HAM QUALITY AND ITS RELATIONSHIP TO CARCASS QUALITY

I. Ultrasonic and other measurements

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Abstract. Ham quality and its relationship to carcass quality were studied in Landrace and Yorkshire pigs at the Puistola testing station.

The research material was as follows: 1) ultrasonic and other measurements and points evaluation of 236 live pigs in three weight classes, and conventional carcass evaluation of these pigs; 2) ultrasonic and other measurements and points evaluation of 97 live pigs, determinations of the specific weight of the ham, and the dissection results on the left half of the carcass.

The subjective points evaluation of ham performed on the live pigs did not correlate with the subjective points evaluation made on the carcasses. Nor did the exterior measurements made on the ham provide sufficient information about the slaughter quality of the ham.

By means of stepwise multiple regression analysis, estimations were obtained for the skin + fat and meat + bone components of the most valuable part of the carcass and of the ham. In these estimations the most important were the dissection results and specific weight of the ham and the ultrasonic measurements. The statistically significant effect of the slaughter weight emerged to such an extent that corrections according to slaughter weight were found necessary in the dissection analysis.

The ham, like the back, is one of the most valuable parts of the pig's carcass. The ham quality has consequently been a matter of interest to animal breeders for decades. Ham quality of both live animals and carcasses was evaluated in points up to the 1960s. The development of technical equipment and methods of measurement has gradually brought about a change in the evaluation of the ham by introducing objective methods. Objective measurements of ham quality that make use of technical devices include linear measurements, measurements of areas, determinations of specific weight, ultrasonic measurements and isotope measurements. Increasing use has been made of various degrees of cutting and dissection of the ham and the carcass as a means of comparing the results obtained in the above ways and also as a direct method of ham evaluation (Blendl 1966 and Partanen 1969).

The aim of the present study is to analyse the possibilities of measuring the slaughter quality of the ham 1) on live pigs at various stages of development, and 2) on the carcass;

and 3) to compare the methods of measurement as expressions of carcass quality; and 4) to examine the relationship between the ham quality and the carcass quality.

It should be pointed out that this study does not examine the possibility of employing the isotope method in the measurement of ham quality. Preliminary tests have been made with K^{40} isotope (LAKANEN & UUSISALMI 1967, MAIJALA & UUSISALMI 1967) but further tests had to be abandoned owing to cost and other practical reasons.

Material and methods

The ultrasonic and other measurements made on Landrace and Yorkshire progeny testing pigs (n = 118 ♂ + 118 ♀) at the Pig Husbandry Experiment Station at Puistola in 1965—66, in live weight classes of 20 kg, 60 kg and 90 kg. The final measurements were made one day before slaughter. Conventional carcass evaluation was made one day after slaughter.

The ultrasonic and other measurements made on live progeny testing pigs (n = 97 ♀) at Puistola in 1966—67 and the carcass evaluation results on the same animals. After the conventional carcass evaluation the left half of the carcass was cut and dissected in the manner presented by UUSISALMI (1969 a). The specific weights of the ham and the shoulder were determined.

Stepwise multiple regression analysis (SCC 1966) was done to explain the thickness of the back fat, the area of the musculus longissimus dorsi and the skin + fat components and meat + bone components of the ham and the most valuable part of the half carcass. In processing the material, use was made of a free model in which the programme selects as a new explanatory variable the variable that produces the greatest increase in the correlation coefficient. The programme employs the F-test as criterion for the factor to be added ($F \geqq 2.000$) or dropped ($F < 2.000$).

Results

236 pigs. Tables 1 and 2 show the averages, the standard deviations and the phenotypical correlations of the ham points of carcass evaluation, the ham points obtained on live pigs (in live weight classes of 90, 60 and 20 kg) and some external measurements. The relationships between the ham points obtained on live pigs and the ham points obtained from carcass evaluation and the external measurements were slight, all the correlation coefficients being between 0.23 and —0.11.

Table 3 shows an estimation for the area of the m. long. dorsi. This model was calculated from the results of measurements on live pigs, by means of stepwise multiple regression analysis. The following measurements pertaining to the ham part occur therein as optional explanatory variables in the second, third and fourth places: width at haunches, fat measurement at 12 cm left of midline of back rump, and the ham points at live weight of 90 kg. The coefficient of the multiple determination of the m. long. dorsi, however, is modest ($R^2 = 0.287$; $R^2 \% = 28.7$) at nine steps.

In a previous study UUSISALMI (1967) has presented an estimation for back fat ($R^1 \% = 75.3$) in carcass evaluation, calculated from ultrasonic and other measurements on live pigs by means of stepwise multiple regression analysis. This estimation did not include

Table 1. Averages and standard deviations of ham points from carcass evaluation, and of ham points and some external measurements of live pigs in various weight classes, at the Puistola Pig Husbandry Experiment Station (n = 236) in 1965—66.

	90 kg live weight		60 kg live weitht		20 kg live weight	
	$\bar{x}$	δ	$\bar{x}$	δ	$\bar{x}$	δ
Carcass evaluation						
Shape and size of hams, points (scale 9—15)	12.56	0.58				
Live pigs						
Ham points (scale 1—5)	3.34	0.69	3.23	0.73	3.23	0.74
Width at haunches, cm	26.28	1.17	23.62	1.31	16.98	1.53
Measurement at haunches, cm	48.61	0.88	46.39	1.17	—	—
Ham measurement, cm	108.80	3.56	95.17	3.70	68.07	4.18

Table 2. The correlation of the ham points of the carcass evaluation with the ham points and some external measurements obtained on live pigs at various classes of live weight at the Puistola testing station, n = 236.

Characteristic from carcass evaluation	Ham points live	weight	classes	Width at haucnhes live	weight	classes
	90 kg	60 kg	20 kg	90 kg	60 kg	20 kg
X	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6
Shape and size of hams	0.09	0.18	—0.03	0.23	0.20	—0.11

	Measurement at haunches live	weight	classes	Ham measurement live	weight	classes
	90 kg	60 kg	20 kg	90 kg	60 kg	20 kg
X	Y_7	Y_8	Y_9	Y_{10}	Y_{11}	Y_{12}
Shape and size of hams	0.19	0.14	—	—0.02	0.00	—0.17

r > 0.13 signif. at 5 % level
r > 0.17 » 1 % »
r > 0.22 » 0.1 % »

other measurement results pertaining to the ham than the three fat measurements on the rump.

97 pigs. Table 4 shows how the skin + fat part of the ham was explained by means of stepwise multiple regression analysis. The optional explanatory variables were the evaluation and measurement results obtained on live pigs, the results of conventional carcass evaluation, and the specific weight of the ham (a total of 32 characteristics). The specific weight of the ham, which was included at the first step, alone explained 61.9 per cent of the total variation of the skin + fat part of the ham. The estimation

Table 3. Area of the m.long. dorsi explained by means of stepwise multiple regression analysis. The optional explanatory variables are the ultrasonic measurements, external mesurements and results of points evaluation on live pigs at the weight of 90 kg, a total of 30 characteristics (n = 236).

Step	Characteristics	r	Cumulative R	Cumulative R^2 %
1	Side fat 9 cm left	—0.43	0.427	18.2
2	Width at haunches	0.18	0.465	21.6
3	Rump 12 cm left (fat)	—0.13	0.491	24.2
4	Ham points	0.20	0.504	25.4
5	Measurement behind shoulders	—0.13	0.514	26.4
6	Shoulder 12 left (fat)	—0.29	0.520	27.0
7	Muscle depth 9 cm left	0.28	0.527	27.7
8	Side fat 8 cm left	—0.37	0.531	28.2
9	Circumference of carcass	—0.04	0.536	28.7

r > 0.13 signif. at 5 % level
r > 0.17 » at 1 % »
r > 0.22 » at 0.1 % »

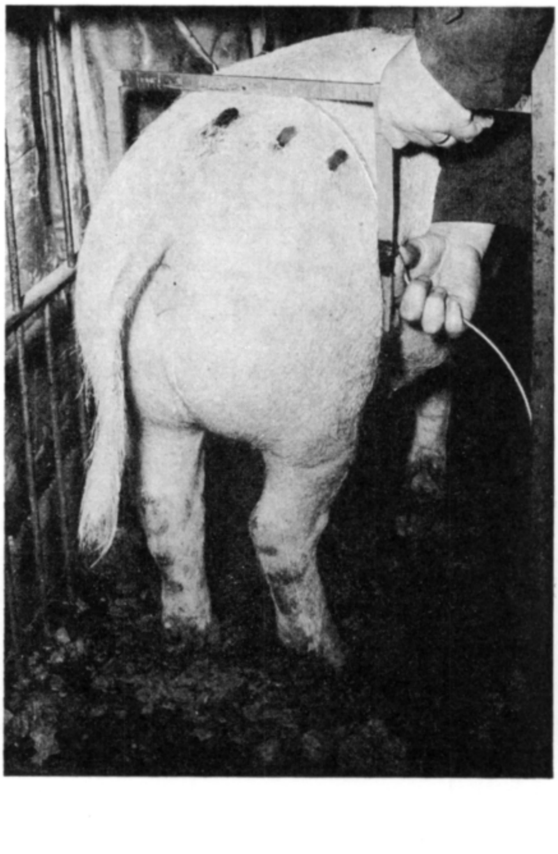

Fig 1. Width and measurement at the haunches. The sites of ultrasonic measurements at the ham.

Table 4. Skin + fat part of the ham is estimated by means of stepwise multiple regression analysis. Optional explanatory variables are results of measurements and determinations on live animals, of conventional carcass evaluation and specific weight of ham. n = 97.

Step	Characteristics	r	Cumulative	
			R	R^2 %
1	Specific weight of ham	—0.79	0.787	61.9
2	Rump 12 cm left (fat on live pigs), mm	0.60	0.816	66.6
3	Carcass weight, kg	0.16	0.832	69.2
4	Back fat (from carcass), mm	0.62	0.845	71.4
5	Feed consumption, fu/kg	0.26	0.854	72.9
6	Rump 15 cm left (fat on live pigs), mm	0.26	0.859	73.8
7	Ham measurement (on live pigs), cm	0.16	0.864	74.6

r > 0.20 signif. at 5 % level
r > 0.26 » » 1 % »
r > 0.33 » » 0.1 % »

Table 5. Meat + bone part of the ham is estimated by means of stepwise multiple regression analysis. Optional explanatory variables are results of measurements and determinations on live animals, of conventional carcass evaluation and specific weight of ham. n = 97.

Step	Characteristics	r	Cumulative	
			R	R^2 %
1	Carcass weight, kg	0.55	0.547	29.9
2	Fat/meat ratio, %	—0.54	0.758	57.5
3	Wither (fat on live pigs), mm	—0.45	0.780	60.8
4	Length of carcass, cm	—0.20	0.795	63.2
5	Hams (points of live pigs)	0.37	0.814	66.3
6	Rump b (fat on live pigs), mm	—0.32	0.826	68.2
7	Depth of muscle 8 cm (on live pigs), mm	0.32	0.837	70.1
8	Witdh at haunches, cm	0.22	0.941	70.7
9	Rump 15 cm left (fat on live pigs), mm	—0.15	0.844	71.2

r > 0.20 signif. at 5 % level
r > 0.26 » » 1 % »
r > 0.33 » » 0.1 % »

also includes the following measurements of the ham obtained with ultrasonic apparatus: rump 12 cm left and rump 15 cm left. Altogether, the R^2 % rose to 74.6.

The meat + bone part of the ham (Table 5) is explained in terms of the same 32 characteristics as was the skin + fat part. As fifth were included in the model the ham of live pigs. Thus the points evaluation of the ham of live pigs, too, seems to be of significance in the evaluation of the ham quality. The model further includes three other measurement results pertaining directly to the ham. Altoghether, the R^2 % rose to 71.2.

Table 6 shows the multiple correlation of the dissection results of the various parts of the carcass, with the estimations of skin + fat and meat + bone parts of ham. Between the estimation of the skin + fat part of the ham and the skin + fat component of the most valuable part of the carcass, R = 0.84 and R^2 % = 71.2; between the estimation of the meat + bone part of the ham and the meat + bone component of the most valuable part of the carcass, R = 0.82 and R^2 % = 67.1. The estimations calculated to explain the two components of the ham are thus also good measurements for the skin + fat and meat + bone components of the most valuable part of the carcass.

Tables 7 and 8 show the estimations for the skin + fat and meat + bone components of the most valuable part of the carcass. The optional explanatory variables were the

Table 6. The multiple correlation of the following dissection results with the characterics included in the estimations of skin+fat and meat+bone parts of ham. Cf. tables 4 and 5.

Dissection results	Characteristics of estimations of			
	a) skin+fat of ham		b) meat+bone of ham	
	R	R^2 %	R	R^2 %
Skin + fat of ham, g	0.864	74.6	0.682	46.5
Meat + bone of ham, g	0.715	51.1	0.844	71.2
Skin + fat of shoulder, g	0.514	26.4	0.619	38.3
Meat + bone of shoulder, g	0.638	40.7	0.589	34.7
Skin + fat of ham + shank, g	0.861	74.1	0.614	37.7
Meat + bone of ham + shank, g	0.712	50.7	0.851	72.4
Ham + shank, g	0.667	44.5	0.727	52.9
Skin + fat of the most valuable part, g	0.844	71.2	0.774	59.9
Meat + bone of the most valuable part, g	0.790	62.4	0.819	67.1
Ham, % of carcass	0.363	13.2	0.601	36.1
Skin + fat of back, g	0.722	52.1	0.710	50.4
Meat + bone of back, g	0.533	28.4	0.613	37.6
Fat of ham, g	0.874	76.4	0.652	42.5
Meat of ham, g	0.709	50.3	0.874	71.7
Bone of ham, g	0.611	37.3	0.571	32.6
Ham, g	0.670	44.9	0.743	55.2
Fat % of ham	0.894	79.9	0.738	54.5
Meat % of ham	0.841	70.7	0.779	60.7

Characteristics included in estimations:

a) Specific wt. of ham
Rump 12 cm left (fat on live pigs)
Carcass weight
Back fat (from carcass)
Feed consumption
Rump 15 cm left (fat on live pigs)
Ham measurement

b) Carcass weight
Fat/meat ratio, %
Wither (fat on live pigs)
Length of carcass
Hams (points from carcass)
Rump b (fat on live pigs)
Depth of muscle 8 cm (on live pigs)
Witdh at haunches
Rump 15 cm left (fat on live pigs)

Table 7. Skin+fat component of the most valuable part of the carcass (hams+carré+back+fore back+shoulders+kidney fat) is estimated by means of stepwise multiple regression analysis. Optional explanatory variables are results of measurements and determination on live animals, of conventional carcass evaluation and specific weights of ham and shoulders, a total of 29 characteristics. n = 97.

			Cumulative	
Step	Characteristics	r	R	R^2 %
1	Specific weight of ham	—0.72	0.719	51.7
2	S. o. l., mm	0.60	0.813	66.1
3	Live weight, kg	0.36	0.840	70.5
4	Back fat (from carcass), mm	0.72	0.859	73.8
5	Specific weight of shoulder	—0.68	0.877	76.8
6	Rump 12 cm left (fat on live pigs), mm	0.61	0.885	78.3
7	S. o. l. (dropped from model), mm	0.60	0.884	78.1
8	Carcass weight, kg	0.20	0.886	78.5
9	Hams (points of live pigs)	—0.16	0.890	79.1
10	Rump 12 cm left (dropped from model)	0.59	0.893	79.7
11	Carcass weight, kg	0.20	0.892	79.6
12	Wither (fat on live pigs), mm	0.52	0 894	80.0

$r > 0.20$ signif. at 5 % level; $r > 0.26$ signif. at 1 % level;
$r > 0.33$ signif. at 0.1 % level

Table 8. Meat+bone component of the most valuable part of the carcass is estimated by means of stepwise multiple regression analysis. Optional explanatory variables are results of measurements and determinations on live animals, of conventional carcass evaluation and specific weight of ham and shoulder, n = 97.

			Cumulative	
Step	Characteristics	r	R	R^2 %
1	M. long. dorsi, cm^2	0.61	0.605	36.6
2	Carcass weight, kg	0.54	0.727	52.9
3	Back fat (from carcass), mm	—0.46	0.823	67.8
4	Specific weight of ham	0.55	0.846	71.5
5	Hams (points from carcass)	0.25	0.854	73.0
6	Rump 6 cm left (fat on live pigs), mm	—0.41	0.859	73.8
7	S. o. l. (from carcass), mm	—0.32	0.865	74.8

$r > 0.20$ signif. at 5 % level; $r > 0.26$ signif. at 1 % level;
$r > 0.33$ signif. at 0.1 % level

measurement results and ponits evaluation results of live animals, the results of conventional carcass evaluation, and the specific weights of the shoulder and the ham (a total of 29 characteristics). In the estimation explaining the skin + fat component, the specific weight of the ham (R^2 % = 51.7) was included first; and, in the estimation explaining the meat + bone component, fourth. Further, the ham points from carcass evaluation still occur almost significantly in the meat + bone estimation. The R^2 % of the skin + fat component has risen to 80.0 and that of the meat + bone component to 74.8. Conversely, it can be seen from Table 9 that the characteristics occurring in the estimations calculated for the skin + fat and meat + bone components of the most valuable part of the carcass measure the skin + fat of the ham (R^2 % = 71.6) and the meat + bone of the ham (R^2 % = 59.6).

Estimations have been constructed for the skin + fat and meat + bone components of the most valuable part of the carcass (Uusisalmi 1969 b) from the same measurement results as in Tables 7 and 8, with the difference, however, that the skin + fat and meat +

Table 9. The multiple correlation of the following dissection results with the characteristics included in the estimations of skin+fat and meat+bone components of the most valuable part of carcass. Cf. tables 7 and 8.

Dissection results	Characteristics of estimations of			
	a) skin+fat component		b) meat+bone component	
	R	R^2 %	R	R^2 %
Skin+fat of the most valuable part, g	0.894	79.9	0.864	74.6
Meat+bone of the most valuable part, g	0.794	63.7	0.865	74.8
Most valuable part of carcass, g	0.829	68.7	0.837	70.0
Skin+fat component, % of carcass	0.881	77.6	0.859	73.8
Meat+bone component, % of carcass	0.816	66.6	0.839	70.4
The most valuable part, % of carcass	—	—	0.306	9.4
Skin+fat of shoulder, g	0.870	75.7	0.664	44.1
Meat+bone of shoulder, g	0.669	44.8	0.646	41.7
Skin+fat of shoulder+shank, g	0.860	74.0	0.676	45.7
Meat+bone of shoulder+shank, g	0.634	40.2	0.615	37.8
Shoulder+shank, g	0.634	40.2	0.435	18.9
Skin+fat of ham, g	0.846	71.6	0.826	68.2
Meat+bone of ham, g	0.734	53.9	0.772	59.6
Skin+fat of ham+shank, g	0.849	72.1	0.838	70.2
Meat+bone of ham+shank, g	0.723	52.3	0.766	58.7
Ham+shank, g	0.678	46.0	0.708	50.1
Skin+fat of back, g	0.777	60.4	0.756	57.2
Meat+bone of back, g	0.605	36.6	0.689	47.5
Skin+fat of back parts, g	0.790	62.4	0.756	57.2
Meat+bone of back parts, g	0.629	39.4	0.682	46.5
Back parts, g	0.501	25.1	0.531	28.2

Characteristics included in estimations:

a) Specific wt. of ham
Back fat (from carcass)
Specific wt. of shoulder
Shoulder 12 left (fat on live pigs)
Carcass weight
Hams (points from live pigs)
Rump 12 cm left (fat on live pigs)
Wither (fat on live pigs)

b) M. long. dorsi
Carcass weight
Back fat (from carcass)
Specific wt. of ham
Hams (points from carcass)
Shoulder 6 cm left (fat on live pigs)
S. o. l. (from carcass)

bone parts of the ham were added to the explanatory variables of the 1969 b study. In the skin + fat estimation of the most valuable part of the carcass there was first included the skin + fat of the ham (R^2 % = 57.2); and in its meat + bone estimation the meat + bone of the ham (R^2 % = 68.6) was included first and the specific weight of the ham second. Altogether, the R^2 % of the skin + fat estimation for the most valuable part of the carcass was thus 82.1 at the sixth step and 85.0 at the twelfth step for the meat + bone estimation. Adding the results of the dissection of the ham to the results of the evaluation of the live animal and of the carcass and to the determinations of specific weight, thus improves the information (by 7.5—13.8 %) obtained concerning the fattiness and the meatiness of the most valuable part of the carcass.

Discussion

It was established earlier that the points evaluation of the ham made on live pigs in various weight classes hardly correlated with the subjective points evaluation in carcass evaluation. The ham points of the carcass evaluation were obtained from official progeny testing, and the evaluation of the live pigs was carried out by the author together with the director of the Puistola Pig Husbandry Experiment Station or some other member of the staff. The exterior measurements taken of the hams of live pigs also correlated poorly with the ham points of the carcass evaluation. Many research workers (Bratzler and Margetum 1953, Kuhn 1957, Haring and Sieburg 1957, Fewson and Le Roy 1959, Pedersen 1961) have come to the result that a points evaluation and exterior measurements carried out on live pigs do not show a sufficient correlation with the carcass quality established from the carcass. It has, likewise, been shown that conventional carcass evaluation in respect of the ham has been merely a subjective judgement. It emerges, on the other hand, that indirectly the ham quality has been affected, e.g. by measurements of back fat and side fat and measurements of the area of the m. long. dorsi. Conventional carcass evaluation gave no confirmation of he ultrasonic measurements made on ham (236 pigs). The weight and the ratio between meat and fat of the hams were not known. The need to dissect the carcasses was obvious.

In the second stage of the study the left half of the carcass was dissected. The ham points obtained on live pigs correlated with the skin + fat component of the most valuable part of the carcass as follows: r = —0.16; and with the meat + bone component as follows: r = 0.34. It was found, on the other hand, that measurements made with ultrasonic instrument on live pigs at the hams at distances of 6 and 12 cm from the midline of the back were of significance in establishing the fattiness of the ham. The correlations of these measurements with the fat of the ham were r = 0.47 and r = 0.60. The points evaluation of the ham done on live pigs was also found to be of significance in determining the meatiness of ham: r = 0.38. It should be emphasized that slaughter weight had a very significant or a significant effect on the skin + fat part and the meat + bone part of the ham and on the ham points.

The present study established the great importance of the specific weight of the ham for the measurement of the skin + fat part of the ham and the skin + fat component of the most valuable part of the carcass. The specific weight of the ham is a better measure of the fattiness of the ham than is e.g. the average back fat or the s.o.l. (Uusisalmi 1969 b).

It may be mentioned that the specific weight of the shoulder in this material is smaller. It does appear, however, in an estimation constructed for the skin + fat component of the most valuable part, at the second step. The skin + fat component of the ham was first in the estimation. The inclusion of the meat + bone part of the ham in the stepwise multiple regeression analysis caused an increase of c. 10 per cent in the information obtained about the meat + bone component of the most valuable part of the carcass as compared with the information obtained about the meat + bone component by means of measurement of the live animal, conventional carcass evaluation and the specific weight of the ham.

Estimations were made by stepwise multiple regression analysis in which measurements made on live animals, results of carcass evaluation and dissection results are concurrently present as optional explanatory variables. This was done because it was thought that selection of insemination boars may be made in the future as follows:

The first test of phenotype of young boars will be performed at an earlier stage than at present. Most of the boars will then be castrated in order to reduce the costs of testing. The uncastrated boars will then be reared in experimental-station conditions until the semen is obtained from them. Naturally, the problems of collecting and storing the semen will have to be solved before that time. After the semen has been obtained, the boars will be slaughtered and the carcasses evaluated and dissected to the extent necessary. The semen of the prime boars will be used expediently.

In aiming at the stated objective, there will probably be reason to continue with research into the determination of the ham and its components.

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SELOSTUS

KINKUN TEURASLAATU JA SEN YHTEYS RUHON TEURASLAATUUN

I. TEURASLAADUN MITTAUKSET ELÄVISTÄ SIOISTA JA RUHOISTA

Unto Uusisalmi

Helsingin Yliopisto, Kotieläinten jalostustieteen laitos

Mitattiin kinkun teuraslaatua ja sen yhteyttä ruhon teuraslaatuun maatiais- ja yorkshire-rotuisista kantakoesioista Puistolan koeasemalla vuosina 1965—67.

2 3 6 s i k a a. Elävistä eläimistä suoritettu kinkun pistearvostelu ja exteriöörimitat eivät sanottavasti korreloituneet ruhosta saatuun pistearvosteluun. Kinkun leikkely kudososiinsa osoittautui tarpeelliseksi ultraäänimittauksilla saatujen tulosten arvon toteamiseksi.

9 7 n a a r a s s i k a a. Valikoivan regressioanalyysin avulla saatiin arvioita ruhon arvokkaimman osan sekä kinkun nahka + rasvalle ja liha + luulle. Arvioissa esiintyivät kinkun leikkelytulokset, ominaispaino ja ultraäänimitat tärkeillä tiloilla. Ultraäänimitoista mm. silavamitta pakaralta (12 cm vasemmalle) korreloitui erittäin merkitsevästi kinkun nahka + rasvaan ($r = 0.60$); samoin kinkun ominaispaino kinkun nahka + rasvaan ($r = —0.79$). Kinkun nahka + rasva korreloitui erittäin merkitsevästi ruhon arvokkaimman osan nahka + rasva -komponenttiin ($r = 0.76$) ja kinkun liha + luu ruhon arvokkaimman osan liha + luu -komponenttiin ($r = 0.83$).