BODY COMPOSITION EVALUATED BY COMPUTER TOMOGRAPHY AND ALLOMETRIC GROWTH OF VISCERA AND ORGANS IN PIGS FROM 30 TO 120 KG

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Abstract – This paper describes the evolution in weight and relative weight of white viscera, organs, flare fat and the volume of tissues with Hounsfield values between -160 and 140 of pigs from 3 different genotypes weighing between 30 and 120 kg. The only differences between genotypes were in the weight of white viscera and flare fat. All the components evaluated increased in weight when live weight increased and all of them (organs and white viscera) except the flare fat decreased in proportion when live weight increased. Allometric coefficients show that flare flat grows faster and volume in a similar way compared to body weight. The other components studied grows more slowly than body weight.

Key Words – heart, liver, kidneys, flare fat, relative development

I. INTRODUCTION

The growth of different tissues in pigs is of interest to stakeholders in order to understand and direct their product to the most adequate market. The growth of viscera, certain organs and flare fat is also a point of interest to determine the yield, because these components do not belong to the carcass and are not the main objective in pig production. The allometric model works well to explain the changes in development during growth [1, 2].

Computer tomography is a methodology that can be used to evaluate composition *in vivo* during growth [3,4] because it can measure the attenuation of X-rays on their way through the body which depends on the density of the different tissues.

The objective of the present study was to examine the allometric growth of organs, white viscera, flare fat and partial volume of pigs from different genotypes from 30 to 120 kg, live weight.

II. MATERIALS AND METHODS

A total of 89 gilts from 3 genotypes (29 Duroc x (Landrace x Large White) [DUx(LDxLW)] 30 LDxLW and 30 Pietrain x (Landrace x Large White) [PIx(LDxLW)] were studied in the project. The piglets were born in the same week. At approximately 21 days the piglets were moved to the weaning unit at IRTA-CAP (Monells) and at a later date transferred to the fattening pens. They were kept in pens of 9-12 pigs (balanced by genotypes) and classified according to 4 target weight groups (30, 70, 100 and 120 kg). The diet was the same for all the pigs and it was based on cereals and soya containing 3365 kcal/kg, 1.05% lysine and 18% crude protein. They were fed *ad libitum.*

When the animals reached the target weight, they were fasted, anesthetized and scanned with the computer tomography equipment (General Electric HiSpeed Zx/i) (Figure 1). Cross-sectional images were taken from cranial to caudal position at 140 kV, 145 mA, 512x512 matrix [5]. At 30 kg images of 7 mm-thick were taken every 7 mm. At 70, 100 and 120 kg, images 10 mm-thick were taken every 10 mm. The volume of tissues of the animal with Hounsfield values between -160 and 140 (that correspond to lean and fat densities, including certain organs and viscera) named partial volume (Figure 2), was obtained from the images by means of the program VisualPork [6].

After scanning, the pigs were stunned with CO_2 90% and then slaughtered in the experimental abattoir (IRTA-Monells). Viscera, organs and flare fat were extracted and weighed. Relative weight to live weight was also calculated.

Data analysis was performed using SAS (SAS Institute Inc., Cary, NC, USA). The model included genotype and target weight as fixed effects. Interaction was not included because it

was not significant. For partial volume, white viscera, organs and flare fat were also included the difference between live weight and average weight, within each target weight, as covariate.

Figure 1. Scanning live pig with CT

Allometric growth of viscera, organs, flare fat and partial volume relative to live weight was calculated according to the following equation: $Y=aX^b$, where Y is the weight of the body component, X is the live weight, a is the intercept and b is the allometric coefficient (slope) relating the growth of Y to that of X. For the data analysis the allometric equation was linearized as $\log_{10}Y=\log_{10}\cdot a+b\cdot\log_{10}X$.

III. RESULTS AND DISCUSSION

Table 1 shows that no significant differences were found in the average live and carcass weights of the animals classified by genotype according to the objectives. The average weight at each target weight also shows the accomplishment of the objectives. The volume of tissues with Hounsfield values between -160 and 140 (partial volume) was also not different between genotypes and increased with increasing target weight.

PIx(LDxLW) presented the lowest weight and relative weight of white viscera and probably due to that, the highest killing out. No significant differences in weight between genotypes were found in the various organs evaluated. Wiseman et al. [7] found that the heart of high lean animals was heavier than those of low lean animals at 20 and 45 kg. PIx(LDxLW) had lower flare fat weight and relative weight and lower liver relative weight than LDxLW, DUx(LDxLW) were intermediate. Wiseman et al. [7] found higher flare fat in low lean pigs compared with high lean pigs.
This weight of white viscera increased with the weight of the pig but the proportion remained constant between 70 and 120 kg (Table 1). The weight of the heart, liver, kidney and brain also increased with the weight of the pig, but not significantly between 100 and 120 kg. However, the proportion of these organs decreased when the weight increased although the difference was not significant between some weight groups. Flare fat weight increased with the weight of the animal but the proportion of flare fat only increased significantly ($P<0.05$) between 70 and 100 kg.

Allometric growth for the viscera, organs, flare fat and partial volume in relation to live weight are presented in Table 2. The growth of the viscera and organs occurred relatively more slowly than the body weight since the allometric coefficient was lower than 1. The lower the coefficient the higher the difference in growth. The brain was the organ that grew most slowly in relation to body weight. Landgraf et al. [2] found similar coefficients for heart (0.72), liver (0.61), kidneys (0.71) and viscera (0.79) when studying the variation in empty body weight.
Flare fat deposition occurred relatively more rapidly (late maturing) than body weight because the coefficient was higher than 1. Due to the fact that flare fat does not come from the carcass, this can affect negatively to its yield.
Allometric coefficients of white viscera and flare fat by genotype showed that viscera of LDxLW animals grew more slowly and flare fat grew faster than those of the other two genotypes studied (results not shown).
The allometric coefficient for the partial volume was close to 1, indicating that its growth was similar to that of the live weight. This result is logical since the volume of lean and fat together (plus some viscera and organs) grows in proportion to the weight of the animal.

IV. CONCLUSION

White viscera and organs increased in weight and decreased in relative weight during growth while flare fat increased in weight and relative weight

during growth because it grows faster. Partial volume of the body increases in a similar way to the live weight of the animal.

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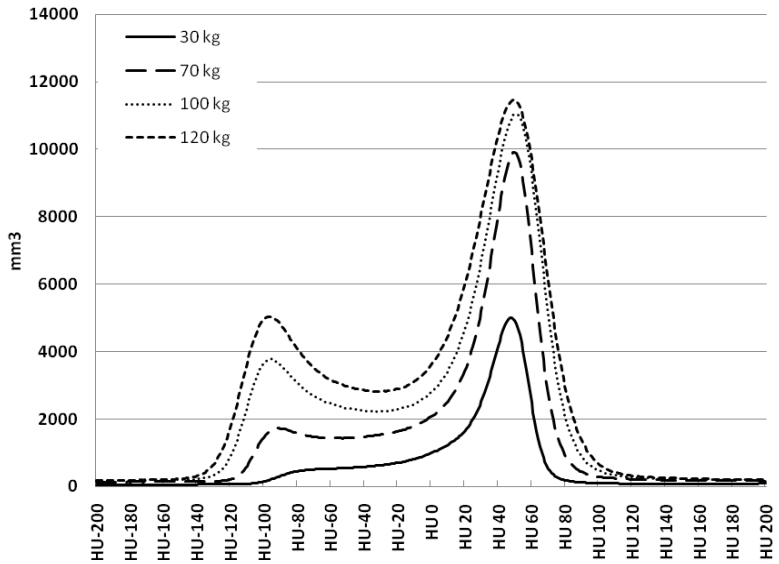

Figure 2. Histogram of the volume associated to each Hounsfield value (HU) by target weight.

Table 1 Least square means and root mean square error of the model (RMSE) of the carcass characteristics and white viscera, organs and flare fat weights and proportions by target weight.

	Genotype			Target weight				
	DUx(LDxLW)	LDxLW	PIx(LDxLW)	30 kg	70 kg	100 kg	120 kg	RMSE
Number of animals	29	30	30	15	15	15	44	
Live weight (kg)	80.8	80.8	79.8	30.2d	69.2c	99.7b	122.7a	3.15
Warm carcass weight (kg)	64.4	64.4	64.8	22.7d	55.7c	80.8b	98.9a	2.44
Cold carcass weight (kg)	62.6	62.8	63.1	22.0d	54.1c	78.7b	96.5a	2.38
Killing out (%)	76.7b	76.7b	78.0a	72.6b	78.2a	78.9a	78.7a	1.67
Chilling losses (%)	2.89	2.76	2.81	3.37a	2.80b	2.65b	2.45c	2.70
Partial volume (cm^3)[2]	699.97	706.15	703.27	248.73d	602.87c	879.96b	1080.95a	16.09
Weight (g)[2]								
White visceras	5702.3a	5934.3a	5118.7b	2649.5d	4857.7c	6414.5b	8418.8a	792.63
Heart	331.4	327.2	319.7	157.4c	350.9b	381.1ab	414.9a	42.95
Liver	1361.8	1423.7	1317.6	686.1c	1308.2b	1667.2a	1809.3a	171.99
Kidney	281.5	277.6	271.6	142.5c	275.7b	324.9a	364.4a	32.36
Brain	84.5	86.4	83.5	70.3c	83.9b	92.4a	92.8a	7.71
Flare fat	537.6ab	618.0a	465.2b	93.1d	329.3c	700.6b	1038.1a	204.04
Relative weight (%)[2]								
White visceras	7.3a	7.7a	6.7b	8.8a	7.0b	6.4b	6.9b	0.84
Heart	0.45	0.44	0.43	0.52a	0.51a	0.38b	0.34b	0.06
Liver	1.83ab	1.91a	1.74b	2.27a	1.88b	1.67b	1.48c	0.20
Kidney	0.4	0.4	0.4	0.47a	0.40b	0.33c	0.30c	0.04
Brain	0.13	0.13	0.13	0.23a	0.12b	0.09c	0.08d	0.01
Flare fat	0.57ab	0.66a	0.51b	0.31b	0.47b	0.70a	0.85a	0.19

[1] Different superscripts within line and effect (genotype or weight) indicate significant ($P<0.05$) differences.
[2] Least squares means by genotype adjusted to live weight of 80.5 kg

Table 2 Estimated allometric growth functions relating partial volume, weights of organs, viscera and flare fat to live weight.

	log a	s.e.	b	s.e.	r	RMSE
Partial volume	3.841	0.008	1.050	0.004	1.00	0.009
Heart	1.231	0.061	0.671	0.031	0.92	0.064
Liver	1.802	0.050	0.700	0.026	0.95	0.053
Kidney	1.212	0.044	0.647	0.023	0.95	0.047
Brain	1.571	0.035	0.191	0.018	0.75	0.037
White visceras	2.153	0.053	0.840	0.027	0.96	0.056
Flare fat	-0.639	0.117	1.736	0.060	0.95	0.123

(1) Allometric functions fitted by linearizing the functions as $\log_{10}Y=\log_{10}\cdot a+b\cdot\log_{10}X$

s.e.: standard error; r: correlation coefficient ; RMSE: Root mean square error