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ALLOMETRIC GROWTH OF PRIMAL CUTS AND TISSUES IN THE PIG

CRESCIMENTO ALOMÉTRICO DE COMPONENTES DO PESO CORPORAL EM SUÍNO

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SUMMARY

Data from 82 purebred and crossbred Large White and Duroc barrows and gilts were used to describe the growth of carcass primal cuts, of tissues, and of several organs. Pigs were allowed ***ad libitum*** to a conventional diet, which contained corn and soybean meal. Pigs were weighted weekly and were slaughtered when attained a liveweight over 90kg. An allometric pattern of growth was assumed. Within the observed range of liveweight, the carcass grew slower than the whole animal. An increase of carcass weight corresponds to a similar increase of lean, but also corresponds to a larger increase of fat tissues. A suggestion to slaughter pigs near to 90kg of liveweight is presented, in order to obtain leaner carcasses.

Key words: allometric growth, carcasses, pigs.

RESUMO

Utilizaram-se 82 suínos, puros e cruzas F1 das raças Large White e Duroc, para descrever o crescimento alométrico dos cortes da carcaça, dos tecidos que os compõem e de vários órgaos. Os suínos foram alimentados ***ad libitum*** com dieta convencional, à base de milho e de farelo de soja. Os animais foram pesados semanalmente, e abatidos quando atingiam peso corporal acima de 90kg. Equações de alometria foram ajustadas aos dados de dissecação das carcaças. Dentro da amplitude de peso vivo estudada, a carcaça apresentou crescimento mais lento do que o peso vivo. Ao aumento no peso da carcaça correspondeu um aumento similar em tecidos musculares, porém os tecidos adiposos cresceram mais rapidamente do que a carcaça. Sugere-se o abate de animais com peso próximo aos 90kg, para a obtenção de carcaças mais magras.

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Palavras-chave: crescimento alométrico, carcaças, suínos.

INTRODUCTION

When pork is marketed on a component basis, the knowledge of its growth patterns is important to set up proper production and slaughter strategies to maximize profit (GU et al., 1992). Thus, a development of a component pricing system for pork (e.g.: AKRIDGE et al., 1990), which reflects the true carcass value, would be desirable. An accurate system allows farmers and industries to realize both economic and technical benefits. The rates of quantitative accretion of each tissue may be used in designing pig nutrition plans. These should attain the pigs nutrient requirements, in a proper manner, at the various stages of growth (SHIELDS et al., 1983).

Relative growth of carcass components in swine, by means of the allometric growth law, was reported previously (McMEEKAN, 1940; DAVIES, 1974a; SHIELDS et al., 1983; WOOD et al., 1983; FEWSON et al., 1990; GU et al., 1992). These results are in agreement that bone tissues have early growth rate, fat tissues have late growth rate, and lean tissues have an intermediate growth rate. Allometric growth of primal cuts was not reported in an unnanimously way, mainly due to differences caused by breed, sex, or pen.

In this paper, overall allometric growth coefficients of some organs and of primal cuts in pigs are reported. Within each primal cut, allometric growth coefficients were fitted for bone, fat, and lean, and for internal cuts, when proper. Remarks on possible profitable strategies for pig slaughter are presented.

MATERIAL AND METHODS

Data for this study came from 82 pigs, 14 male and 20 female Large White, 17 male and 17 female Duroc, and 6 male and 8 female crossbred. Pigs were raised in Centro Agropecuario da Palma, Universidade Federal de Pelotas, for three consecutive years, housed in concrete floor conventional facilities, in groups up to six animals. Pigs were fed ***ad libitum*** with a diet, in accordance to NRC requirements. The basic components of the diet were corn and soybean meal. Pigs were freely allowed to fresh water.

All pigs were weighted once a week. An animal was removed from the pen when it attained a liveweight near to 95kg. This procedure assumes that the growth of primal cuts and of internal organs is most related to the augment of liveweight rather than of age. After removal, the animals were allowed only to water, during 12h, and in the following 12h, no water or food was given. Slaughter was followed by exsanguination, warm carcass measurements and weighting of organs (green inwards, heart, kidneys, liver, spleen and lungs). Carcass dissection occured after at least 24h of chilling (2-4°C). The primal cuts were obtained according to the Brazilian Method of Carcass Evaluation (ASSOCIAÇÃO BRASILEIRA DE CRIADORES DE SUÍNOS, 1973). Cold carcass measurements were performed on the left-side half carcass. Each primal cut was entirely split into bone, lean, fat, and skin. Skin weights were not obtained. In some primal cuts (e.g.: loin), internal cuts were obtained (e.g.: tenderloin) and weighted before dissection was completed. All weights are expressed in kilograms.

Several regressions, assuming an allometric pattern of growth, were fitted using the following model (HUXLEY, 1924):

$$Y = a X^b$$

where: Y is the weight of an organ, or of a primal cut, of an internal cut (the part);
X is the liveweight, the carcass weight, or the weight of a primal cut (the whole);
b is the allometric growth coefficient.

The parameter a, the value of Y when X=1, has no biological interpretation. The model was linearized as $\ln Y = \ln a + b \ln X$. This allows to fit the regressions as ordinary straight lines. The allometric coefficients were t-tested under one of the two following hypotheses: (1) Ho:B=1, to determine if the allometric coefficient may define a fast, slow or equivalent pattern of growth; (2) Ho:B=0, to determine if the growth of a primal cut, or of a body component has already finished. If the estimated value of b was positive, the first hypothesis was tested; if b had a negative estimate, the second hypothesis was tested. The t-tests were computed as t=(b-Bo)/SEb, which distributes as Student's t, with the degrees of freedom of the error term. Bo equals to one or to zero, respectively, for the first and the second hypothesis above.

A preliminar analysis included the effects of breed and of sex in the model, as class effects, and interactions with the X variable of each model. No interactions were statistically significant. This preliminar result allowed the fitting of a single, overall allometric coefficient, valid for the three breeds, and for both sexes.

RESULTS AND DISCUSSION

Descriptive statistics for the weights of all items used as the wholes to fit the allometric equations are presented in Table 1. One should give special attempt to the minimum and to the maximum values, since those set the range of validity of each allometric growth coefficient. As an example, equations which use the liveweight as the whole may be used to describe the relative growth of several parts only for liveweights between 89.5 and 101.0kg.

Table 1 - Descriptive statistics for the items used as the wholes to fit the allometric equations.

Item	Mean	Std.Dev.	Minimum	Maximum
Liveweight	94.81	2.72	89.50	101.00
Warm carcass	75.54	2.22	69.00	81.00
Cold carcass	73.57	2.19	67.40	79.20
Ham	11.26	0.60	9.90	12.40
Shoulder	5.87	0.53	4.60	7.00
Loin	7.06	0.76	4.56	8.82
Ribs	5.45	0.70	3.60	7.20
Breast	1.79	0.37	0.90	2.93
Neck	3.01	0.38	2.29	3.88
Head	2.93	0.34	2.25	4.28

The estimates of the allometric regression equations parameters, which used the liveweight as the whole, are presented in Table 2. These equations were fitted for the organs and for carcass weights. In the same table, results of the t-tests are presented. In Table 3, the parameters and the t-tests concerning the equations which used the warm and the cold carcass as the whole. No equations were fitted for the organs, using the carcass weights as the whole.

Within the range of liveweight, the green inwards (stomach plus intestines) had a great growth rate (b = 2.464±0.767). The heart (b = -0.098±0.455) and the kidneys (b = -0.497±0.659) had already finished their growth. The latter two coefficients did not differ significantly from zero. The very high standard errors (SE) obtained for the allometric coefficients of liver, spleen, and lungs (all values of SE over 1) do not allow to make secure remarks regarding the growth of these organs. Excessive variability found in the growth patterns of these organs should be verified in further research. The results obtained do not agree with those reported by TESS et al. (1986). The carcass grew slower than the liveweight, indicating that other components of body weight were growing faster than the carcass.

Table 2 - Parameters of the allometric equations fitted regarding the liveweight as the whole, and corresponding t-tests probabilities for the allometric coefficients.

Item	ln a	b ± SE_b	Prob.*	Prob.**
Green inwards	-9.103	2.464 ± 0.767	0.0599	---------
Heart	-0.613	-0.098 ± 0.455	---------	0.8300
Kidneys	1.060	-0.497 ± 0.659	---------	0.4527
Liver	-0.957	0.307 ± 1.053	0.5124	---------
Spleen	-8.652	1.467 ± 1.324	0.7252	---------
Lungs	-0.905	0.231 ± 1.025	0.4547	---------
Warm carcass	1.169	0.693 ± 0.085	0.0006	---------
Cold carcass	1.248	0.670 ± 0.090	0.0004	---------

* Under H_o: B=1
** Under H_o: B=0.

Table 3 - Parameters of the allometric equations fitted for the primal cuts, regarding the warm or the cold carcass as the whole, and corresponding t-test probabilities* for the allometric coefficients.

Primal Cuts	Warm Carcass			Cold Carcass		
	ln a	b ± SE_b	Prob.	ln a	b ± SE_b	Prob.
Ham	-0.944	0.778±0.185	0.2337	-0.797	0.748±0.184	0.1746
Shoulder	-1.936	0.856±0.335	0.6684	-1.583	0.779±0.332	0.5075
Loin	-1.920	0.895±0.412	0.7995	-1.503	0.803±0.408	0.6306
Ribs	-4.264	1.376±0.471	0.4271	-3.935	1.308±0.466	0.5106
Breast	-3.577	0.957±0.800	0.9572	-5.546	1.421±0 .779	0.5904
Neck	0.908	0.043±0.486	0.0524	0.309	0.183±0.479	0.0920
Head	-3.623	1.085±0.402	0.8331	-3.687	1.107±0.395	0.7872

* Under H_o: B=1.

The internal growth of tissues, in each primal cut, is described by the allometric equations presented in Table 4. Those equations were fitted using each primal cut as the whole. The allometric coefficients estimated for lean growth ranged from 0.547 to 1.111. The bacon and the lean of the neck grew slower than the whole, and in the other primal cuts, lean grew at the same speed as the whole. The bone grew slower than the whole in the ham (b = 0.310±0.237), shoulder (b = 0.571±0.172), loin (b = 0.553±0.188), and breast (b = 0.559±0.159). In the neck it grew at the same rate that the whole (b = 0.983±0.342), as well as in the ribs (b = 1.538±0.305). All the allometric coefficients for fat growth were larger than unity (range: from 1.109 to 1.638), but were significantly different from one only in the loin, ribs, and neck. It was observed that two internal cuts of the loin (tenderloin and rib chops) grew slower than the loin (b = 0.406±0.156, and b = 0.612 ±0.075, in that order).

Table 4 - Parameters of the allometric equations fitted for the tissues or internal cuts, regarding the corresponding primal cut as the whole, and corresponding t-test probabilities* for the allometric coefficients.

Primal Cut	Tissue Cut	ln a	$b \pm SE_b$	Prob.
Ham	Lean	-0.299	0.909±0.124	0.4701
	Bone	-0.544	0.310±0.237	0.0047
	Fat	-2.259	1.155±0.498	0.7563
Shoulder	Lean	-0.877	1.111±0.108	0.3071
	Bone	-1.151	0.571±0.172	0.0147
	Fat	-1.985	1.109±0.287	0.7059
Loin	Lean	-2.015	1.071±0.238	0.7668
	Bone	-0.876	0.553±0.188	0.0198
	Fat	-2.674	1.579±0.224	0.0116
	Tenderloin	0.023	0.406±0.156	0.0003
	Rib chops	0.391	0.612±0.075	0.0000
Ribs	Bacon	0.016	0.547±0.101	0.0000
	Bone	-3.943	1.538±0.305	0.0816
	Fat	-2.311	1.638±0.146	0.0000
Breast	Lean	-0.677	1.042±0.078	0.5917
	Bone	-1.489	0.559±0.158	0.0066
	Fat	-2.313	1.247±0.217	0.2584
Neck	Lean	-0.175	0.798±0.072	0.0063
	Bone	-2.447	0.983±0.342	0.9960
	Fat	-2.781	1.617±0.305	0.0464

* Under H_o: B=1.

The results of the present paper should not be compared directly to those reported by DAVIES (1974b), since this author slaughtered pigs with weights ranging from 2 to 64kg. He also fitted allometric equations to individual muscles, leading to a great improvement in the comprehension of the causes of growth of the primal cuts. A main conclusion of that author was that the muscles which had the largest allometric coefficients were those "related to the functional demands of an increase in body size". Further research should verify this hypothesis, as well as the use of other mathematical models in describing pig growth patterns. An example is found in SIEBRITS (1986), which suggests the use of the logarithmic form of the Gompertz function.

The slaughter weights of the pigs in this study correspond nearly to the commercial range of slaughter weights verified in Brazilian industries. Interpretation of the results should be done regarding this fact. The changes in slaughter weight, although in a small range (11.5kg), may produce slight but important modifications in carcass composition of the pig, with important economical consequences. It can be concluded that the increase of liveweight is mainly followed by an increase in the fatty tissues. The energy cost of fat deposition in the pig is higher than of the protein deposition (TESS et al., 1984). Within the studied range, slaughtering of lighter pigs, with liveweight near to 90kg, should be preferred, since an excessive amount of fat in the carcass is undesirable. Although the lean tissues grow at the same speed of their corresponding primal cuts, the simultaneous increase of fat should be avoided.

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