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Interrelationships between carcass weight, dimensions and tissues thickness measurements on Churro Galego Bragançano and Suffolk Lambs *

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The goal of this study was to identify a reduced pertinent set of variables from an original data set of 18 carcass measurements in order to avoid redundancy and collinearity problems or to simplify data analysis and the development of the linear regression models. Forty-six (46) male lambs, 26 of Churro Galego Bragançano Portuguese local breed and 20 of Suffolk breed were used. Lambs were slaughtered and carcasses weighed approximately 30 min after in order to obtain hot carcass weight (HCW). After cooling at 4žC for 24 h a set of seventeen carcass and measurements were recorded. The data interrelationships common factor analysed following the common factor analysis procedure. Carcass width and perimeter measurements showed high and positive correlations with HCW (from 0.74 to 0.91) and between themselves (from 0.55 to 0.80). However, HCW was lowly correlated with leg length (0.17) and moderately correlated with measurements that characterise carcass lengths and perimeters (from -0.39 to 0.56). Subcutaneous fat thickness measurements made at different anatomical positions were lowly correlated with HCW (lower than 0.20), even though high correlations were observed among the fat thickness measures (higher than 0.67). Four common factors were retained and identified: carcass weight (factor I), breast bone tissue thickness (factor II), subcutaneous fat thickness (factor III) and conformation (factor IV), which account for 81.9% of the variation on the eighteen original variables. This study shows that common factors analysis can be used to condense the information given by large sets of variables, by selecting a reduced number of variables, which avoids collinearity problems and simplifies the development of carcass composition estimation models.

Keywords: Lambs; Carcass; Tissue; Measurements; Common Factors.

1 Introduction

Since Pálsson (1939) pioneering studies with carcass and tissues measurements, many others have attempted to develop models to predict carcass composition through the use of carcass weight, carcass dimension measurements (Stanford et al., 1997; Wood et al., 1980), subcutaneous fat thickness (Cadavez et al., 2002; Jones et al., 1992; Wood et al., 1980), *longissimus* muscle depth (Delfa et al., 1996; Jones et al., 1992) and total tissues thickness measurements (Kirton & Johnson, 1979; Kirton et al., 1984), as independent variables. Most of the models were developed by multiple linear regression procedures where collinearity among the independent variables was not evaluated. However, collinearity problems among the independent variables should be expected, as these are both genetically and phenotypically correlated (Simm & Dingwall, 1989), and it is known that models based on multicolinear variables can limit inferences and the accuracy of predictions (Chatterjee et al., 2000). When a large set of potential independent variables is available, the first step in the data analysis should be their description and interpretation in order to evaluate if a subset of

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these variables can be used to replace the entire original set. The variables reduction is an interesting procedure since it can be used to avoid collinearity or to simplify data analysis and model development. The common factor analysis has been used as a tool to understand what the data are measuring and to detect multicollinearity problems in data on buffalos (Shahin et al., 1993), rabbits (Shahin & Hassan, 2000) and ducks (Shahin, 1999a, 1999b, 2000). Therefore, the goal of the current study is to identify a reduced number of variables from a set of measurements of HCW, carcass dimension, and tissues, to be used as independent variables in order to avoid collinearity and simplify the development of multiple linear regression models to predict carcass attributes.

2 Material and methods

2.1 Animals

Forty-six male lambs, 26 of Churra Galega Bragançana (CGB) Portuguese local breed, and 20 of Suffolk (SU) breed, of the experimental flock of the Agrarian Superior School of Bragança, were used in this study. The lambs were raised with the mothers in natural suckling until slaughter and had access to pasture, natural meadow hay and to commercial concentrate mixture and mineral-vitamin supplementation. Lambs were slaughtered order to obtain HCW range of 8.0 to 15.0 kg that covers the main requirements for lamb consumption in Portugal (Lambs were slaughtered between 16 and 30 live weight). Slaughter was performed after 24 hours fasting and carcasses were weighted approximately 30 min after slaughtering in order to obtain the HCW according to Fisher and de Boer (1994).

2.2 Carcass measurements

After 24 h cooling at 4žC carcasses were suspended in a gamble with 21 cm width between legs. The following carcass measurements were taken: 1. carcass length (K, mm) - from de base of the tail to the base of the neck (Pálsson, 1939); 2. leg length (F, mm) - the smallest distance from the perineum to the interior face of the tarsal-metatarsal articular surface (Pálsson, 1939); 3. width of the buttocks (G, mm) - the width measured using the measuring calliper at the level of the proximal edge of the patellae (Fisher & de Boer, 1994); 4. circumference of thorax (U, mm) - the circumference measured using a tape held horizontally around the thorax at the level of the caudal portion of the scapula; and, 5. circumference of buttock (CB, mm) - the circumference measured using a tape held horizontally around the buttocks at the level of the caudal insertion (Fisher & de Boer, 1994).

After quartering all carcasses, tissue measurements were performed with a calliper on maximum depth of the cut surface of *longissimus* muscle, as follows:

1. *longissimus* muscle depth between the 12^{th}-13^{th} ribs (B12, mm);
2. *longissimus* muscle depth between the 1^{st}-2^{nd} lumbar vertebrae (B1, mm);
3. *longissimus* muscle depth between the 3^{rd}-4^{th} lumbar vertebrae (B3, mm);
4. subcutaneous fat thickness between the 12^{th}-13^{th} ribs (C12, mm);
5. subcutaneous fat thickness between the 1^{st}-2^{nd} lumbar vertebra (C1, mm);
6. subcutaneous fat thickness between the 3^{rd}-4^{th} lumbar vertebra (C3, mm).

The *longissimus* muscle perimeter was traced to an acetate sheet and the *longissimus* muscle area was measured, using a digital planimeter Koizumi Placom KP-90, between the 12^{th}-13^{th} ribs

(LEA12, cm^2), the 1^{st}-2^{nd} (LEA1, cm^2) and the 3^{rd}-4^{th} (LEA3, cm^2) lumbar vertebra. Total breast bone tissue thickness was taken with a sharpened steel rule at middle of the 2^{nd} (BT2, mm), 3^{rd} (BT3, mm) and 4^{th} (BT4, mm) sternebras. The carcasses left side was dissected into muscle, bone, subcutaneous fat, intermuscular fat, kidney and pelvic fat and remainder (major blood vessels, ligaments, tendons and thick connective tissue sheets associated with some muscles).

2.3 Statistical analysis

The data were analysed using the SAS software (SAS Institute Inc., 2002-2004). Summary statistics were computed by the PROC MEANS procedure and the PROC FACTOR procedure was used to perform a principal components common factor analysis and the factors retained were those with eigenvalue higher than one (Krzanowski, 1990). Models to predict muscle weight (kg) and proportion (gkg^{-1}) were developed, through the PROC REG procedures, based on stepwise multiple regression using as independent variables a subset of the original variables selected by the principal components common factor analysis. Variables were only retained in the model when they significantly ($P < 0.05$) contributed to the accountable variance.

3 Results and discussion

3.1 General results

Table 1 shows the mean, CV, minimum and maximum for the HCW, carcass dimension, tissues thickness, and area measurements. The HCW had a CV around 17% and it is expected that the variation on this variable affects the variation observed in the carcass dimension and tissues thickness and area measurements. However, in spite of the large variation observed in HCW, the carcass dimension measurements (F, K, G, U and CB) had the lowest CV (from 5.7 to 8.1%). Similar results were reported in buffalos (Shahin et al., 1993), in rabbits [Shahin (2000)) and in lambs (Timon & Bichard, 1965).

In buffalos, Shahin et al. (1993) reported CV of 5% in the carcass dimension measurements that reflect bone lengths, and 14% in measurements that reflect the development of muscle and fat tissues (carcass widths). These results show that BW increase has less effect on bone growth and development than on muscle and fat tissues growth and development. Therefore, the variation imposed by the BW increase is less sharp in carcass length measurements than in the carcass width measurements; this is in agreement with the expected results since bone tissue has high precocity (Butterfield et al., 1983; Butterfield, 1988). Similar results have been presented by Anous (1986) in a study about carcass and leg dimensions measurements of several sheep breeds explored in France.

Table 1: Mean, CV, minimum and maximum for HCW, carcass dimensions and tissues measurements

Traits	Mean	CV	Minimum	Maximum
HCW (kg)	12.2	16.7	8.0	15.0
Carcass measurements (mm)				
F	272.9	7.7	230.0	310.0
K	723.9	8.1	613.0	820.0
G	208.9	6.0	183.0	230.0
U	618.5	5.7	550.0	675.0
CB	545.5	5.9	474.0	605.0
Subcutaneous fat thickness (mm)				
C12	1.3	44.5	0.4	2.5
C1	1.2	57.1	0.4	3.2
C3	2.1	64.0	0.3	5.4
Breast bone tissue thickness (mm)				
BT2	16.4	20.8	7.8	24.3
BT3	14.7	23.7	8.0	23.6
BT4	12.9	25.8	5.7	20.7
Longissimus muscle depth (mm)				
B12	24.9	15.7	17.3	32.7
B1	26.6	15.4	19.8	35.0
B3	24.0	12.1	17.5	32.6
Longissimus muscle area (cm^2)				
LEA12	10.5	19.3	6.4	14.6
LEA1	10.7	18.1	6.7	14.9
LEA3	10.4	15.9	6.7	14.2
Lean weight (kg)	6.9	17.8	4.4	9.0
Lean proportion (g kg^{-1})	638.6	4.6	595.5	694.9

HCW = hot carcass weight; F = leg length; K = carcass length; G = width of the buttocks; U = circumference of thorax; CB = circumference of buttocks; C12 = subcutaneous fat thickness between the 12^{th}-13^{th} ribs; C1 = subcutaneous fat thickness between the 1st-2nd vertebrae; C3 = subcutaneous fat thickness between the 3^{rd}-4^{th} vertebrae; BT2 = breast bone tissue thickness at 2^{nd} *sternebra* level; BT3 = breast bone tissue thickness at 3^{rd} *sternebra* level; BT4 = breast bone tissue thickness at 4^{th} *sternebra* level; B12 = *longissimus* muscle depth between the 12^{th}-13^{th} ribs; B1 = *longissimus* muscle depth between the 1^{st}-2^{nd} lumbar vertebra; B3 = *longissimus* muscle depth between the 3^{rd}-4^{th} lumbar vertebra; LEA12 *longissimus* muscle area between the 12^{th}-13^{th} ribs; LEA1 = *longissimus* muscle area between the 1^{st}-2^{nd} lumbar vertebra; LEA3 = *longissimus* muscle area between the 3^{rd}-4^{th} lumbar vertebra.

This study showed that the subcutaneous fat thickness measurements (C12, C1 and C3) had the highest CV (above 44.5%) of all the measures recorded. These results are in agreement with the high variability observed in the carcass fat tissues by Teixeira et al. (1996) and Safari et al. (2001). Afonso and Thompson (1996) also observed that subcutaneous fat area measurements, obtained by computer tomography, grow faster than BW. The adipose tissue is late maturing (Butterfield, 1988) compared to carcass weight, and the increase in BW leads to high variations in this tissue and in the associated fat thickness measurements. The adipose tissue is the most susceptible to variations induced by nutritional factors. Therefore, tissues measurements that reflect carcass fatness, like subcutaneous fat thickness, are highly conditioned by the relation between BW at slaughter and potential mature BW, as stated by Taylor (1980), Taylor et al. (1980) and Taylor et al. (1989).

The breast bone tissue thickness (BT2, BT3 and BT4) measurements had CV values greater than that observed for HCW and lower than that observed in subcutaneous fat thickness measurements. These results seem to reflect the lower variation observed in this tissue but also the ease of measurement. Snowder et al. (1994) observed a higher CV in C (subcutaneous fat thickness above the maximum depth of the *longissimus* muscle) measurement than in GR (total tissue thickness at the 12^{th} rib 110 mm from the midline) measurement and attributed this finding to differences in the scale or magnitude of their measure. The GR measurement, being a measurement of larger magnitude, is easier to measure and presents smaller measurement errors (Young & Deaker, 1994). The breast bone tissue thickness measurements have a magnitude higher (from 5.9 to 13.6 times) than the subcutaneous fat thickness measurements; therefore, the breast bone tissue thickness measurements will present smaller errors especially in very young animals that have little subcutaneous fat.

The CV observed for *longissimus* muscle depth (B12, B1 and B3), *longissimus* muscle area (LEA12, LEA1 and LEA3) and lean weight (varying from 12.1 to 19.3%) were similar to that observed in the HCW. These results can be explained by the isometric muscle growth when compared to the BW growth as described by Butterfield et al. (1983) and Butterfield (1988). It is then expected that the variation in HCW will be directly reflected in the *longissimus* muscle depth and area measurements variation as was observed in our results and in previous works (Safari et al., 2001; Timon & Bichard, 1965).

The lean proportion had a low CV, 79.5% lower than that observed for lean weight. Similar results were also reported by Fortin (1986) and are, probably, associated to the low variability on muscle proportion during animal growth (Butterfield, 1988).

3.2 Variables interrelationships

Table 2 shows the coefficients of linear correlation between hot carcass weight, carcass dimensions and tissues measurements. The HCW had high and positive correlations coefficients (higher than 0.74) with the measurements that characterise carcass widths (G) and perimeters (U and CB). However, HCW had a low correlation coefficient (0.17) with leg length (F), and a medium one (0.56) with carcass length (K). It is interesting to note the very low correlation coefficient (0.04) between the carcass length (K) and the buttocks width (G). These results shows that the increase in carcass length (F and K measurements) is less dependent on the increase in HCW than on the carcass width (G) and perimeter (U and CB) measurements. These results are in agreement with those of Boccard et al. (1964), who stated that in early ages the BW growth is more related to the growth of body width dimensions (tissue accretion) than to the growth due to bone elongation.

Table 2: Coefficients of linear correlation between the hot carcass weight, carcass dimensions and tissues measurements

	HCW	F	K	G	U	CB	B12	B1	B3	LEA12	LEA1	LEA3	C12	C1	C3	BT2	BT3
F	0.17																
K	0.56	0.79															
G	0.74	-0.39	0.04														
U	0.91	0.42	0.70	0.55													
CB	0.91	0.09	0.46	0.73	0.80												
B12	0.52	-0.21	-0.04	0.50	0.38	0.54											
B1	0.62	-0.27	0.10	0.71	0.49	0.57	0.64										
B3	0.51	-0.18	0.14	0.53	0.41	0.52	0.60	0.66									
LEA12	0.59	-0.43	-0.10	0.69	0.34	0.60	0.67	0.61	0.55								
LEA1	0.75	-0.16	0.23	0.65	0.59	0.75	0.57	0.65	0.58	0.75							
LEA3	0.59	-0.03	0.17	0.49	0.42	0.61	0.26	0.43	0.37	0.49	0.56						
C12	0.12	0.32	0.29	-0.13	0.18	0.24	-0.31	-0.27	-0.23	-0.10	-0.05	0.26					
C1	0.03	0.21	0.05	-0.11	-0.00	0.11	-0.25	-0.35	-0.17	0.02	-0.14	0.27	0.75				
C3	0.14	0.47	0.35	-0.21	0.21	0.20	-0.06	-0.27	-0.13	-0.07	-0.10	0.10	0.67	0.68			
BT2	0.57	0.41	0.61	0.12	0.55	0.46	0.19	0.18	0.19	0.30	0.33	0.39	0.39	0.38	0.54		
BT3	0.46	0.46	0.58	0.02	0.46	0.29	0.11	0.13	0.13	0.19	0.22	0.31	0.29	0.37	0.51	0.90	
BT4	0.49	0.49	0.57	0.11	0.51	0.40	0.19	0.10	0.10	0.24	0.21	0.21	0.30	0.44	0.55	0.81	0.89

Coefficient of linear correlation for null hypothesis $r = 0$, $P < 0.05$ if $R \geq 0.374$ and $P < 0.01$ if $R \geq 0.478$; HCW = hot carcass weight; F = leg length; K = carcass length; G = width of the buttocks; U = circumference of thorax; CB = circumference of buttocks; C12 = subcutaneous fat thickness between the 12^{th}-13^{th} ribs; C1 = subcutaneous fat thickness between the 1st-2nd vertebrae; C3 = subcutaneous fat thickness between the 3^{rd}-4^{th} vertebrae; BT2 = breast bone tissue thickness at 2^{nd} *sternebra* level; BT3 = breast bone tissue thickness at 3^{rd} *sternebra* level; BT4 = breast bone tissue thickness at 4^{th} *sternebra* level; B12 = *longissimus* muscle depth between the 12^{th}-13^{th} ribs; B1 = *longissimus* muscle depth between the 1^{st}-2^{nd} lumbar vertebra; B3 = *longissimus* muscle depth between the 3^{rd}-4^{th} lumbar vertebra; LEA12 *longissimus* muscle area between the 12^{th}-13^{th} ribs; LEA1 = *longissimus* muscle area between the 1^{st}-2^{nd} lumbar vertebra; LEA3 = *longissimus* muscle area between the 3^{rd}-4^{th} lumbar vertebra.

The correlation coefficients among HCW and *longissimus* muscle area and depth measurements were positive with some range in their estimated values (from 0.51 to 0.75). The subcutaneous fat thickness measurements had low correlation coefficients with HCW (from 0.03 to 0.14), nevertheless, they showed high and positive (from 0.67 to 0.75) correlation coefficients among themselves. Low correlation coefficients among HCW and subcutaneous fat thickness measurements were also found by Safari et al. (2001) in a study with lambs from several breeds. The low correlation coefficients among HCW and subcutaneous fat thickness measurements in multi-breeds data sets reflect the diversity in the degree of maturity. At similar carcass weight, lambs from breeds with large differences in the mature BW, as the two breeds used in this study, will present differences in the adipose tissue development as described by Thonney et al. (1987) and Taylor et al. (1989).

The breast bone tissue thickness measurements showed high and positive coefficients of linear correlation between themselves (higher than 0.81) and moderate sized coefficients with HCW (from 0.49 to 0.57). Similarly, the subcutaneous fat thickness and breast bone tissue thickness measurements had low to high positive coefficients of linear correlation. A high variation in the coefficient of linear correlation was observed among anatomical locations, which can be explained by the measurement errors.

The collinearity can be evaluated by the analysing the coefficients of linear correlation between all pairs of variables. Clearly, these results suggest collinearity problems between HCW and carcass width (G) and perimeter (U and CB) measurements, which are in agreement with the findings from Boccard et al. (1964) in sheep, and from Shahin et al. (1993) in buffalos. Similarly, collinearity problems have been also identified between measurements from the same tissue but obtained in different anatomical regions. However, the interpretation of the coefficients of linear correlation is a problematic work and does not provide a complete picture of all data interrelationships.

3.3 Common factor analysis

Table 3 shows the common factors pattern, after varimax rotation, communalities, unique factor, eigen values, variance explained and description of the four common factors retained by the mineigen criterion through the factor analysis on the original variables. The contribution of the original variables to each factor can be evaluated by its loading (variable-factor correlation) on each one of the extracted common factors. The common factor analysis was able to identify four common factors which accounted for 81.9% of the variation on the 18 original variables, leaving 18.1% of the variation for the 18 unique factors.

The factor I was characterized by the high and positive loadings (factor-variable correlation) in the HCW (0.84), in the carcass dimension measurements (from 0.64 to 0.88), and in the *longissimus* muscle depth and area measurements (from 0.67 to 0.86). This factor accounted for 35.1% of the variation in the 18 original variables and was identified as HCW. Factor II accounted for an additional 18% variation in the original variables and showed high and positive loadings (from 0.81 to 0.90) on the sternum tissues thickness measurements, being identified as sternum tissues thickness. Factor III accounted for an additional 14.5% variation of the 18 original variables and showed high and positive loadings (from 0.62 to 0.89) on subcutaneous fat thickness measurements, being identified as subcutaneous fat thickness. Factor IV accounted for an additional 14.3% variability in the 18 original variables. It was identified as carcass length due to its high and positive loadings on carcass (K, 0.87) and leg (F, 0.80) length measurements that reflect carcass lengths. Variables with high loadings in the same common factor are correlated between themselves and, being collinear, carry redundant information. In multiple linear regression models, the use of collinear variables as independent variables does not improve the models precision and creates instability in the regression coefficients estimation as stated by (Shahin, 1999a, 2000) and Shahin and Hassan (2000).

Table 3: Factor pattern, after varimax rotation, communalities, unique factor, eigen values, variance explained and description of the four common factors retained by the mineigen criterion through the factor analysis on the original variables

Variables	Rotated common factors I	II	III	IV	Communalities	Unique factor
HCW	0.84	0.25	0.08	0.43	0.947	0.053
F	-0.30	0.38	0.13	0.80	0.883	0.117
K	0.13	0.39	0.05	0.87	0.924	0.076
G	0.88	-0.13	-0.02	-0.02	0.798	0.202
U	0.64	0.24	0.05	0.66	0.902	0.098
CB	0.86	0.12	0.22	0.34	0.911	0.089
B12	0.68	0.26	-0.36	-0.18	0.686	0.314
B1	0.80	0.04	-0.34	0.03	0.759	0.241
B3	0.69	0.13	-0.27	-0.04	0.574	0.426
LEA12	0.82	0.22	-0.02	-0.37	0.861	0.139
LEA1	0.86	0.09	-0.05	0.08	0.761	0.239
LEA3	0.67	0.06	0.40	0.05	0.618	0.382
C12	-0.05	0.14	0.89	0.20	0.862	0.138
C1	-0.09	0.34	0.86	-0.13	0.885	0.115
C3	-0.12	0.55	0.62	0.16	0.725	0.275
BT2	0.28	0.81	0.25	0.27	0.867	0.133
BT3	0.14	0.90	0.15	0.24	0.902	0.098
BT4	0.17	0.87	0.19	0.25	0.882	0.118
Eigen Values	7.16	4.63	1.78	1.18	-	-
% Variation	35.14	17.98	14.47	14.32	-	-
Factor description	HCW	BT	C	CL	-	-

Coefficient of linear correlation for null hypothesis $r = 0$, $P < 0.05$ if $R \geq 0.374$ and $P < 0.01$ if $R \geq 0.478$; HCW = hot carcass weight; F = leg length; K = carcass length; G = width of the buttocks; U = circumference of thorax; CB = circumference of buttocks; C12 = subcutaneous fat thickness between the 12^{th}-13^{th} ribs; C1 = subcutaneous fat thickness between the 1st-2nd vertebrae; C3 = subcutaneous fat thickness between the 3^{rd}-4^{th} vertebrae; BT2 = breast bone tissue thickness at 2^{nd} *sternebra* level; BT3 = breast bone tissue thickness at 3^{rd} *sternebra* level; BT4 = breast bone tissue thickness at 4^{th} *sternebra* level; B12 = *longissimus* muscle depth between the 12^{th}-13^{th} ribs; B1 = *longissimus* muscle depth between the 1^{st}-2^{nd} lumbar vertebra; B3 = *longissimus* muscle depth between the 3^{rd}-4^{th} lumbar vertebra; LEA12 *longissimus* muscle area between the 12^{th}-13^{th} ribs; LEA1 = *longissimus* muscle area between the 1^{st}-2^{nd} lumbar vertebra; LEA3 = *longissimus* muscle area between the 3^{rd}-4^{th} lumbar vertebra.

Communality indicate how much of the variation in the original variables is captured in the factors retained (Krzanowski, 1990). Mathematically they are the sum of the squared loadings for the retained factors. The communalities of the four extracted common factors explained 94.7 to 57.4% in the original variables variation, leaving 5.3 to 42.6% variation for the 18 unique factors specific to each of the 18 original variables. Communalities were particularly high for HCW (0.95) and for carcass dimension measurements (from 0.80 to 0.93). The subcutaneous fat thickness and breast bone tissue thickness measurements had communalities ranging from 0.73 to 0.90. The lowest communalities were observed for *longissimus* muscle area and depth measurements, with variations among anatomical locations. These higher communalities on carcass dimension measurements were also observed in buffalos by Shahin et al. (1993), showing that variability in carcass dimension measurements can be accounted for by their interrelationships. Variables with high loadings in the same factor are redundant since they do not add any information to each other when used as independent variables in multiple linear regression models. Moreover, the inclusion of collinear variables as independent variables in multiple linear regression models can give rise to collinearity problems.

Clearly, results from common factors analysis identify four sets of collinear variables which carry redundant information:

1. the set formed by HCW, carcass dimension (G, U, PCB) and *longissimus* muscle area (LEA12, LEA1 and LEA3), and depth (B12, B1 and B3) measurements, all with high and positive loadings in factor I;
2. the set of breast bone tissue thickness (BT2, BT3 and BT4) measurements, all with high and positive loadings in factor II;
3. the set of subcutaneous fat thickness (C12, C1 and C3) measurements, all with high and positive loadings in factor III; and
4. the set formed by leg length (F) and carcass length (K) measurements, both with high and positive loadings in factor IV.

4 Conclusions

The common factor analysis is an efficient technique to understand the interrelationships between variables in large data sets, and allowing identification of problems of collinearity. The set of eighteen original variables can be reduced to four variables that contain a high proportion of variation present in the original data set, supplied by its interrelationships (correlations). The *longissimus* muscle area and depth measurements are collinear therefore, only one of these variables needs to be retained. The depth measurements should be preferred since they can be measured more quickly and with lower errors than the area measurements. The results presented in this work show that the HCW information can be complemented with one subcutaneous fat thickness, one breast bone tissue thickness and one carcass length measurement.

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