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CORRELATIONS BETWEEN CARCASS CHARACTERISTICS OF LAMBS

A. Asghar* and N.T.M. Yeates**

Simple and partial correlations between various characteristics (or organs) of carcasses from 23 Dorset Horn x Poll Merino breeding lambs were computed with the aim of knowing those correlations which are independent of plane of nutrition and age of the lambs. A large number of characteristics showed significant simple correlation, but when the variations due to plane of nutrition and age were held constant, only a small number of the correlations were found to be significant. This suggests that many of the variables were related mainly due to their common association with plane of nutrition and age of the lambs, whereas the other correlations which were independent of these factors can provide much more useful basis for predecing composition of carcass.

INTRODUCTION

The evaluation of quality of meat is based on two main considerations: firstly, to meet the requirements of the trade, and secondly to satisfy the consumer's preference. The former is concerned with "carcass quality" and the latter with "meat quality." Carcass quality is assessed on the basis of conformation, finish (fat status) and colour of the lean, corresponding to the species, sex and age of the animal, but their relative importance and hence the grade varies considerably from country to country (Yeates, *et al.* 1975). Irrespective of these variations, the information about the relative proportion of three major tissue. that is, bone, muscle and fat, which is an intrinsic indicative of carcass quality is always desired. The direct method for estimating the proportion of these tissues is by anatomical approach. But, this method cannot be adopted for general practice, especially when speed and minimum interference with the carcass are prerequisites.

* Present Address: Department of Food Technology, University of Agriculture, Lyallpur (Pakistan).

** Department of Animal production, Faculty of Rural Science, University of New England, Armidale (Australia).

This motivated several workers to look for indices by which relative proportion of the bone, muscle and fat can be found out in intact carcass for commercial assessment (Baily *et al.* 1961; Cole *et al.*, 1962; Butter field, 1963; Field *et al.*, 1963; Orme, 1963; Birkett *et al.*, 1965; Superlock and Bradford, 1965; Timon and Bichard, 1965; DuBose *et al.*, 1967). For example, some of the workers have suggested the use of length, depth and/or area of the *L. dorsi* muscle at a point in the lumbar region for predicting the total amount of muscle in the carcass, while others did not find high correlation between these variables. Similar disagreement exists over other reported results. This possibly is due, partly, to the fact that the relation of different parts, organs and tissues to carcass weight is exponential rather than linear (Tulloh, 1963), and partly due to the interaction between carcass components and ante-mortem history of the animal (Asghar, 1969).

The present study aims at knowing those correlation coefficients (partial) between different parameters of lamb's carcass which are independent of the nutritional history and age of the animal. This information may be used for predicating the carcass composition from simple measurements of the appropriate characteristics of carcasses.

MATERIALS AND METHODS

The data on 23 Dorset Horn x Poll Merino breeding lambs (all by one sire; their sex, nutritional status and growth history being known) were used in this study (Asghar, 1969). The primary data on different characteristics of the carcasses were collected according to the procedures of Hankins and Howe (1946) and Thwaites *et al.* (1964). The primary data on weight of the parts (or organs or tissues) were converted into percentage of the dressed carcass weights, so as to find a base which has the property (not possessed by paimary data) as being more constant (Simpson *et al.*, 1965).

Statistical Analysis: Simple and partial correlation between various measurements of carcasses were computed according to the standard method, using Bar-3 Fortran Programme of Burr (1968) on computer IMB 1620, Model 2.

RESULTS AND DISCUSSION

Simple and partial correlations matrices of 22 variables of the lamb's body are recorded in Table 1 and 2 respectively. The data in Table 1 show a number of significant correlations, but an examination of the results in

TABLE 1. SIMPLE CORRELATION COEFFICIENTS BETWEEN CARCASS CHARACTERISTICS OF LAMB

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1 LIVE WEIGHT (kg)																								
2 CARCASS WEIGHT (kg)	·975																							
3 CARCASS LENGTH (cm)	·961	·937																						
4 LEG LENGTH (cm)	·860	-·804	·842																					
5 *EYE LENGTH (cm)	·873	·705	·636	·795																				
6 *EYE LENGTH (cm)	·648	-·724	·581	·419	·630																			
7 *EYE AREA (cm²)	·782	·844	·715	·534	·832	·861																		
9 SUBCUTANEOUS FAT THICKNESS (cm)	·788	·847	·696	·511	·737	·810	·893																	
9 L. DORSI MUSCLE %	·306	·379	·511	·231	·467	·577	·177	·501																
10 +MUSCLE %	-·680	-·693	-·557	-·474	-·548	-·462	·487	-·982	·074															
11 +BONE %	-·591	-·713	-·705	-·530	·686	-·649	-·784	-·879	-·560	·567														
12 +FAT %	·685	·795	·602	·428	·692	-·632	·707	·519	·299	-·500	·363													
13 +MUSCLE % (FAT FREE BASIS)	·524	·616	·465	·250	·615	·638	·797	·827	·635	-·525	-·305	·576												
14 +BONE % (FAT FREE BASIS)	-·521	-·616	·465	-·250	-·615	-·638	-·797	-·827	-·635	·175	·108	-·676	1000											
15 FIBRE DIAMETER (μ)	·664	·690	·591	·480	·612	·525	·760	·757	·544	-·449	·715	-·655	·647	-·657										
16 SARCOMERE LENGTH (μ)	·454	·518	·484	·350	·488	·436	·420	·540	·673	-·201	-·610	·445	·764	-·764	·863									
17 GROSS FLESHING INDEX	·611	·722	·430	·272	·666	·765	·801	·826	·462	-·505	-·674	·827	·762	-·767	·627	-·227								
18 NET FLESHING INDEX	·590	·700	·426	·265	·666	·765	·793	·820	·547	-·573	-·574	·505	·755	-·758	·646	-·165	·330							
19 °FEET %	-·653	·698	·517	-·745	-·562	-·637	-·632	-·764	-·274	·626	·674	-·732	-·593	·524	-·573	-·311	-·790	·750						
20 HEAD %	·620	-·709	·541	-·563	·675	·625	-·762	-·760	-·426	·466	·766	·680	-·774	·774	·586	-·542	·809	-·571	·713					
21 BRAIN %	·847	-·905	·845	·659	·840	-·790	·864	·826	-·565	·607	·835	-·839	·809	·803	·773	-·628	·893	-·801	·730	·773				
22 HEART %	-·700	·756	-·611	·410	-·627	-·565	·733	-·789	·254	·714	·698	·736	-·587	·567	·506	-·236	-·728	·700	·785	·696	·767			
23 LIVER %	-·467	-·265	·241	-·103	-·745	-·073	·158	·111	·183	·286	·207	·281	-·114	·134	-·046	·059	·231	-·146	·147	·457	·194	-·161		
24 KIDNEYS %	-·853	-·876	·629	-·722	·617	-·530	-·668	-·706	-·244	·621	·611	-·696	·515	·515	·650	-·409	-·509	-·548	·670	·735	-·786	·691	-·534	

SIGNIFICANT LEVELS AT 5%, 2%, 1% & 0.1% PROBABILITIES ARE ·423, ·432, ·537 AND ·652 RESPECTIVELY

* OF L. DORSI MUSCLE, + BASED ON 3 RIB CUT, ° CONSISTING OF TAIL, NECK + METASTERNUM. THE REMAINING PERCENTAGES ARE BASED ON CARCASS WEIGHT.

TABLE-2 *PARTIAL CORRELATION COEFFICIENTS BETWEEN CARCASS CHARACTERISTS OF LAMB

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1. LIVE WEIGHT (KG)																								
2. CARCASS WEIGHT (KG)	.847																							
3. CARCASS LENGTH (CM)	.848	.708																						
4. LEG LENGTH (CM)	.383	.396	.500																					
5. *EYE LENGTH (CM)	.419	.619	.352	.349																				
6. *EYE WIDTH (CM)	.287	.469	.244	.001	.239																			
7. *EYE AREA (CM²)	.459	.671	.423	.089	.594	.688																		
8. SUBCUTANEOUS FAT THICKNESS (CM)	.339	.553	.382	-.463	.244	.517	.489																	
9. L. DORSI MUSCLE %	-.495	-.074	.233	.103	.480	.326	.264	-.152																
10. * MUSCLE %	-.491	-.290	.461	.003	-.017	-.460	-.106	-.375	.647															
11. * BONE %	-.406	-.475	-.347	-.054	-.325	-.474	-.415	-.483	.070	.201														
12. * FAT %	.456	.437	.084	.024	.230	.124	.256	.540	-.544	-.190	-.509													
13. *MUSCLE % (FREE FAT BASIS)	.282	.441	.591	-.117	.471	.138	.505	.349	.242	.093	-.733	.221												
14. *BONE % (FREE FAT BASIS)	-.202	-.401	-.504	.417	-.477	-.138	-.506	-.354	-.242	-.093	.732	-.221	-1.000											
15. FIBRE DIAMETER (µ)	.465	.401	.468	.068	-.128	-.203	-.453	-.104	.050	.196	.103	-.197	-.121	.121										
16. SARCOMERE LENGTH (µ)	-.466	.429	.444	.405	-.021	-.496	-.295	-.105	.445	.645	.431	-.137	.038	-.098	.288									
17. GROSS FLESHING INDEX	.469	.606	-.034	-.427	.501	.491	.590	.442	-.123	-.275	-.383	.365	.736	-.736	-.218	-.364								
18. NET FLESHING INDEX	.385	.524	-.180	-.464	.495	.509	.555	.351	-.011	-.284	-.341	.296	.137	-.157	-.204	-.301	.969							
19. * FEET %	-.098	-.092	.245	.376	.126	-.160	-.418	-.245	.334	.338	-.098	-.267	.041	-.045	-.138	.331	-.345	-.369						
20. HEAD %	-.431	-.436	-.393	.424	-.394	-.200	-.431	-.322	.405	-.243	.520	-.415	-.423	.479	-.012	.462	-.635	-.506	.332					
21. BRAIN %	-.494	-.483	-.504	-.028	-.315	-.420	-.528	-.301	-.072	.163	.553	-.361	-.457	.457	.131	-.053	-.276	-.207	-.042	.514				
22. HEART %	-.47	-.278	.456	.479	-.168	.032	-.353	-.339	.216	.447	.167	-.458	-.050	.050	.376	.405	-.293	-.751	.482	.640	.187			
23. LIVER %	-.589	-.545	-.341	-.431	-.362	-.483	-.246	-.303	.215	.292	.662	-.581	-.372	.377	-.423	.096	-.403	-.327	-.180	.691	.678	.191		
24. KIDNEYS %	-.484	-.455	-.410	.093	-.362	.078	-.098	-.171	.168	.253	.531	-.432	-.302	.302	-.136	.006	-.314	-.250	.365	.729	.333	.281	.595	

SIGNIFICANCE LEVELS AT 5%, 2%, 1% AND 0.1% PROBABILITIES ARE ±456, .529, .575 AND .695 RESPECTIVELY

* ADJUSTED FOR NUTRITIONAL STATUS AND AGE OF LAMBS. FOR OTHER DETAIL, REFER TO FOOTNOTE TABLE-1.

both the tables indicates that many of the correlations are spurious. Apparently, nutritional status and age of the lamb exerted considerable influence on their relationship. However, the following variables were found to be significantly associated with each other, independent of plane of nutrition and age of the animal.

The live-weight was significantly related with carcass weight (r = .847), carcass length (r = .648), 'eye' area of *L. dorsi* muscle (r = .469), and gross-fleshing index (r = .469). Carcass weight was associated with carcass length (r = .708), the length, depth, area and subcutaneous fat thickness of *L. dorsi* muscle (r = .619, .469, .671 and .553 respectively), gross- and net-fleshing index (r = .604, .524), percentages of bone (r = —.475), head (r = —.634), and of brain (r = —.603). Carcass length was correlated with leg length (r = .500) and brain (r = .564).

The 'eye' length of *L. dorsi* muscle was related to 'eye' area (r = .634), percentages of bone (r = —.523), fat-free muscle (r = .471) and bone (r = —.471), and gross- and net-fleshing index (r = .501, .495 respectively). 'Eye' depth of the *L. dorsi* muscle was associated with its area (r = .686), subcutaneous fat—thickness (r = .532) and gross- and net-fleshing index (r = .496, .509 respectively). 'Eye' area of *L. dorsi* muscle was correlated with subcutaneous fat-thickness (r = .583), percentages of fat-free muscle and bone (r = .505, —.505, respectively), gross- and net-fleshing index (r = .590, .555 respectively) and percentage of brain (r = —.528). The subcutaneous fat-thickness was associated with the percentages of bone and fat (r = —.489, .510 respectively).

The *L. dorsi* muscle percentage was related with the percentage of bone (r = — .564). Muscle percentage was associated with percentage of fat (r = — .916). The percentage of bone was related with the percentages of fat (r = —.584), head (r = .520), brain (r = .553), and of kidneys (r = .531). The percentage of fat-free muscle (negatively) and of fat-free bone (positively) were related with the percentage of head (r = .479) and brain (r = .457).

Gross-fleshing index was associated with net-fleshing index (r = .979) and percentage of head (r = —.635). There was a negative relationship between net-fleshing index and percentage of head (r = —.506). The percentage of head was associated positively with percentages of brain (r = .514) and liver (r = .691). In all these cases, partial correlation coefficients were statistically significant, although the values were slightly lower than those of simple correlations (Table 1). This reveals that part of the relationship among the variates depended on the nutritional status and age of the lamb, but most of it was inherent.

The partial correlations between weight of carcass and liver (r = —.545), bone and liver (r = .642), brain and liver (r = .478), *L. dorsi* muscle percentage and total muscle (r = .647), fat percentage and liver (r = —.507), and kidney and liver (r = .595) were found to be significant (Table 2), although their simple correlation coefficients were non-significant (Table 1). This implies that for any given plane of nutrition and age, these variables of lambs are interrelated, that is, they tend to have a constant ratio, unaffected by plane of nutrition and age of the animals.

On the other hand the simple correlation coefficients of carcass length with percentage of fat-free muscle (r = .465) and bone (r = —.465) and of head with kidney (r = .457) differed significantly from zero (Table 1), while the partial correlations between these variables still more so (Table 2). This suggests that a correlation, existing between the plane of nutrition or age and these variables, tended to reduce and proportionally falsify the apparent association between the concerned variates of lamb's body. All the remaining non-significant partial correlation between other variates depended for the most part on nutritional history and age of the lambs.

Besides uncovering many new correlations between different characteristics of lamb's body, the present study also substantiates some of the correlations reported for beef carcasses by Cole *et al.* (1962), Birkett *et al.* (1965), Butterfield (1963) and DeBose *et al.* (1967). Present results also throw some light on the mode of effect of nutritional stress on different parts and organs of the lambs. Two views seem to exist regarding the effect of different nutritional levels during growth on body composition and conformation of animals. The first originates from the work of Hammond and his associates (namely, McMeekan, 1940; Palsson and Verges, 1952); according to which low plane of nutrition during growth has differential effect on the tissue and organs of the animal body. This was later interpreted by Hammond (1944) in terms of a theory of partition of nutrition according to metabolic rate of the tissue and organs.

The other view is that low plane of nutrition causes more or less uniform retardation of development except in adipose tissue (Wallace, 1948; Wilson, 1952, 1954, 1958; Tulloh, 1963; Elsley *et al.*, 1964). This group probably supports the proposition of Maynard (1947) that fat is an accumulation product rather than a tissue representing true growth. However, Pomeroy (1955) considers fat as a part of the animal growth, irrespective of the latter's age and size.

In the present study the correlations between certain variables of carcass were found to be independent of plane of nutrition and age, while in other cases the correlations were influenced significantly by these factors. This suggests a differential effect of nutritional stress on different tissues or organs of the lambs. If the effects were uniform on all the tissues and organs (with respect to body weight) then the partial correlations between all the variables of carcass would have been independent of nutritional plane, that is, the partial correlation coefficients would have not been significantly different from those of simple correlations. The work of Butterfield (*1965*) and the extensive studies by Seebeck (1967, 1968) have also shown differential effect of nutritional stress on various body components and organs of cattle.

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