05$) lean cuts yield and in a lower ($P < 0.05$) fat cuts yield of pigs fed PBPS diets. Consequently, the lean to fat cuts ratio was lower ($P < 0.05$) for pigs on the traditional diet.

Table 3. Growing parameters of pigs.

Groups	T1	Groups			Sex		RMSE
		T2	T3	Barrows	Gilts		
Pigs	n.	20	20	20	30	30	-
Initial body weight (BW)	kg	28.00	27.80	28.50	28.07	28.10	4.12
BW on 133rd day of trial	"	101.20	100.50	97.56	99.86	99.80	11.36
Final BW (216th day) ⁽¹⁾	"	157.00	154.05	150.06	156.79	151.07	14.86
ADG 1 st -133 rd day	g/d	550	547	519	540	539	78.16
ADG 133 rd -216 th day	"	672	645	633	686 ^a	618 ^b	107.22
ADG 1 st -216 th day	"	597	585	563	596	569	67.13
Pens	n.	4	4	4	6	6	-
Feed intake 1 st -133 rd day	kg DM/d	1.88	1.88	1.90	1.89	1.89	0.01
Feed intake 133 rd -216 th day	"	3.27	3.23	3.13	3.24	3.18	0.01
Feed intake 1 st -216 th day	"	2.40	2.38	2.34	2.39	2.35	0.01
FCR 1 st -133 rd day	kg DM/kg ADG	3.42	3.44	3.60	3.50	3.51	0.52
FCR 133 rd -216 th day	"	4.87	5.01	4.94	4.72 ^a	5.15 ^b	0.43
FCR 1 st -216 th day	"	4.02	4.07	4.16	4.01	4.13	0.82

⁽¹⁾ Data collection stopped when one half of the pigs attained the BW of about 160 kg.

^{a,b} = $P < 0.05$

Table 4. Slaughtering parameters.

Groups		Groups			Sex		RMSE
		T1	T2	T3	Barrows	Gilts	
Pigs	n.	20	20	20	30	30	-
Days of trial	"	222.7	223.5	224.2	222.0	225.0	7.57
Slaughtering BW	kg	159.50	159.75	158.88	158.92	159.83	0.98
Dressing out	%	83.1	80.52	81.55	81.92	81.53	2.76
Full gut weight	kg	9.75	10.81	9.68	9.70	10.46	1.08
Lean meat yield (F-o-M)	%	51.49	53.23	53.71	51.43 ^A	54.19 ^B	2.51
Right side (RS)	kg	66.89	64.61	64.70	65.45	65.35	2.69
Ham	% RS	22.75	23.82	22.68	22.87	23.30	0.82
Shoulder	"	12.70 ^b	13.56 ^A	13.71 ^A	13.27	13.38	0.47
Loin	"	19.97 ^b	20.30 ^a	20.77 ^a	19.80 ^A	20.89 ^B	0.67
Neck	"	6.59 ^b	7.00 ^{a,b}	7.17 ^a	6.79	7.06	0.39
Lean cuts yield	"	62.03 ^a	64.70 ^b	64.34 ^b	62.74 ^A	64.63 ^B	0.95
Fatty cuts yield	"	30.28 ^b	27.43 ^a	28.38 ^a	29.73 ^A	27.66 ^B	1.07
Lean cuts/Fatty cuts	"	2.06 ^a	2.39 ^b	2.28 ^b	2.12 ^A	2.36 ^B	0.16

^{a,b} = $P < 0.05$; ^{A,B} = $P < 0.01$

Table 5. Meat pH and colour values.

Groups		Groups			Sex		RMSE
		T1	T2	T3	Barrows	Gilts	
Pigs	n.	20	20	20	30	30	-
pH at 45' L. dorsi		6.46	6.34	6.49	6.48	6.38	0.18
pH at 45' Semimembranosus		6.47	6.56	6.54	6.54	6.52	0.20
pH at 24 h Semimembranosus		5.94	5.82	5.77	5.74	5.95	0.20
<i>Colour L. dorsi:</i>							
	L	45.45	43.53	45.72	45.64	44.16	3.55
	a	8.63	8.76	9.91	8.96	9.24	1.73
	b	3.15	2.67	3.73	3.22	3.15	1.40
Hue		0.35	0.29	0.36	0.34	0.32	0.14
Chroma		9.27	9.19	10.68	9.58	9.85	1.79
<i>Colour Semimembranosus:</i>							
	L	36.77 ^a	33.24 ^b	34.78 ^b	35.38	34.48	2.05
	a	14.52 ^a	12.07 ^b	11.75 ^b	12.95	12.65	2.10
	b	4.73	4.01	3.50	4.57	3.59	1.23
Hue		0.31	0.29	0.33	0.34	0.29	0.10
Chroma		15.30 ^a	12.80 ^b	12.32 ^b	13.76	13.18	2.06

^{a,b} = $P < 0.05$.

Table 6. Fatty acid composition of thigh subcutaneous fat.

Groups		Groups			Sex		RMSE
		T1	T2	T3	Barrows	Gilts	
Samples	n.	20	20	20	30	30	-
C _{16:0}	%	24.86	25.56	25.30	25.53	24.95	1.25
C _{18:0}	"	13.00	13.53	12.68	13.11	13.03	0.81
C _{18:1}	"	45.88	43.91	45.42	45.39	44.75	1.84
C _{18:2}	"	8.10	8.63	8.08	8.06	8.48	1.11
Saturated fatty acids	"	39.66	41.16	39.88	40.60	39.87	1.84
Monounsaturated fatty acids	"	49.43	47.50	49.30	49.04	48.44	1.81
Polyunsaturated fatty acids	"	8.52	9.04	8.47	8.54	8.81	1.17
Saturated/Unsaturated		0.69	0.73	0.69	0.71	0.69	0.05
Unsaturation index ⁽¹⁾		66.88	65.98	66.62	66.30	66.69	2.41

No significant differences were observed

⁽¹⁾ Calculated according to Micossi *et al.* (1996).

Table 7. Hams' weight and weight losses during seasoning (over a 12-month period).

Groups		Groups			Sex		RMSE
		T1	T2	T3	Barrows	Gilts	
Thighs	n.	20	20	20	30	30	-
Trimmed weight (TW)	kg	12.50 ^a	12.32 ^a	11.87 ^b	11.93	12.53	0.84
Weight after first salting	"	12.13	11.89	11.43	11.55	12.08	0.86
Weight after resting	"	10.57	10.22	9.87	10.00	10.45	0.82
Final weight (12 months)	"	9.27	8.94	8.65	8.76	9.14	0.76
Weight losses ⁽¹⁾ :	% TW						
After salting	"	2.93 ^a	3.53 ^b	3.73 ^b	3.20	3.59	0.84
After resting	"	15.39 ^a	17.02 ^b	16.82 ^b	16.19	16.63	0.93
End of seasoning (12 months)	"	25.84 ^a	27.47 ^b	27.11 ^b	26.54	27.07	1.11

^{a, b} = $P < 0.05$;

⁽¹⁾ trimmed weight was used as covariable.

Significant differences ($P < 0.01$) (indicating on the whole a higher degree of leanness in the females) were detectable between the two sexes with regard to lean meat yield and loin percentage, as well as lean and fatty cuts yields and their ratio.

The trend of post-mortal glycolysis and the colour parameters of loin (table 5) were similar among groups, while ham colour showed some differences: pigs on the traditional diet demonstrated higher ($P < 0.05$) "L", "a" and "Chroma" values.

The fatty acid relative composition of ham fat is shown in table 6; no significant differences among groups were perceived.

Ham weight and weight losses during seasoning are shown in table 7. Pigs fed the traditional diet had heavier ($P < 0.05$) trimmed hams; this difference was not detectable in the following phases. Weight losses after salting, resting and at the end of the seasoning period were constantly more pronounced ($P < 0.05$) for pigs receiving PBPS.

Discussion

Previous studies on the use of PBPS in heavy pig production have demonstrated that good results were attained either by using the "plain" by-product (i.e. without the addition of other sugar industry by-products) at 15% (Martelli *et al.*, 1999) or by using vinasse-added PBPS at 10% on a DM

basis (Martelli *et al.*, 2000) when compared to pigs that did not receive PBPS in the diet. In the present experiment plain PBPS was used at a higher level (20%), identical to the highest level used in vinasse-added PBPS trial (Martelli *et al.*, 2000). In this latter experiment a significant ($P < 0.05$) reduction of feed intake was observed when vinasse-added PBPS was included at 20%. Findings from the present experiment do not confirm this result and could indicate that the decrease in feed intake was related to the addition of vinasse rather than to PBPS itself.

Due to some alterations of fermentative process, a negative associative effect between high levels of dietary fibre and dairy whey has been described by Fèvrier and Chauvel, (1977) and Fèvrier and Lachance (1988). Piva *et al.* (1998) *in vitro* found a lower fermentative activity (which corresponds to a lower production of volatile compound, i.e. VFA, that can contribute to meet pig maintenance requirements) when dairy whey was associated with a high level of PBPS rather than to a low level of PBPS. These considerations could explain the slight dose-dependent worsening of growth rhythm observed for PBPS-fed pigs in the present experiment.

Although pigs on the experimental diets had similar growth parameters (ADG and FCR) and carcass traits (dressing percentage and lean meat

yield), carcass dissection pointed out some differences among groups. Pigs belonging to PBPS diets showed, in fact, higher percentages (on right side) of shoulder, loin and neck that resulted in a higher proportion of lean cuts and in a reduction of fat cuts.

The differences between the sexes could be considered as physiological and related to the different hormonal status of entire female and castrated male pigs.

The absence of differences in the fatty acids composition of subcutaneous fat in thighs is in accordance with previous findings on control vs. PBPS-fed pigs (Martelli *et al.*, 1999 and 2000).

Concerning colour parameters of m. *Semimembranosus*, lower "L" and "a" values were observed for PBPS-fed pigs. A lower "L" value could indicate a higher water retention capacity of meat deriving from pigs receiving PBPS diets (Russo *et al.*, 1985). However, pigs on PBPS diets also showed lower "a" values, indicating a lower redness of meat, which corresponded to lower Chroma values.

Regardless of dietary treatments, "L" values from the present experiment were quite low when compared to previous data recorded on the same muscle deriving from traditionally fed and PBPS-fed pigs (Martelli *et al.*, 1999); considering that in the present experience hybrid pigs were used (instead of Landrace x Large White animals), we can assume genetic reasons to explain this result. This hypothesis agrees with the findings of Novelli *et al.* (1993) who found (by Minolta CR200) lower "L" values of *Semimembranosus* for Hypor when compared to "traditional" breeds (Large White and Landrace); furthermore also Trombetta *et al.* (1992) found lower reflectance values (measured by F-o-M) of *Semimembranosus* deriving from hybrids (type was not specified) in comparison with traditional breeds. Concerning the differences observed on meat colour, further research is needed to highlight the possible effects of genetics and by-products on colour parameters.

With regard to ham weights during the seasoning period, the higher losses observed for thighs deriving from PBPS-fed pigs could be related to the above-mentioned higher degree of leanness in pigs receiving high levels of dietary fibre. On the whole, these data fall within Parma ham standards (Mordenti *et al.*, 1994).

Conclusions

Our data suggest that PBPS can be used in practical dairy whey-diluted swine diets at 10% level (DM basis) -and can partially replace barley-without determining any significant adverse effect on the growth performance of pigs. At slaughtering a higher degree of leanness in PBPS-fed pigs was observed, resulting in both an improvement in the proportion of lean cuts and in a more marked seasoning weight loss in thighs; nevertheless this last parameter remains within the typical values of Italian ham production.

These results could be of particular interest in the framework of a reduction in feed costs in Northern Italy where both these by-products (sugar beet pulp and dairy whey) are readily available and do not implicate additional costs for transport.

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