RELATIONSHIPS BETWEEN RABBIT MEAT QUALITY COMPONENTS

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Abstract - Meat quality traits were measured on forty-six commercial rabbit carcasses from two synthetic breeds. Colour measurements (Minolta L*, C* and H*) were taken on the carcass surface, on several muscle surfaces (muscles *Longissimus (pars lumbaris)* at the 2nd, 4th and 7th lumbar vertebrae, *Trapezius (pars thoracica)*, *Coccygeofemoralis, Gluteus accesorius, Biceps femoris* and *Gracilis*). pH of m. *B. femoris* (pHBF) and pH of *L. dorsi* at the 5th lumbar vertebra (pHLD) were recorded, and muscular fat content of half carcass (Fat) was also measured. Principal component analyses were made selecting different sets of traits. When all the variables were used, the first three principal components (PC) only explained a 37% of the variance. A principal component analysis with colour measurements of muscles *Longissimus lumborum* and *Biceps femoris*, pHLD, pHBF and Fat, explained a 68% of the variance with the first four PC. The whole set of variables were well summarised by the luminosity (L*) and Chroma (C*) of *Longissimus lumborum* surface measured at the 4th lumbar vertebra, pHLD and Fat. When the data were projected on the plan defined by the first two PC, two separated group of points appeared, corresponding to the animals of each breed.

INTRODUCTION

Studies on rabbit meat quality have been mostly concentrated in pH measurements (OUHAYOUN and DELMAS, 1988; BLASCO et PILES, 1990; XICCATO *et al.*, 1990; HADDAD *et al.*, 1994) and only recently carcass colour and muscular fat content have been included in some studies (BATTAGLINI *et al.*, 1994; XICCATO *et al.*, 1994; CABANES-ROIRON *et al.*, 1994). Meat colour measurements are usually taken on meat cuts in beef, lambs or pigs, but rabbit carcasses are commercialised as a whole, thus colour carcass measurements taken at different muscle sites seems to be a sensible quality criterion. PLÁ *et al.* (1995) have measured colour at different muscle sites on the rabbit carcass, and CABANES-ROIRON and OUHAYOUN (1994) used subjective measurements on raw and cooked meat, among which carcass colour was included.

All these traits (colour at different carcass sites, pH of different muscles, muscular fat content) are correlated. Thus, it would be convenient to find a smaller set of measurements that could explain most of the observed variability in meat quality. KARLSSON (1992) proposes the use of principal component analysis for evaluating pig meat quality when several correlated measurements are used in the evaluation. The objective of this work is to use this technique for evaluating results from rabbit meat quality measurements.

MATERIAL AND METHODS

Forty-six commercial rabbit carcasses from two synthetic breeds were used in the experiment. The breed V was formed by crossing two commercial dam hybrids, and has been selected for litter size for 15 generations. The breed R was formed by crossing a commercial terminal sire hybrid with a Californian breed and has been selected on growth rate between the 4th and the 9th week of life for 10 generations. Breed R has a higher adult weight and arrives to the slaughter weight one week before than breed V (BLASCO and GÓMEZ, 1993). The animals were reared in the experimental farms of the University of Valencia and then slaughtered at the Spanish commercial weight, being their average carcass weight 1.143 kg. The animals were slaughtered without transport in the experimental abattoir of the University. They were refrigerated at 3° during 24h before measuring colour. Animals were taken at random from both sexes.

Colour was measured with a CR-300 Minolta Chromameter, which gives the average of three measurements of L*,a* and b* in each point. Chroma $C^*=(a^{*2}+b^{*2})^{1/2}$ and Hue $H^*=\tan^{-1}(b^*/a^*)$ were calculated. Carcass colour was measured at the level of the muscles *Longissimus (pars lumbaris)*, *Trapezius (pars thoracica)*, *Coccygeofemoralis, Gluteus accesorius, Biceps femoris* and *Gracilis*. The measures of m. *Longissimus* were made at three points (2nd, 4th and 7th lumbar vertebrae). Colour of m. *Longissimus* was also measured at the 1st lumbar vertebra cut and at the 7th lumbar vertebra cut (in both cases at the left and right sides). The colour data are a subset of the data used by PLÁ *et al.* (1995).

Muscular fat content (intermuscular and intramuscular fat content) was evaluated in the meat of one side of the carcass by ether extraction on Soxtex (AOAC, 1990). Muscular pH of the *B. femoris* (pHBF) and pH of the *m. Longissimus* (pHLD) at the level of the 5th lumbar vertebra were taken on the chilled carcass.
Least square means were calculated for the carcass measurements by using a model in which the fixed effect of breed was considered. Previous analyses did not show any sex effect, therefore this effect was not considered in the model. Residual correlations between measurements where computed. Principal component analyses were made selecting different sets of traits. The GLM procedure of the SAS package (SAS, 1990) was used.

RESULTS AND DISCUSSION

The means of colour measurements of all the muscle surfaces and cuts has been published by PLÁ *et al.* (1995). Table 1 shows the means of pH measurements, muscular fat content and colour measurements taken on the carcass, on the *B. femoris* and *L. dorsi* surfaces. Breed differences were found in Chroma and Hue of several muscle surfaces. Meat colour, muscular fat content and pH's were the same for both breeds.

Table 1 : Least Square Means (LSM) and residual standard deviation (SD) of the Meat Quality Variables used in the Principal Component Analysis.

	L2L	L2C	L2H	L4L	L4C	L4H	L7L	L7C	L7H
LSM	57.7	4.38	46.3	57.0	4.56	46.7	57.9	3.71	31.1
SD	2.14	1.24	9.82	1.89	1.23	9.69	2.54	0.89	19.6
	BL	BC	BH	pHLD	pHBF	FAT			
LSM	53.6	7.37	56.1	5.80	5.75	5.28			
SD	2.64	1.32	5.61	0.093	0.097	0.990			

pHLD: pH of the *m. Longissimus*.pHBF: pH of the *Biceps femoris*.FAT: muscular fat content. BL, BC, BH: Lightness, Chroma and Hue of the *Biceps femoris* surface, L2L, L2C, L2H, L4L, L4C, L4H, L7L, L7C, L7H: Lightness, Chroma and Hue of the *Longissimus lumborum* surface at 2nd , 4th and 7th lumbar vertebrae.

Several principal component analyses were performed. When all the variables were used, the first three principal components (PC) only explained a 37% of the variance, indicating that all colour measurements, pH and fat have low relationships (tables 2, 3 and 4). When only colour measurements were considered, the first three PC explained a 44% of the variance, and when only B. femoris and L. dorsi were considered, the percentage of the variance explained by the first three PC was a 53%.

Table 2 : Coefficients of Correlation between the variables used in the Principal Component Analysis.

	PHLD	pHBF	FAT	BL	BC	BH	L2L	L2C	L2H	L4L	L4C	L4H	L7L	L7C	L7H
pHLD															
pHBF	0.43	1													
FAT	-0.09	0.20	1												
BL	0.22	0.29	0.15	1											
BC	-0.38	-0.08	0.06	0.01	1										
BH	0.30	0.11	-0.10	0.63	-0.42	1									
L2L	0.00	0.12	-0.04	0.42	-0.15	0.41	1								
L2C	0.03	-0.28	0.00	0.08	0.25	-0.07	-0.21	1							
L2H	0.28	0.00	-0.32	0.00	0.39	0.00	0.07	0.46	1						
L4L	-0.14	0.07	-0.11	0.16	0.05	0.02	0.68	-0.01	0.17	1					
L4C	0.03	-0.18	-0.13	0.13	0.18	0.00	-0.16	0.75	0.44	-0.08	1				
L4H	0.12	-0.10	-0.24	-0.01	0.13	0.08	0.08	0.42	0.53	0.06	0.51	1			
L7L	-0.27	-0.06	0.02	0.25	0.00	0.26	0.55	-0.02	0.10	0.67	-0.04	-0.08	1		
L7C	0.26	0.00	-0.18	0.18	0.27	-0.09	-0.05	0.38	0.16	-0.08	0.35	0.23	-0.33	1	
L7H	0.15	-0.14	-0.17	0.14	0.33	0.06	0.01	0.40	0.43	-0.03	0.43	0.71	-0.05	0.53	1

See traits in table 1

The two muscles considered as more representative in rabbit meat quality studies are m. *Longissimus* and m. *B. femoris* (BLASCO *et al.*, 1993). A principal component analysis that select surface colour measurements and pH of both muscles, plus muscular fat content in half carcass, explained a 60% of the variance with the first three PC. A 68% of the variance was explained by the first four PC (table 5). Table 4 shows the correlations between the variables used in the analysis.

Table 3 : Coefficients of correlation between Hue values (upper diagonal) and Chroma values (down diagonal) of muscle surfaces.

	L2	L4	L7	T	P	G	B	GR
L2	1	0.53	0.43	0.14	0.34	0.41	-0.01-0.19	
L4	0.75	1	0.71	0.15	0.30	0.33	0.08	0.12
L7	0.38	0.35	1	0.12	0.36	0.44	0.06	-0.09
T	0.23	0.16	0.09	1	0.17	0.09	0.28	-0.15
P	0.36	0.22	-0.04	0.31	1	0.57	0.23	-0.19
G	0.37	0.17	0.28	0.22	0.34	1	0.26	-0.19
B	0.25	0.18	0.27	0.25	0.42	0.23	1	0.04
GR	0.12	-0.01	0.35	0.22	0.04	0.11	0.201	

L2, L4, L7: *Longissimus lumborum* at 2nd, 4th and 7th lumbar vertebrae. T: *Trapezius (pars thoracica)*.P: *Coccygeofemoralis.* G: *Gluteus accesotius.*B: *Biceps femoris.*GR: *Gracilis..*

Table 4 : Coefficients of correlation between lightness values of several muscle surfaces.

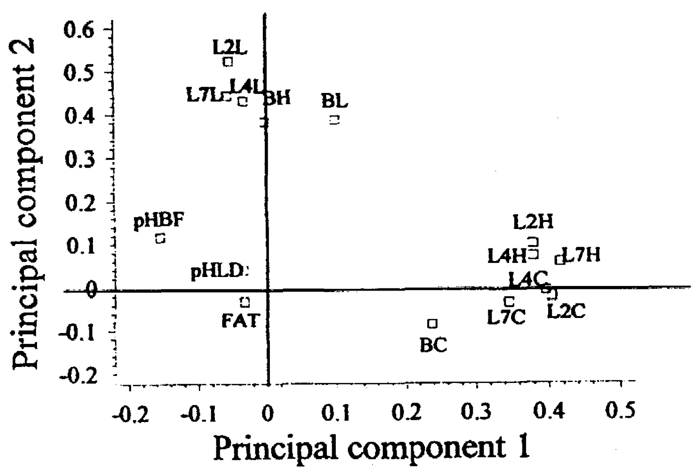
	L2	L4	L7	T	P	G	B	GR
L2	1							
L4	0.68	1						
L7	0.55	0.67	1					
T	0.29	0.38	0.341					
P	0.43	0.30	0.19	0.42	1			
G	0.40	0.40	0.41	0.15	0.41	1		
B	0.42	0.16	0.25	0.41	0.42	0.30	1	
GR	0.12	0.05	-0.04	-0.41	-0.19	-0.04	-0.11	1

See traits in table 3

Table 5 : Results of the Principal Components analysis.

Component	% Variance explained	Cumulative %
First	28	28
Second	18	46
Third	14	60
Fourth	8	68

Figure 1 : Projection of the variables in the plane defined by the two first principal components
(See table 1 for traits)



The coefficients of the eigenvectors for the first two PC (i.e., the projection of the variables in the plane defined by the first two PC) is represented in figure 1. A group of colour variables (C* and H* of *Longissimus lumborum* measured on several lumbar vertebrae sites) is located on the first PC, far from the origin, which means that they are important to describe the observed variation, and also that they explain nearly the same variation. Another group of colour variables (L* of *Longissimus lumborum* measured on several lumbar vertebrae sites) is located on the second PC far from the origin, explaining an independent cause of variation from the first PC. All measurements located near each other explain approximately the same, and they are positively correlated. It seems that using only the colour measurements on *L. dorsi* at the second or fourth lumbar vertebra, a large part of the variation would be explained (table 5). PLÁ *et al.* (1995) reccommend to take the 4th lumbar vertebra measurement because it gives intermediate values from the 2nd and 7th vertebrae.

Measurements like pH or Fat, that are near the origin , are not well represented by both PC (their projection shows that they are almost perpendicular to the axes defined by both PC).

Figure 2 : Projection of the variables in the plane defined by the tthird and fourth principal components
(See table 1 for traits)

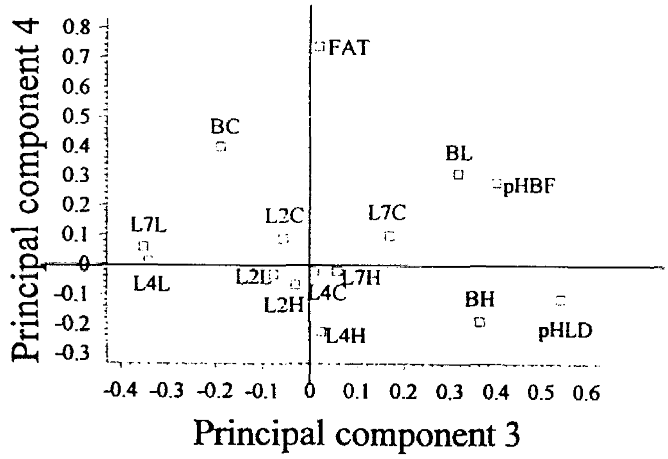
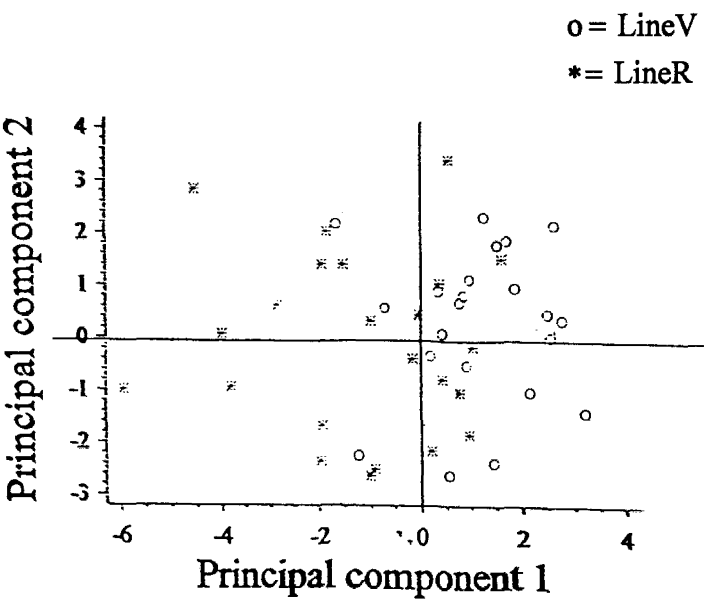


Figure 3 : Projection of the data in the plane defined by the two first principal components



If we represent the variables in the plan defined by the PC three and four (figure 2) we find pH of *L. dorsi* and muscular fat content near the other two PC that would explain up to the 68% of the total variation (table 5). Therefore, the whole set of variables are well summarised by the luminosity (L) and Chroma (C) of *Longissimus lumborum* measured on the 4th lumbar vertebra, the pH of *L.dorsi* measured at the 5th lumbar vertebra and muscular fat content of half carcass. Only the three first variables explain a 60% of the observed variation in the data.

If we project the data on the plan defined by the first two PC we observe that breed R and breed V are distributed along the first axe defining two separated group of points. Breeds V and R differ by the components C and H of the colour, which are represented in this axe (figure 3).

The principal component analysis suggest to reduce the number of descriptive variables from 15 to four. Besides, it summarises well the relationships between the quality traits. It can be argued that the general aspect of a rabbit carcass does not depend only on the colour taken at the L. dorsi surface, and it should be noted that colour traits of different muscle surfaces are not highly correlated. Nevertheless, the colour of *Longissimus lumborum* is clearly appreciated in rabbit carcasses, and it is a quality trait independent of the other two traits proposed by the analysis.

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