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Prediction of carcass composition by ultrasonic measurement and the effect of region and age on ultrasonic measurements

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ABSTRACT

This study aimed to determine the relationship between age characteristics and sheep carcass composition with real time ultrasound. Data was collected from 34 Karayaka ewes and 20 female lambs. Skin and subcutaneous fat thickness, and muscle area, depth and width, were measured between the 12th and 13th thoracic vertebrae and 3rd and 4th lumbar vertebrae. The twenty female lambs were slaughtered to determine the muscle, bone and fat amount in their carcasses. The ultrasound measurements from the two regions were not significantly different ($P > 0.05$). It was also determined with ultrasound that the age of the animal had an effect on subcutaneous fat thickness and skin thickness ($P < 0.05$). In addition, there was a significant positive correlation among the ultrasound measurements in both regions with the carcass measured by dissection, and live weight. The coefficients of determination (R^2) ranged from 0.76 to 0.99 in the multiple regression models for carcass composition using ultrasound. In conclusion, the present study suggests that the use of ultrasound skin thickness and muscle area and depth measurements, coupled with live weight, can be used to estimate carcass composition.

1. Introduction

Determination of carcass composition and meat yield before slaughter is important for animal breeders and for the meat production sector in order to select animals with desired carcass qualities (Teixeira et al., 2006). The evaluation of carcass composition in sheep has been done with subjective methods such as carcass grading after slaughter and objective methods like ultrasound, computed tomography and magnetic resonance imaging before slaughter (Stanford et al., 1998; Akcapinar and Ozbeyaz, 1999; Silva and Cadavez, 2012). One of the methods used in the prediction of carcass composition is based on cut-section composition. This method is based on the high positive correlation between the composition of carcass tissues and the tissues of the cut section. A number of studies have been conducted with this method (Hedrick, 1983; Yakan and Unal, 2010; Sari et al., 2012). However, it is destructive, very time consuming and not possible to use on live animals. To overcome these limitations, some imaging techniques have been applied and real time ultrasound (RTU) has emerged as the one with the greatest potential for carcass composition prediction (Emenheiser et al., 2010; Orman et al., 2010; Ripoll et al., 2010). Generally, carcass composition is predicted from RTU measurements taken from the *Longissimus thoracis et lumborum* muscle (LM) and the subcutaneous fat layer surrounding the LM. With ultrasound, measurements are usually taken from the 6th thoracic vertebra to the last lumbar vertebra (Silva et al., 2005; Teixeira et al., 2006; Ripoll et al., 2009; Thériault et al., 2009). It is more difficult to take ultrasound measurements in sheep than other species due to the wool layer and the soft and loose outer layer of subcutaneous fat. In the prediction of carcass composition with ultrasound, species, age, sex, live weight and technical equipment can all have an influence (Stanford et al., 1995; Silva et al., 2005).

The current ultrasound study was conducted to determine the effects of location and age on some Karayaka sheep traits, namely skin and subcutaneous fat thickness; and muscle area, muscle depth and width; and also to estimate carcass composition.

2. Materials and methods

This study, which was approved by the Animal Studies Ethics Committee of Ondokuz Mayis University in Samsun, Turkey, was carried out on a private farm in Tekkekoy District of Samsun Province in northern Turkey. The farm is located at 41°12′N, 36°27′E and at an altitude of 380 m. In the study, 34 Karayaka ewes (18

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at 2 years and 16 at 3 years) at 45.2 ± 5.2 kg live weight and 20 six-month-old female lambs at 29.1 ± 1.8 kg live weight were used. The ewes were grazed on pasture during the day and each animal was provided 100 g of concentrate in the evening. Water was available ad libitum. Lambs suckled their mothers for 3 months and each lamb was provided fodder and 150 g of lamb concentrate/day. After weaning, lambs were grazed on pasture and 200 g of lamb concentrate was provided daily.

The ultrasound measurements were performed with a portable real-time ultrasound device (Aloka SSD-500) with a 3.5 MHz, 12.5 cm linear transducer. The resolution of the scanner calipers was 0.1 cm. Wool was sheared from the measurement areas before RTU image acquisition, and the animals were manually immobilized and acoustic gel was applied to provide good contact between the probe and the skin. The thickness of skin and subcutaneous fat and LM depth and width were measured between the 12th and 13th thoracic vertebrae (12–13T) and 3rd and 4th lumbar vertebrae (3–4L) (Silva et al., 2005; Teixeira et al., 2006). Following physical palpation and preparation, the transducer was placed between 12–13T and 3–4L, lateral to the vertebral column and parallel to it. All measurements were taken on the left side and 4 cm from the vertebral column. After capturing the scan image, the depth (ULD), width (ULW) and area of muscle (ULA), thickness of skin (UST) and subcutaneous fat thickness (UFT) at that point were measured with the electronic calipers (resolution 0.1 cm) of the scanner. Area of muscle (ULA) was measured with ultrasound on live animals on the same image after the borders of the muscle had been drawn (Orman et al., 2010).

After the ultrasound measurements were obtained on all live experimental animals, the lambs were separated from the flock and not fed for 12 h before slaughtering at a commercial slaughter unit with standard procedures. The fore and hind limbs were then separated at the radiocarpal and tarso-metatarsal articulations, respectively. The head, skin and all internal organs were removed. Cold carcass weights were recorded after chilling at 4 °C for 24 h. The carcasses were symmetrically halved and the left side was jointed, according to the procedure of Colomer-Rocher et al. (1988), into primal cuts, namely leg, foreleg, back (between the 6th and 13th thoracic vertebrae), loin, neck and breast + flank (Fig. 1) (Colomer-Rocher et al., 1988; Akcapinar and Ozbeyaz, 1999). All of the lambs' back sections were weighed separately. After weighing, the sections were separated into dissectible muscle, bone and fat, and weighed separately. The following equation was used to calculate carcass muscle, bone and fat amounts: TCA = [(Cold Carcass Weight × AC_i)/Back Weight], where TCA is the total amount of muscle, bone or fat in the carcass and AC_i are presents the amount of cut section tissues (muscle, bone or fat) (Akcapinar, 1978).

2.1. Statistical analysis

The ultrasound measurements taken from the two locations on animals of the same age were analyzed with the Student's *t*-test. Variance analysis was used for the comparison of ultrasound measurements from the lambs and ewes of different ages. The Duncan test was applied to determine significant differences among the groups. The relationship between the ultrasound measurements from the two locations and live weight and carcass composition were determined with Pearson's correlation test. Multiple regression analyses following a stepwise procedure were performed to determine the relationship between ultrasound measurements and live weight (LW) as the independent variables and carcass composition (muscle, fat and bone), dressing percentage, cold carcass weight and back muscle, fat and bone, as the dependent variables. The best model was evaluated with coefficient of determination (R^2) and the residual standard deviation (RSD) was determined from the fitted model (John, 1971; Sahin et al., 2008).

3. Results

The results of the ultrasound measurements taken between the 12–13T and 3–4L of lambs and ewes are shown in Table 1. The differences of both regions between the UST, UFT, ULA, ULD and ULW values of ewes and lambs were not significant ($P > 0.05$). UST and UFT measurements from the thoracic region were affected by age ($P < 0.05$). Measurements at the 3–4L vertebrae showed a significant effect of age on UST values ($P < 0.05$). The phenotypic correlation coefficients between the 12–13T and 3–4L measurements and live weight and carcass composition are provided in Table 2. In the measurements from the 12–13T, there was a high positive correlation between UFT and live weight, cold carcass weight, dressing percentage and carcass fat ($P < 0.01$); ULD and live weight, cold carcass weight and carcass fat ($P < 0.01$); ULW and live weight, cold carcass weight and carcass muscle ($P < 0.01$); ULA and live weight, cold carcass weight and carcass fat ($P < 0.01$); and UST and carcass muscle and carcass bone ($P < 0.01$) while live weight, cold carcass weight ($P < 0.05$). The measurements taken at the 3–4L vertebrae showed a high positive correlation between UFT and live weight, cold carcass weight and carcass fat ($P < 0.01$) and dressing percentage ($P < 0.05$); ULA and dressing percentage ($P < 0.01$), and ULD and live weight and cold carcass weight ($P < 0.05$). There was also positive correlation between UST and dressing percentage, carcass fat ($P < 0.05$) but a high negative correlations between UST and carcass muscle and carcass bone ($P < 0.01$). The coefficients of determination and residual standard deviations for the multiple regressions are shown in Table 3. A regression model built to estimate carcass composition using ultrasound measurements taken from the 3–4L area showed that ULA, UST and LW can be used to estimate cold carcass weight ($P < 0.001$), and that LW and ULA can be used to estimate dressing percentage. In addition, LW, UST, ULA and ULD measurements can be used to determine back fat, carcass fat and carcass muscle amounts ($P < 0.01$). The regression analysis performed on 12–13T measurements revealed that the LW values alone can be used to estimate carcass fat, back fat and cold carcass weight with 76–79% accuracy ($P < 0.05$). However, dressing percentage and carcass muscle amounts were not found estimable with regressions due to the insignificant parameters ($P > 0.05$).

4. Discussion

The present study showed that for ewes and lambs in the same age category, the values of UST, UFT, ULA, ULD and ULW were not significantly different ($P > 0.05$) at the 3–4L and 12–13T regions; the location of the ultrasound measurement therefore had no significant effect on the results (Table 1). These results supported those of previous studies that compared the findings from these two regions (Hopkins et al., 1998; Teixeira et al., 2006; Ripoll et al., 2010). Furthermore, results from other breeds at similar ages for UFT and ULD (Stanford et al., 1995; Jones et al., 2004; Silva et al., 2005; Leeds et al., 2008; Sahin et al., 2008), ULW (Stanford et al., 1995; Orman et al., 2010), ULA (Stanford et al., 1995; Pajor et al., 2005; Silva et al., 2006; Leeds et al., 2008) and UST (Silva et al., 2005) were lower than those determined in the Karayaka lambs in the current study, and values for ULD (Romdhani and Djemali, 2006; Aksoy et al., 2007; Husain et al., 2007; Orman et al., 2010), ULA (Yarali and Karaca, 2004; Sahin et al., 2008; Orman et al.,2010) and UST (Ripoll et al., 2009) were higher than in the present study. Those differences may have been due to breed of animal, age, sex, live body weight and type and technical specifications of the ultrasound equipment (Stanford et al., 1995; Akcapinar and Ozbeyaz, 1999; Silva et al.,