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ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

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Estimation of Carcass Composition of Sheep, Goats and Cattle by the Urea Dilution Technique

Samir S. Hanna
Department of Animal Production, College of Agriculture, University of Basra, Basra, Iraq

Abstract: The study involved 30 local Iraqi sheep and goats (15 each) and 10 Friesian x local dry cows. Urea Space Volume (USV) was calculated from 2 collection periods of blood samples following infusion of urea at 12 (US 12 kg) and 30 (US 30 kg) min after infusion and then as a proportion of live weight (BW) or Empty Body Weight (EBW). All animals were slaughtered within 2 d of the USV trials. Sheep recorded the highest percentage (80.57%) of carcass soft tissue followed by goat (79.10%) and cattle (77.77%). Cattle bone/meat ratio was significantly lower than that of sheep or goats. Water content of cattle soft tissue was higher (74.78%) than that of sheep (64.86%) and goats (69.76%); however, fat% showed reverse percentages (15.39% for sheep and 9.025% for cattle). The pooled regression between either BW or EBW and carcass soft tissue composition was similar. Water content indicated positive slope; whereas protein and fat showed negative slope with either BW or EBW. BW or EBW effectively predicted the amount of fat and protein in the carcass soft tissue rather than their percentages when pooled data were used. Initial Plasma Urea Concentration (PUC) mean did not differ significantly among the three studied species. All correlation coefficients between urea concentration at zero time and soft tissue composition were negative and significant except that of protein% and fat%. However, positive and significant correlation coefficients between US12 and kg of water, protein, fat and ash in carcass soft tissue (ranged 0.921-0.948) were found. US expressed as kg or % to either BW or EBW after 12 min of infusion showed higher correlation and regression coefficients than that of urea concentration at zero time with reverse direction. Correlation coefficients within each species between soft tissue compositions with urea concentration at zero time were non-significant except for protein amount of goats and ash% of cattle ($p<0.05$). For sheep and goats, correlation coefficients using water, fat and protein of sheep only (expressed in kilograms) and US at 12 min (kg) or as percentages to BW and EBW were highly significant ($p<0.01$). Cattle resulted in significant correlation values ($p<0.05$ and $p<0.01$) for water% with US at 12 min as percentages to body weight or empty body weight.

Key words: Body composition, sheep, goat, cattle, prediction, urea space

INTRODUCTION

Body energy reserves, mainly represented by fat and muscle body content, as well as body composition, are important determinants of carcass quality in livestock (Mora *et al*., 2007). Although Body Condition Score (BCS) has been demonstrated to be an adequate estimator of these body variables under most practical conditions (Villaquiran *et al*., 2005), the qualitative and subjective character of this measurement must be considered when precise and repeatable data are required.

A number of approaches to predict the body composition of live animals are tried including use of the urea dilution technique. Agnew *et al*. (2005) reported that urea seemed to meet all the requirements of a satisfactory tracer. It is nontoxic, non foreign to the body and shows an even and rapid distribution throughout total body water without any physiological effect. The urea dilution procedure has no detrimental effects on performance characteristics of feedlot steer cattle (Wells and Preston, 1998). For these reasons, in addition to being an easy and accurate measurement, urea is an ideal candidate tracer to estimate Empty Body (EB) water *in vivo*. Total body water volume can be estimated by dividing the total amount of urea infused by the increase in plasma urea concentration before and after infusion. Many studies have examined the relationships between urea space and body composition in sheep, beef cows and dry cows. Bartle *et al*. (1987) evaluated some of these equations and concluded that urea dilution was a valid estimator of body composition in growing-finishing cattle. The urea dilution technique could be a valuable research tool if multiple estimates of body composition over time are needed when the slaughtering of the animal is not desired (Wells and Preston, 1998). Therefore, the objective of this study was to evaluate the usefulness of this technique in estimating carcass soft tissue composition in Iraqi Arabi sheep, local goats and Friesian x Local cattle.

MATERIALS AND METHODS

Animals and management: Mature Arabi ewes (no = 15), Iraqi local nannies (no = 15) and ten Friesian x local

Iraqi cross dry cows were randomly selected for slaughter at the commencement of the trail. They were selected from the herd at the Animal Farm, College of Agriculture, University of Basra. Animals remained at the same management and feeding regimens during the last two years before this study. They offered mixed diets of local grass and concentrate supplements, with forage proportions in diets ranging proportionately from 0.30-0.60 (DM basis). Concentrates used included some of the following ingredients: barley, wheat bran, corn and soybean meal in addition to a vitamin and mineral supplement.

Urea space determination: Feed was withheld but water was available for 24 h before the urea dilution was performed. Urea dilution was performed 1 d before slaughter. Animal weight was determined 10 min before the urea was administered. The technique used was described in detail by Preston and Kock (1973). A 12-gauge needle was inserted into the jugular vein and a catheter was introduced through the needle. The needle was then removed and the catheter was firmly taped to the neck and closed with a three-way stopcock. A 15-mL blood sample was taken and put into a plastic tube containing 30 mg of sodium oxalate. The catheter was then flushed with heparin solution (100 heparin units/mL, 0.1% benzyl alcohol and 0.9% sodium chloride). A solution containing 20% urea dissolved in 0.9% saline was infused through the catheter over a 2-min period. The volume injected was calculated to provide 130 mg urea/kg body weight. The catheter was flushed with 5 mL of heparin solution after the infusion and after each sample. Zero time was defined as the end of the 2-min period. Samples were obtained at 0, 12 and 30 min after the infusion. Thirty seconds before each sampling, 10 mL of blood was taken and discarded to ensure that the heparin solution contained in the catheter did not dilute the sample. The blood was kept at room temperature before centrifugation for 20 min at 2,460 * g and plasma was removed and frozen at -20°C until analysis. Plasma Urea Concentration (PUC) was determined by using a kit provided by Biochemeca and Diagnostica mbH. The coefficient of variation between determinations of the same sample was less than 1%, as recommended by Preston and Kock (1973). The solution used for infusion was also analyzed for urea concentration.

The US was calculated by the precise quantity of urea infused by the difference in plasma urea concentration before and after infusion at 12 (US12, kg) or 30 (US30, kg) min. The US was also expressed as a proportion of LW (US12/BW, or US30/BW, kg/kg) and empty BW (EBW; US12/EBW or US30/EBW, kg/kg), respectively.

$$\text{Urea space (\%)} = V\ (ml) * C\ (mg/dl)/D\text{-}PUC\ (mg/dl) * BW\ (kg) * 10$$

(Bartle *et al*., 1983)

Where, V is the volume infused, C is the concentration of the urea solution, D-PUC is the difference in PUC before and after the infusion and BW is body weight or empty BW. Omitting BW in the formula resulted in calculation of urea space volume. A density factor (0.99299 L/kg, density of water at body temperature) was used to convert liters to kilograms. Urea space was calculated at 0, 12 and 30 min after infusion.

Carcass measurements: Animals were slaughtered at the Animal Farm, College of Agriculture, University of Basra. Animals body was divided into carcass and non-carcass fractions; weight of these parts were recorded. Contents of gastrointestinal tract and bladders that were not a part of the empty body were determined by the difference between weights before and after washing. Carcasses were split longitudinally and chilled at 4°C. Cooler shrinkage was assumed to be water loss. The right side of the carcass was physically separated into soft tissue and bone. Soft tissue was ground and mixed for 3 min and then frozen at -20°C until analysis. Proximate analysis (protein, fat and ash) of the carcass soft tissue was determined as described by AOAC (1990).

Statistical methods: Correlation coefficients between urea space (kg, % EBW and % BW) and carcass soft tissue composition (protein, fat, moisture and ash, expressed in percentage of the total matter and in kilograms) were calculated for the three species groups of animals (pooled data) (SPSS, 1999). Partial correlation coefficients between US and carcass Soft Tissue Composition (STC) were calculated for each species group by excluding species and weight (SPSS, 1999).

Simple and multiple regression analyses were performed by SPSS (1999) to develop equations for prediction of STC from US expressed in kilograms, percentage of EBW and percentage of BW. Independent variables in the model were BW (24 h feed deprived), EBW, US % BW (calculated for each time-sample), US% EBW and US in kilograms. Dependent variables studied were carcass protein, fat, water and ash, expressed both as a percentage of EBW and in kilograms. The STEPWISE procedure (SPSS, 1999) was then used to study the effect of additional variables in the model on the coefficient of determination (R^2).

RESULTS AND DISCUSSION

Carcass soft tissue composition: Since there are species differences in body and carcass weight, our

Table 1: Means of body weight, empty body weight, carcass weight, carcass proximal components and initial Plasma Urea Concentration (PUC) of sheep, goats and cattle (±standard error)

	Species		
Item	Sheep	Goats	Cattle
No. animals	15	15	10
Body weight (kg)	53.34±3.11	40.56±2.66	192.74±14.81
Empty body weight (kg)	49.25±1.24	35.38±1.98	169.97±7.83
Cold carcass weight (kg)	26.27±2.10	20.19±2.23	103.56±9.23
Soft tissue (%)	80.57^{a}±1.80	79.12^{b}±1.23	77.77^{c}±1.05
Bone/meat ratio	41.46^{a}±0.03	40.75^{a}±0.02	34.31^{b}±0.02
Soft tissue weight (kg)	42.98±1.22	32.22±1.16	148.15±2.27
Water (%)	64.88^{c}±0.89	69.76^{b}±0.82	74.78^{a}±1.23
Protein (%)	18.73±1.77	18.14±1.78	16.33±1.12
Fat (%)	15.39^{a}±0.56	11.18^{b}±0.46	9.02^{c}±0.57
Ash (%)	1.00^{b}±0.001	0.92^{c}±0.01	1.13^{a}±0.02
PUC (mmol/L)	4.97±0.14	5.20±0.15	4.24±0.15

Means within each row with different letter significantly differ at 5%

Table 2: Linear equations between either Body Weight (BW) or Empty Body Weight (EBW) and percentages (%) or weight (kg) of carcass soft tissue components for the pooled data

Independent	Item	Intercept (a)	Slope (B)	SE	R^2 (%)
BW	Water (%)	64.77	0.0521	0.005	68.84
	Fat (%)	14.67	-0.0286	0.005	47.38
	Protein (%)	19.89	-0.0168	0.004	34.67
	Ash (%)	0.90	0.0012	0.0007	87.65
EBW	Water (%)	64.70	0.059	0.006	67.72
	Fat (%)	14.71	-0.032	0.005	47.09
	Protein (%)	20.00	-0.020	0.004	38.39
	Ash (%)	0.988	0.0014	0.00006	90.66
BW	Water (kg)	-3.053	0.599	0.004	99.80
	Fat (kg)	2.409	0.057	0.003	91.90
	Protein (kg)	1.439	0.122	0.003	98.00
	Ash (kg)	-0.066	0.009	0.000	99.80
EBW	Water (kg)	-2.887	0.667	0.020	96.30
	Fat (kg)	2.442	0.064	0.004	88.10
	Protein (kg)	1.581	0.135	0.006	92.80
	Ash (kg)	-0.066	0.010	0.000	96.80

comparison here was concentrated on percentages only. There were significant ($p<0.05$) differences in carcass soft tissue due to different species (Table, 1). Sheep recorded the highest percentage (80.57%) followed by goat (79.12%), whereas cattle had the lowest (77.77%). However, bone to meat ratio was lowest ($p<0.05$) in cattle in comparison to sheep and goats. This explains that cattle had more meat and less fat than both sheep and goats. Water content was higher ($p<0.05$) in cattle soft tissue (74.78%) than sheep (64.88%) and goats (69.76%). Fat% behaved completely in reverse to water%, since sheep got the highest value (15.39%) and cattle the lowest one (9.02%). Protein% did not show statistically differences among species. These results were in agreement with previous studies on the same genotypes of sheep, goats and cattle (Tahir *et al*., 1986, 1987, 1992; Mohammed, 1988; Al-Saigh and Al-Jassim, 1998).

Relationship of body weight and empty body weight with carcass soft tissue composition: Linear equations expressed as a percentage of soft tissue for estimating the carcass soft tissue components from BW are presented in Table 2. Equations developed with the pooled data produced higher coefficients of determination (R^2) for ash% followed by water% and generally smaller model SE than protein% and fat%. The pooled models to predict contents of water, protein and ash resulted were nearly similar when prediction was either BW or EBW, as all coefficients, SE and R^2 were very close. These results confirmed the above findings, that cattle were heavier than sheep and goats, however, they recorded low protein% and fat% but high level of water%.

Positive slopes in the equations for percentage of water indicated the tendency of the carcass soft tissue to have proportionally more water in cattle than sheep or goats, as body weight of cattle bigger than that of sheep or

goats. However, negative slopes for protein and fat indicated that cattle soft tissue protein and fat were less than that of sheep and goats. Body weight or EBW was accurately estimating the ash content in soft tissue as determinant coefficient reached 90%. Body weight or empty body weight was effectively predicted the amount of fat and protein in the carcass soft tissue rather than their percentages when the pooled data were used (R^2 ranged 91.90-99.80 or 88.10-96.80% for body weight and empty body weight respectively). Swartz *et al.* (1991), Velazco *et al.* (1997), Wuliji *et al.* (2003) and Ngwa *et al.* (2006) found different results in predicting whole-carcass protein and fat in young Holstein calves, Holstein steers and goats respectively.

In general, equations obtained for BW and composition were similar to those for EBW either for the amount or the percentages. Gut fill has been reported to introduce substantial variability in regression models for prediction of body composition (Preston and Kock, 1973). Perhaps the period of feed deprivation and the low level of roughage of the diets accounted for this effect.

Urea space and carcass soft tissue composition: Initial Plasma Urea Concentrations (PUC) mean did not differ significantly among species. Their values for sheep, goats and cattle were 4.97±0.14, 5.20±0.15 and 4.24±0.15 mmol/L, respectively (Table, 1). Carcass soft tissue composition data were used to estimate correlation coefficients (r) with US at 0, 12 and 30 min after infusion.

For the pooled data (Table 3), all correlation coefficients between urea concentration at zero time and soft tissue composition were negatively significant ($p<0.01$) except those of protein% and fat%, which were positive and significant ($p<0.01$ and 0.05 respectively). However, significant correlation coefficients ($p<0.01$) between US and kilograms of water, protein, fat and ash in carcass soft tissue ranged from 0.921-0.948 at 12 min. Kock and Preston (1979) reported that correlation coefficients between US and body water were highest at 12 min. The correlation coefficients in this study did not show any particular pattern after the infusion. Urea space had higher and positive correlation coefficients with protein and fat when expressed in kilograms than when calculated as a percentage of the total carcass soft tissue (Table 3). Urea space expressed as kg or as percentages to either BW or EBW after 12 min of infusion showed higher correlation coefficients and regression (Fig. 1) with soft tissue compositions than that of urea concentration at zero time with reverse sign. Correlation coefficients for US at zero, 12 min (kg, % to BW and EMB) and kilograms or % of fat in carcass soft tissue got the least value (0.342, -0.515, -0.535 and -0.373 respectively). Calculating US as a percentage of BW or EBW did not increase correlation coefficients for any of the carcass soft tissue components.

Correlation coefficients within each species were presented in Table 4. Correlations between soft tissue compositions with urea concentration at zero time were non-significant except for protein amount of goats and ash% of cattle ($p<0.05$). When STC was expressed as a percentage, r values were low and not significant for all components. For sheep and goats, correlation coefficients using water, fat and protein of sheep only (expressed in kilograms) and US at 12 min (kg) or as percentages to BW and EBW were highly significant ($p<0.01$).

Cattle resulted in significant correlation values ($p<0.05$ and $p<0.01$) for water% with US at 12 min as percentages to body weight or empty body weight (Table 4). It is possible that in the leaner animals, urea equilibrated faster (mostly at 12 min) with body water than in fatter animals (Agnew *et al.*, 2005), explaining the appearance of maximum correlations values at different times after infusion for different species.

Urea showed fast disappearance from the blood in this study, which can be due to kidney excretion of both ammonia and urea, transference of urea to salivary glands and to the rumen via saliva, or diffusion of urea through the rumen wall (Swartz *et al.*, 1991). Therefore, Velazco *et al.* (1997) suggested that the amount of urea being excreted should be established for young, lean cattle, as the metabolism of urea could be different in fast-growing calves than in older ruminants, because D-PUC and protein deposition decreased as animals became older.

Table 3: Pooled data correlation coefficients between urea concentration at zero time and urea space after 12 min of infusion (kg) with soft tissue composition amounts and percentages

Soft tissue composition	Urea zero time	Urea 12 (kg)	Urea 12/BW	Urea 12/EBW
Water (kg)	-0.601**	0.927**	0.946**	0.861**
Protein (kg)	-0.577**	0.921**	0.942**	0.896**
Fat (kg)	-0.594**	0.948**	0.960**	0.920**
Ash (kg)	-0.596**	0.936**	0.954**	0.868**
Water (%)	-0.469**	0.689**	0.696**	0.553**
Protein (%)	0.512**	-0.533**	-0.539**	-0.364*
Fat (%)	0.342*	-0.515**	-0.535**	-0.373*
Ash (%)	-0.561**	0.968**	0.966**	0.897**

**Correlation is significant at the 0.01 level (2-tailed), *Correlation is significant at the 0.05 level (2-tailed)

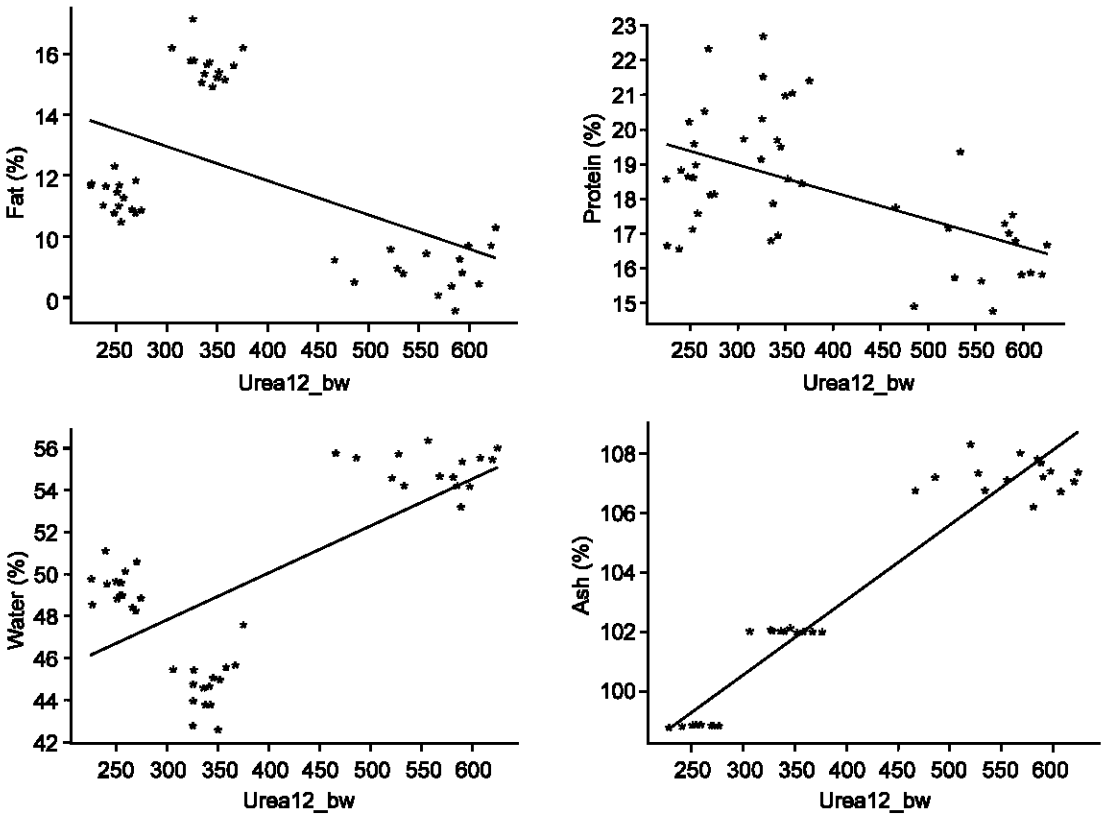

Fig. 1: Relationship between soft tissue component (%) and urea space at 12 min/body weight

Table 4: Correlation coefficients between urea concentration at zero time and urea space after 12 min of infusion (kg) with soft tissue composition amounts and percentages of different species

Species	Soft tissue composition	Urea zero time	Urea 12 (kg)	Urea 12/BW	Urea 12/EBW
Sheep	Water (kg)	-0.005	0.961**	0.910**	0.902**
	Protein (kg)	0.258	0.473	0.488	0.446
	Fat (kg)	-0.087	0.730**	0.729**	0.723**
	Ash (kg)	-0.022	0.895**	0.900**	0.867**
	Water (%)	0.039	0.406	0.411	0.400
	Protein (%)	0.325	-0.013	-0.012	-0.013
	Fat (%)	-0.105	-0.308	-0.307	-0.310
	Ash (%)	0.121	-0.211	-0.201	-0.209
Goats	Water (kg)	0.483	0.926**	0.922**	0.930**
	Protein (kg)	0.551*	0.769**	0.739**	0.770**
	Fat (kg)	0.342	0.655**	0.665**	0.656**
	Ash (kg)	0.470	0.964**	0.960**	0.961**
	Water (%)	0.072	-0.202	-0.200	-0.200
	Protein (%)	0.463	0.429	0.430	0.425
	Fat (%)	-0.159	-0.370	-0.375	-0.373
	Ash (%)	0.209	0.498	0.490	0.491
Cattle	Water (kg)	-0.357	-0.209	0.056	0.234
	Protein (kg)	-0.187	-0.232	-0.026	0.471
	Fat (kg)	-0.199	0.058	0.153	0.264
	Ash (kg)	-0.233	-0.168	0.079	0.151
	Water (%)	0.026	0.708*	0.577*	0.815**
	Protein (%)	0.031	-0.138	-0.127	0.545*
	Fat (%)	0.055	0.345	0.138	0.108
	Ash (%)	0.549*	0.481	0.012	-0.644**

**Correlation is significant at the 0.01 level (2-tailed), *Correlation is significant at the 0.05 level (2-tailed)

It can be concluded that urea space at 12 min is feasible to calculate and is effectively related to soft tissue composition of live animals.

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