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ANATOMICAL MEANING OF THE SPECIFIC GRAVITY OF HAMS FROM NON-CASTRATED LARGE-WHITE MALE PIGS

B. DESMOULIN, B.L. DUMONT *, B. JACQUET et R. TOMASSONE

Institut National de la Recherche Agronomique

C.N.R.Z. Jouy-en-Josas -78- France

Since the results obtained by BROWN et al, 1951, the specific gravity is used for the indirect estimation of the pig carcass composition. This determination does not seem to have the same significance when applied either to total carcass (ALEXANDROWICZ et al, 1970) or to its different cuts (ADAM et SMITH, 1964, JOBLIN, 1966, BOCHNO et al, 1967). The weight P of one cut of the carcasses is often little indicative of its composition (DESMOULIN, 1969) : its relative water specific gravity becomes more explicit on condition that the immersed weight Pi really indicates the quantitative variation of the tissue constituents. According to the previously described methods of determination (DESMOULIN, 1970), when using the two values P and Pi, it is possible to establish grading diagrams for the cuts according to their specific gravity (DESMOULIN et BOURDON, 1971).

The present study exclusively concerns hams taken out from carcasses of non-castrated males pigs slaughtered at 80 or 100 Kg live weight. The specific gravity of the right ham was determined and the amounts of dissected tissues measured. The left ham of the same pigs were processed into "Jambon de Paris". The aim of our study was to show how the measurement of the immersed weight of the ham brings a synthetical criteria for its tissue composition. Moreover an attempt was made to find a physical characteristic liable to predict the value of the hams during processing.

MATERIAL AND METHODS

1°) Determination of the specific gravity and dissection

a) The measurement of the weight Pi of the immersed hams requires direct and vertical transmission of the hydrostatic lift upon the weighing device (suspension by one only right stick). Moreover, the internal temperature of the hams (+ 4°C) and that of the water (+ 7°C) are in a state of suitable balance. In the relation $d = P / P - Pi \cdot \delta$, the correction by 7°C of the specific gravity of the water (δ = 0,9993) is neglected. The weights P and Pi are measured with an absolute error ($\pm$ 0,5 g) which results in an experimental error as regards the specific gravity of the hams ($\Delta d \# 1.10^{-3}$).

b) After a short period of drying in a cold-room, the hams were dissected into anatomical components according to MESLE, GIRON et DUMONT, 1959 . The 6 characteristics measured (skin : Pe External Fats : Ge Internal fats : Gi Muscles : Mu Bones : os and aponeurosis : Ap) are compared with the two global measurements, ie.. gross weight : P and immersed weight : Pi.

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*We greatly appreciate the cooperation of Dr ROY for the dissection.

2°) Processing into "Jambons de Paris"

After a more or less long lasting stockage, the "Jambons of Paris" were processed as follows : Ist Trimming shape, pumping, brine cover - drainage - boning and 2nd Trimming. The losses due to the successive trimmings (external and internal fats - fat veins) as well as those following the boning determine the anatomical yield before cooking: RA.

$$RA = \frac{\text{Gross weight} - (\text{Fats Ist and 2nd} + \text{Bones})}{\text{Gross weight}}$$

This criterion is an important component of the final yield as the losses after cooking depend on the technological qualities of the meat. Determined at the technical center of meat processing "CTSCCV" (B. JACQUET), the anatomical yield: RA is the 9th anatomical character of this analysis.

3°) Factor analysis of correspondences

a) The tissue composition of the 32 hams is characterized after synthesis of certain data and the components explaining the variations of the immersed weight Pi or those of the anatomical yield are determined. The multiple and stepwise regression analysis thus define:

$$Pi = f\ (P, Mu, Gi + Ge, Os, Pe + Ap)$$

$$RA = f\ (P, Mu, Gi + Ge, Os, Pe + Ap, Pi)$$

b) The 9 characters measured (P, Pi, Mu, Gi, Ge, Os, Pe, Ap and RA) on each one of the 32 hams studied define 9 X 32 = 278 variables. According to R. TOMASSONE (I970), the factor analysis of correspondences establishes the matrix of the proximities or distances between the hams (or subjects) and the characters (or attributes) which define them. The factors (or axis) of inertia common to the subjects + attributs as a whole are discriminating of the total variation. These factors differenciate individually the hams by classifying the discrimating tissue characteristics.

RESULTS

I) Average composition of the hams

For I6 pigs slaughtered at 80 Kg and I6 pigs slaughtered at I00 Kg, the mean characteristics ($\bar{x}$ - s) of the hams are shown in the table I according to each stage studied.

TABLE I - Amounts of tissue components (g) and criteria studied

Slaughter weight	gross weight P	muscles Mu	external fats Ge	internal fats Gi	bones Os	Aponeurosis Ap	Skin Pe	Immerged weight Pi	Anatomical yield RA
80 Kg	6I57	39I0	I026	228	566	49	300	367	60,7
	300	334	62	66	62	I0	49	39	3,0
I00 Kg	7558	4754	I294	297	640	58	320	442	6I,0
	463	430	385	65	54	I9	4I	37	2,4

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When the gross weight of the ham increased by 22,7 p. I00 between 80 and I00 Kg slaughter weight, the weight of the bones increased by I3 p. I00, that of the muscles by 2I,5 p. I00. The weights of the total fats (Ge + Gi), showing a clear positive allometry ($\alpha \neq$ 2,I) increased by 26,9 p. I00. According to these different variations, the immersed weight (Pi) increased by 20,4 p. I00. On an average, the specific gravity (I, 062 - I,063) and the anatomical yield (60,7 - 6I,0) of the hams are not very much influenced by the slaughter weight.

After having associated on the one hand Ge and Gi, on the other hand Ap and Pe, the correlation coefficients between the characters are the following (Table 2)

TABLE 2 - Single correlations (r) between the different characters

P	Mu	Ge+Gi	Os	Ap et Pe	Pi	RA	(r)
I,00	0,95	0,66	0,66	0,5I	0,84	0,27	P
	I,00	0,40	0,65	0,53	0,90	0,50	Mu
		I,00	0,2I	0,09	0,29	- 0,40	Ge + Gi
			I,00	0,42	0,77	0,38	Os
				I,00	0,49	0,23	Pe + Ap
					I,00	0,60	Pi
						I,00	RA

2) Explaining variables and multiple correlations

Each characteristic being more or less inter-dependant, the multiple and stepwise regression analysis classifies, by order of importance, the explaining variables of the immersed weight (Pi) and then those of the anatomical yield (RA).

a) Explanation of the immersed weight

The explaining variables of Pi are computed in the following order of importance with multiple correlations $r_{I,\ 2..à..5}$.

Pi = 40,2 + 0,084 Mu (rI = 0,899)
Pi = 26,I + 0,065 Mu + 0,248 Os (rI2= 0,93I)
Pi = - I4,2 + 0,083 Mu + 0,260 Os - 0,053 P (r_{I23} = 0,933)

Thus, 87 p. I00 of the total variation of Pi are explained by the Muscles + Bones weights (positive components) and the gross weight of the cut (negative component). The others variables do not improve the final explanation ($r_{I\ a\ 5}$ = 0,935). The positive allometry of the fats contained in the hams is indirectly represented by the gross weight of the cut as 3rd negative component of the Pi variations.

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b) Explanation of the anatomical yield

The explaining variables of RA are computed in the following order of importance with lower multiple correlations than those obtained with Pi.

RA = 48,5 + 0,030 Pi	(r I = 0,604)
RA = 54,I + 0,040 Pi - 0,006 GT	(r I2 = 0,856)
RA = 56,I + 0,049 Pi - 0,006 GT - 0,009 Os	(r I23 = 0,870)

Thus 76 p. I00 of the total variation of RA are explained by the immersed weight (positive component) and the fats + Bones weights (negative components). The others variables: Muscles (en> 0), gross weight, skin and aponeurosis (en <0) do not improve the final explanation (r I, 2..a..6 = 0,884).

3) Grading diagrams of hams according to their specific gravity

Graph I shows the classes of specific gravity including the individual distribution of the hams at each stage of slaughtering. A ham weighing 6I00 g is situated in the class d > I,065 by Pi > 380 g and in the class d < I,060 by Pi < 350 g. For a ham weighing 7600 g, we may differenciate the same classes by Pi > 465 g and Pi < 430 g. this intra-class distribution is analysed as follows.

4) Factor analysis of correspondences between the hams and their tissue characteristics

The grading of the hams (32 subjects) and of their characteristics (9 attributes) is defined symmetrically by the proximities between these 278 variables. Graph II shows the distances between the attributes synthesizing the grading factors of the total variation.

a) Factor I, computing 5I,5p. I00 of the total variation, opposes external and internal fats to muscles and bones. This factor constitutes the variation of the ratio lean mass/fatty mass.

b) Factor 2, computing 25,8 p. I00 of the total variation, opposes internal fats to the others attributes including external fats. This discrimination is based on the ratio external Fats/ Internal fats.

c) Factor 3, computing II, 0 p. cent of the total variation, opposes particularly bones to muscles; is the discrimination resulting from the ratio muscles/bones

d) Factor 4 and 5, computing respectively 6 et 4 p. cent of the total variation, differenciate skin or aponeurosis compared to the others attributes. These minor variables depend on the accuracy of the dissection measurements.

Factors I and 2 closely relate the variation of the immersed weight to those of the anatomical yield (proximity of these attributes) by 5I,5 + 25,8 = 77,3 p. I00 of the total variation.
On the other hand, Factor 3 indicates that Pi and Mu constitute a dissociated whole of RA and Os by II p. cent of the total variation. This very analytical method of individual variations defines more accurately the bodily-ratios and their importances in ham grading.

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Table 3 shows some individual results. The position of these subjects comparable to those of their attributes is shown in graph II.

a) According to the ratio muscle/fat, the hams number II and 20 are opposed to number 60 and 47. Hams 28 and 29 are identical.

b) according to the ratio external Fats/ internal fats, the hams number 49 and I9 are opposed to 03 and 27.

c) The discrimination resulting from the ratio muscles/bone differenciates the ham number 83 by example.

The linear representation of each grading factor of the hams and of their characters may be used as rectangular coordinates (factor I and 2 ; or I and 3, ect...) The pool of variables which bring nearer the subjects and their attributes can be defined in this way.

DISCUSSION

- The weight P of the ham is positively related with its muscle mass (r = + 0,95) but also with the other tissue components : fats (r = + 0,66) bones (r = + 0,66) Aponeurosis and skin (r = + 0,5I). Finally, this criteria does not give an accurate information about the bodily-ratios between the differents constituents.

- On the other hand, the immersed weight Pi (or specific gravity) of the ham is a good criteria for estimating the lean mass amount : muscles + bones ($r_{I\ 2\ 5}$ = + 0,93I). As regards the explanation of Pi, the positive allometry of the fat deposit only intervenes as a 3rd negative component through the gross weight. The single correlation between the weights of the dissected fats and the immersed weight (r = + 0,29) is much lower than the correlation obtained with the gross weight (r = + 0,66).

■ Therefore, the specific gravity of the ham is a good criteria for its lean mass without giving direct information about the variations of its fat mass.

- The anatomical yield obtained during the processing of the "jambons de Paris" is closely bound to the specific gravity of the cut by the two grading factors : ratios lean mass/fat mass and external fat/ internal fat which explain 77,3 p.I00 of the total variation. on the other hand II,0 p. I00 of this total variation is still characterized by the ratio muscle/ bones. In this case, the immersed weight is much influenced by the amount of muscles, whereas the anatomical yield remains more directly influenced by the bone mass. This fact limits the accuracy of estimating of anatomical yield by means of the specific gravity. However, this estimation (r = + 0,60) still constitutes a better approach than that obtained only by the gross weight of the ham (r = + 0,27).

■ Contrary to a great mumber of authors, we have shown that the specific gravity does not exclusively characterize the differences in fat deposits. In the ham, this determination gives indeed an accurate estimation of the lean mass. Previous researches(DESMOULIN, I970) show that, In the case of the pig-breast or bellow, the specific gravity is indicative of the fatty masses. The anatomical significance of the specific gravity, expressing the allometry of the tissular growth, varies according to the different body factions. The criteria improving carcass grading should take into account the utilization value of the cuts having the most economical importance. The grading diagramsof these cuts according to their specific gravity may be very useful.

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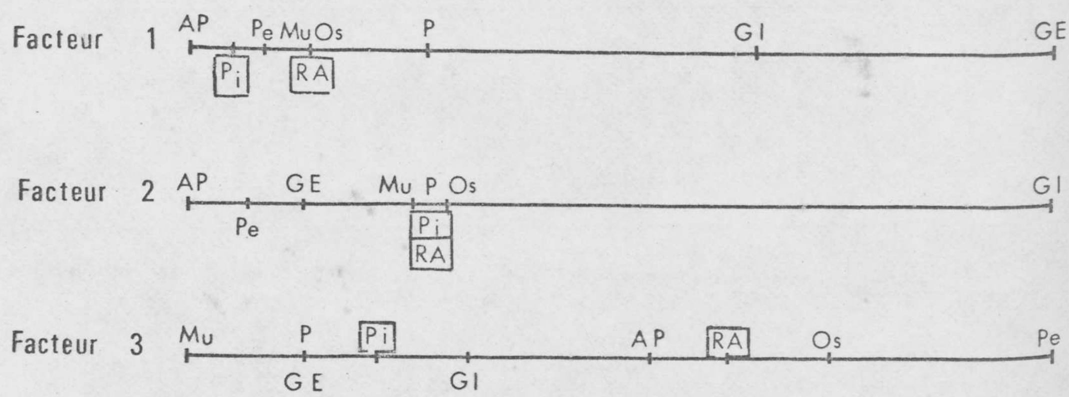
TABLE 3 - Some individual results corresponding to the factor analysis

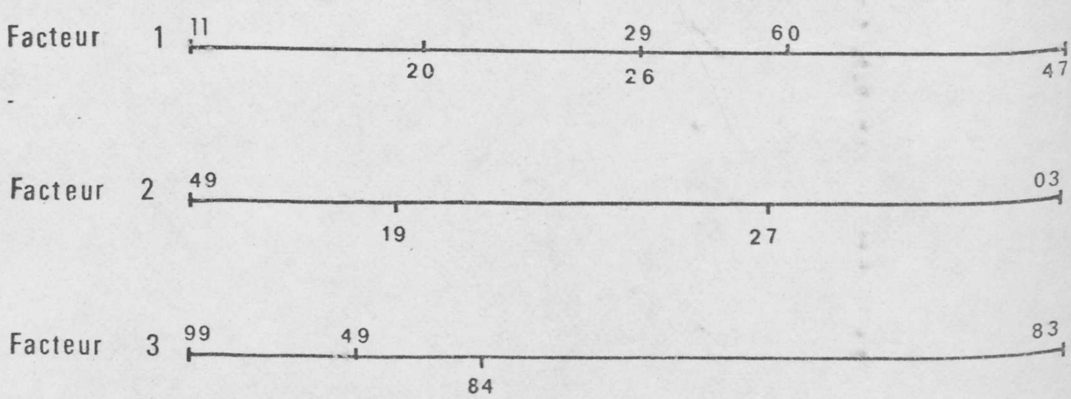
Attributes / Subjects		P	Mu	Ge	Gi	Os	Ap	Pe	Pi	RA	
80. Kg	II	643I	4500	705	I50	54I	50	390	420,0	67,9	Fact. I
	29	6I65	3988	II06	I6I	526	6I	252	382,5	63,2	
	60	5926	3630	II40	I90	5I9	40	352	308,0	56,4	
I00Kg	20	7559	5I77	I072	249	7II	57	299	488,0	64,9	
	26	7253	4636	I265	2I3	648	53	339	448,0	62,I	Muscles
	47	7522	4488	I762	280	530	54	3I0	362,0	56,4	Fats
80 Kg	49	6360	4020	I25I	I52	505	6I	3I7	365,5	59,5	Fact. 2
	03	6427	44I4	820	423	552	28	282	342,5	59,I	External fats
I00Kg	I9	7276	4600	I358	I85	635	40	3I5	459,0	62,2	
	27	7565	4545	I540	440	590	60	272	4I6,0	60,4	Internal fats
80 Kg	83	5888	3422	I084	229	64I	62	382	348,5	58,5	Fact. 3
	49	6360	4020	I25I	I52	505	6I	3I7	365,5	59,5	Muscles
I00Kg	84	7555	4505	I523	294	678	40	324	442,0	58,I	Bones
	99	835I	5609	I2I6	338	680	78	340	489,5	64,6	

Graphique 2 ANALYSE FACTORIELLE DES CORRESPONDANCES

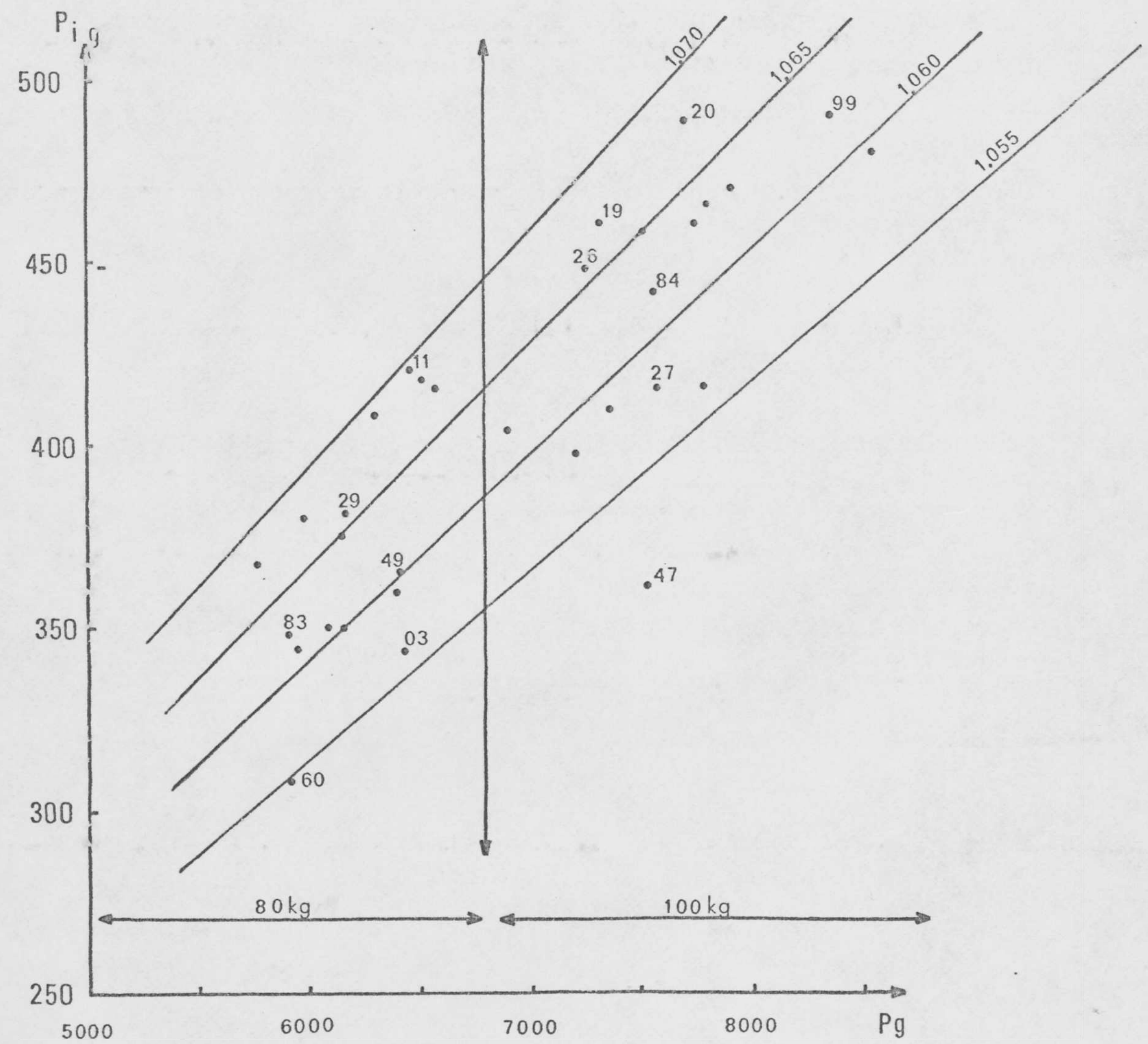
1° Attributs : COMPOSANTES TISSULAIRES



2° Sujets : JAMBONS DISSEQUES



Graphique 1   Abaque de classement des Jambons suivant la densité



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