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Study of the Assessment Method for N Excretion in Sustainable Heavy Pigs Production

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Abstract

Italian heavy pigs, with an average slaughtering body weight of 150-170 kg, are world-wide famous for its Parma ham production. Because the requirement of market diversity, producers are interested in ham production following the procedure of Italian pork industry. However, with ever growing public concern about nitrogen (N) pollution in the environment, it is necessary to determine a suitable method to measure N excretion from heavy pig production. The N retention was calculated by factorial method and compared with estimations of other methods available in literature. The results showed that the N percentage of heavy pigs is 2.43% ± 0.07% on body weight basis and the percentage of N excretion was approximately 69.62% ± 0.20 of N intake. Regarding the N excretion of estimation methods, the proposal of Xiccato et al. was closer to reality of the heavy pig production than other methods and could be used as a standard way to calculate the N excretion. Besides the overall standard, it is opportune to make a N balance sheet for every individual farm under specific conditions. Only in this way, the farmers can realize their deficiencies and will voluntarily follow the Good Management Practice (GMP) indications so as to guarantee a sustainable development of pig production.

Keywords-Heavy pigs, N excretion, Factorial method, Assessment methods

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1. Introduction

In Italy, most pigs are slaughtered at a body weight of 150-170 kg (9 months of age), giving carcasses of 125-140 kg that are used to supply the cured pork industry, especially to produce seasoned Parma ham [1]. These facts lead to the particularities of Italian pig production differing from the other European community countries. According to data provided by the Italian Pig Breeders Association, the heavy pig production is predominant and most traditional pig production systems occupying more than 59% of total pig production, which amounts 9,157,000 heads/year [2]. Most Italian heavy pigs were Large White and Landrace, both purebred and crossing breed involving Duroc or spotted breeds. As the requirement of market diversity, ever more producers all over the world are also interesting in producing ham following the system of Italian pork industry technology using the same breeds.

However, the specialised heavy pig production will let off more N than normal pig production in which the pigs are slaughtered at about 90-110 kg. The methods for controlling environment pollution caused by animal production in European Union (EU) should function as a reference. In EU, several relative directives (Nitrates Directive 91/676/EEC and IPPC Directive 96/61/EC) have been introduced since last decade of 20th century in order to control N pollution and the maximum quantity of N/ha cannot be higher than 170 kg [3]. From this point of view, the quantity of N excretion per head can be obtained by N intake minus N retention, which allows an accurate assessment of N excretion for animal production with different typologies and categories. Particularly, the integrated pollution prevention and control directive aims to reduce emissions of ammonia to air, water and soil from large farms [4]; while the Nitrates Directive sets the criteria for the assessment of the N content of animal manures. Unfortunately, these criteria are not completely suitable for heavy pig production because of different protein or amino acid content in feed and different slaughtering weight. Several methods to evaluate the N (CP) retention of growing pigs are available in literatures [3, 5, 6, 7]. With the recording of feed intake and corresponding N content in the feed, it is easy to evaluate N excretion with suitable estimation of N retention; nevertheless in practical condition the N retention it is not available and difficult to obtain.

The aims of the present study were: 1. to determine the N retention of heavy pigs using factorial method 2. to compare N excretion calculated with those estimated by different methods mentioned above; 3. to compare N balance sheet estimated with different assessment methods for N excretion.

2. Materials and Methods

2.1 Experimental Design

The experiment was carried out in a representative heavy pig farm located in North-western Italy, where the heavy pig production is prevalent. Two productive cycles were recorded from November 2007 to January 2009. The growing pigs were commercial hybrids of HBI line (Krusca ♂ (Duroc × Hampshire) × Stambo F1 ♀ (Hampshire × Landrace)), which is characterized by high feed utilization and growth performance.

The data obtained from two productive cycles were divided into three levels: farm group (FG), testimonial group (TG) and experimental group (EG). Each cycle had a duration of about 7 months. For FG, 730 pigs with initial body weight (IBW) of 32.2 ± 7.1 kg were fattened from November 2007 to June 2008 (Cycle 1), while 720 pigs with IBW of 31.4 ± 5.5 kg were fattened from June 2008 to January 2009(Cycle 2). To monitor the feed consumption and the growth of different periods, 42 pigs from each cycle were weighed every 44 days as TG. TG in cycle 1 had IBW of 36.1 ± 2.7 kg and was fed 220 days, while TG in cycle 2 has IBW of 31.7 ± 2.6 kg and was fed 218 days. TG groups were housed in 3 pen (14 pigs each) and diet were delivered twice a day by hand after weighting. From each cycle, three

randomly selected pigs were individually housed and fed separately and named experimental group (EG). IBW of the pigs were 38, 35 and 33 (cycle 1) and 31, 32 and 32 (cycle 2) kg for FG, TG, EG, respectively. After 208 days feeding, the animals were slaughtered and dissected to determine N content in final body weights (FBW).

The commercial feed was mixed with whey (1:2.5) and successively mixed with water so that the dilution ratio became 1:3.5. The feeding regime was following the Parma ham regulation.

2.2 Calculation of N Content in the Body and N Excretion

N content in the six pigs of EG were calculated using the factorial method. Pigs were slaughtered after 12 h starvation. The blood was collected and visceral organs were taken out and weighed, Bowels were emptied and washed. All meat was separated in the different cut and deboned. Subcutaneous and perivisceral fat was separated. All tissues and organs were weighed and sampled for N analysis. Samples of each dissected part were frozen and successively lyophilized. Total N body content was calculated as the sum of the weights of every dissected part of body multiplying their corresponding N content analytically measured [8].

N content in the body were calculated by the equation of Manini *et al.* [5]:

$$\text{N content} = 44.46b\text{BW}^{1.0087(b-1)}\text{BW}^{0.0087}$$

where $b = 0.685 + 0.0037\text{MUS}$ (MUS: Muscle percentage in carcass, %); BW: Body weight, kg;

The N content estimated by ERM [3] is about 2.5% of body weight, while the value estimated by Xiccato *et al.* is 2.4% of body weight. Based on the N percentage in FBW, assuming N percentage in piglets as 2.5% of IBW [3], actual N retention (NR) of different groups of heavy pigs could be calculated by the difference between N in IBW and N in FBW obtained by factorial method or different estimation methods.

The NR estimated by NRC [6] can be derived by the following equation:

$$\text{NR} = (0.47666 + 0.02147\text{BW} - 0.00023758\text{BW}^2 + 0.000000713\text{BW}^3) \times \text{CFFLG} / 2.55/6.25$$

$$\text{CFFLG} = (\text{Final CFFL} - \text{Initial CFFL})/ \text{Duration} \times 4.54$$

Where: CFFL: carcass fat-free lean (considered as muscle in this study), kg; CFFLG: Carcass fat-free lean gain, kg/day. Duration: the duration of the feeding trial.

Because the equation of NRC was based on the data of pigs slaughtered around 120 kg, while that of Manini was derived from that data of pigs from 80 kg to 160 kg, the two equations (NRC+Manini) was also combined in order to calculated NR, i.e. NRC equation for growing pigs from weaning to 80 kg and Manini equation from 80 kg to 160 kg.

Successively, N excretions were calculated as the multiplication of feed intake and N content in corresponding feed minus NR calculated with different methods.

2.3 Statistical Analyses

All the data obtained were analysed using ANOVA of SPSS12.0.

3. Results and discussions

3.1 Growth Performance and N Intake

As the animals from the two productive cycles had similar IBW and were fed with similar diet, the data from groups of the same level were analysed together. During the first 176 days, the trends of BW, average daily gain (ADG) and feed conversion ratio (FCR) of growing heavy pigs measured every 44

days in TG and EG are shown in Figure 1. There were no significant differences between TG and EG for all the parameters compared, which showed EG is representative of TG.

The growth performance of heavy pigs in FG, TG and EG had no significant differences among the groups for ADG (0.59-0.60 kg/d), FCR (3.30-3.47) and N intake (9.74-

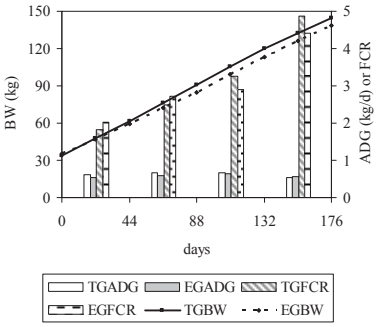

Figure 1. Growth performance in testimonial group (TG) and experimental group (EG). Note: TGADG: Average Daily Gain (ADG) in TG; EGADG: ADG in EG; TGFCR: Feed Conversion Rate(FCR) in TG; EGFCR: FCR in EG; TGBW: Body Weight (BW) in TG; EGBW: BW in EG.

Table 1. Body dissection and corresponding N percentage of experimental heavy pigs (mean ± s.e., kg)

	Blood	Viscera	Muscle	Fat	Bone	Bristle	EBW	FBW
Cycle 1	12.19±0.58	15.10±0.42	65.11±0.82	42.10±6.12	20.46±0.25	0.31±0.06	155.30±7.46	158.80±7.57
Cycle 2	12.12±0.15	15.06±1.08	64.98±3.41	41.70±3.54	20.43±0.96	0.30±0.06	154.50±2.10	158.00±2.00
Cycle1, 2	12.16±0.38	15.08±0.7	65.05±2.04	41.90±4.47	20.44±0.63	0.30±0.06	154.90±4.93	158.40±4.97
N%	2.26	2.71	3.68	0.40	3.37	0.73	2.48*	2.43*

*: Calculated on the base of N content analysed in laboratory. EBW: Empty body weight; FBW: Final Body weight.

Viscera includes Bowels, Liver, Heart, Lung, Spleen, Kidney, Tongue, Stomach.

10.60 kg/head) with similar IBW and FBW (158-166 kg), which means the EG group could be considered as representative of the others two groups. Regarding growth performance, the pigs in this study had higher ADG and lower FCR than those reported by Martelli *et al.* [9] when the pigs with similar IBW and FBW were fed with similar diets. ADG were lower than those (0.73-0.79 kg/d) reported by Manini et al. even though FCR were similar. Furthermore, FCR in this study were slightly higher than those of finishing pigs in the USA where the pigs were slaughtered younger than heavy pigs [10]. All these comparisons imply that the growth performance of heavy pigs in this study was very satisfying and the feeding level of this farm is rather advanced.

3.2 N Content in the BW and N Retention

The three experimental heavy pigs of each cycle were slaughtered and dissected (Table 1). N percentage in FBW was 2.43 % ± 0.07. As there were no significant difference among EG, TG and FG for growth performance, the N percentage in FBW could be considered the same.

Based on the N percentage in FBW, assuming N percentage in piglets as 2.5% [3], actual N retention of different groups of heavy pigs were calculated (factorial method). Since there are many methods available in literature to predict N retention, it is very important to make sure which is the most suitable in a specific situation as the correctness of calculating N retention is directly related to the calculation of

N excretion. The results of the comparison among N content obtained by factorial method and some available equations are reported in Table 2.

There were no significant differences among N retention of FG, TG and EG for different assessment method, while evident differences could be observed among the values calculated with different methods. The methods of Xiccato *et al.* and ERM had results nearer to the factorial method than the methods of NRC [6], Manini et al. [5] and the combination of them. It should be noted that the prediction of NRC is based on the data for the pigs slaughtered around 120 kg; while the prediction of Manini et al. is based on the pigs of 80-160 kg. Since the databases were different between the two methods, the combination of them showed far beyond the reality.

3.3 N Excretion

Using N intake and NR, it was easy to assess a N balance. By factorial method, the percentage of N excretion was about 69.62 % ± 0.20 of N intake. This value is in the range from 53.6% to 80% reported in literature [11]. This value is rather good, even though the value of N excretion percentage was slightly higher than that of Denmark (65%), France (68%) and Netherlands (65.9%) [12, 13] considering the slaughtering weights in these countries.

In Figure 2, the differences between values of N excretion calculated with different methods and the value calculated with factorial method were expressed in percentage. It can be noted that the values calculated with the method of Xiccato *et al.* [8] were most similar with those obtained by factorial method which meant the equation proposed by Xiccato *et al.* [8] is suitable for the estimation of N excretion from heavy pigs. ERM [3] equation underestimated the percentage of N excretion for FG, TG and EG. Similarly, NRC equation shows underestimated values of 1.71%, 2.77% and 3.64% for FG, TG and EG respectively. Conversely, the equation of Manini et al. and the combination of NRC+Manini overestimates the value far beyond the actual value (more than 29% and 15-16% respectively).

Based on the above mentioned consideration, the comparison of productive performance and annual N excretion was made only by the proposal of ERM, Xiccato et al., and factorial method. Because of shorter number of cycles per year (1.66) and lower N percentage in the feed (2.40%), N consumption per place per year (17.38 kg) or N retention per place per year (5.26 kg) in this study were lower/higher than those of the farms indicated by ERM (3.00, 2.80%, 19.50 kg, 6.05 kg respectively). The values in the study were in the range of those of Xiccato *et al.* [7].

Table 2. N retention (kg/pig) calculated by different equations (mean±s.e.)

	FG			TG			EG		
Factorial method	3.17^{b}	±	0.01	3.21^{b}	±	0.06	2.97^{b}	±	0.02
ERM	3.28^{b}	±	0.01	3.32^{b}	±	0.06	3.02^{b}	±	0.11
Xiccato *et al.*	3.15^{b}	±	0.01	3.19^{b}	±	0.06	2.96^{b}	±	0.11
NRC	3.44^{a}	±	0.01	3.41^{a}	±	0.02	3.09^{a}	±	0.03
Manini	1.03^{d}	±	0.00	1.02^{d}	±	0.00	0.96^{d}	±	0.02
NRC+Manini	2.01^{c}	±	0.01	2.10^{c}	±	0.02	1.79^{c}	±	0.08

The values in the same column with different letters differ ($p<0.05$). FG: farm group; TG: testimonial group; EG: experimental group.

Due to the growing public concern regarding environmental impacts of N excretion from animal production, N flow and surplus have been studied by many authors [14] at the farm level and many measures had been proposed to reduce N excretion. However, the critical control of N surplus from animal production is a radical way to reduce its environmental impacts [15]. Optimal quantities of protein available to animals should be supplied since the degradation of excess digestible protein resulted in an

increased energy loss in urine and an elevated heat loss and in contrast, energy sparing due to reduced protein content increased fat deposition [16]. Furthermore, since the productive performance and N balance of a farm depend on

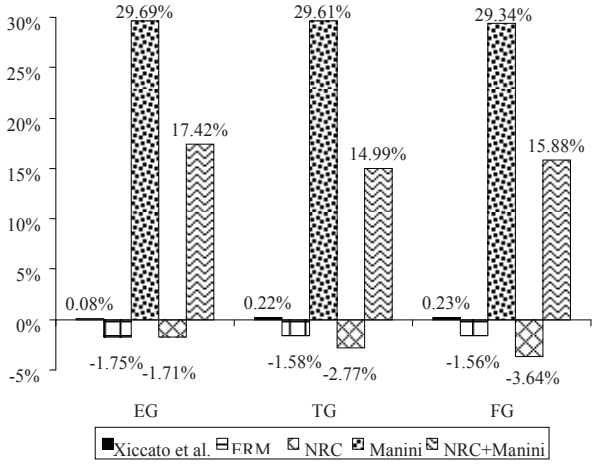

Figure 2. Difference of N excretion obtained with different methods comparing with the factorial method.

many variables like genetics of animals, kind and process of feedstuff used, feeding level etc., it is essential to have a N balance sheet for each individual farm. The assessment method can be used only when the information is unavailable or limited. Only in this way, the farmers can be stimulated to take every best available technique to reduce N excretion and environmental surplus.

4. Conclusions

The factorial study (slaughter technique) showed that the N percentage of heavy pigs was 2.43% ± 0.07 of BW and the percentage of N excretion was about 69.62% ± 0.20 of N intake. Comparison between these values with those estimated by other assessment methods showed that the proposal of Xiccato *et al.* was most suitable for the farm situation for pigs destined to ham production. However, it is advisable to do a N balance sheet for and/or by every single farm in order to encourage farmers to adopt available measures to reduce N excretion as so to allow heavy pig production more sustainable.

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