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# Use of Ultrasound Measurements to Predict Carcass Characteristics of Egyptian Ram-Lambs

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## ABSTRACT

Four ultrasound measurements were used to establish prediction equations to predict weight of carcass components of forty five Egyptian ram-lambs at 12 months of age. The measurements were depth, width, area of eye muscle (*Longissimus dorsi*) and thickness of fat covering at the 12$^{th}$ and 13$^{th}$ ribs area. Data were analysed by least squares procedure of General Linear Model (GLM) using SAS statistical package (SAS, 2004) and simple correlation coefficients and prediction equations were calculated. Correlation coefficients between ultrasound and carcass *Longissimus dorsi* muscle area were positive and significant in Barki (0.55) and Rahmani (0.83) ram-lambs. Body weight contributed 66% of the variation in total trimmed meat weight of Egyptian ram-lambs. Whereas, ultrasound *Longissimus dorsi* muscle area came next and scored a partial determination of 16% increasing the model's $R^2$ to 82%. The obtained results clearly indicate that ultrasound measurements could be used for accurate prediction of carcass components in Egyptian ram-lambs.

**Key words:** Ossimi, Barki, Rahmani, prediction, ultrasound measurements, carcass composition

## INTRODUCTION

Ultrasound method is useful for estimating carcass composition. Ultrasound technology has practical value for meat producer in predicting an animal's readiness for slaughter, carcass classification, lean growth and comparison of fatness of different genotypes or for selection programs of sheep with superior carcass traits (Leeds *et al*., 2007). Sheep body composition has been significantly improved after 3-4 years of selection using indices based on ultrasonically measured backfat, muscle depth and live body weight (Simm *et al*., 2002). Ultrasound measurements (depth of *Longissimus dorsi* and depth of subcutaneous fat over *Longissimus dorsi*) have been shown to be valuable predictors of lamb carcass saleable meat yield (Hopkins *et al*., 1996), while 3 years of selection based on reduced ultrasound backfat thickness measurement at a given live weight increased carcass lean by 13.5 g $kg^{-1}$ and reduced carcass fat in lambs by 13.8 g $kg^{-1}$ (Cameron and Bracken, 1992). Additionally, ultrasound measurements in the multiple regression equations for predicting carcass composition provided only a small improvement in the accuracy of the prediction and expressed doubts about the usefulness of these measurements as predictors of carcass composition (Yates *et al*., 1993).

Ultrasonography is a non-invasive technique that has been used to predict carcass composition and quality, avoiding damage of the product and providing highly valuable data (Silva *et al*., 2006; Leeds *et al*., 2008; Teixeira *et al*., 2006). Therefore, ultrasound can afford breeders, producers and researchers the ability to estimate carcass composition traits *in vivo* and thus contribute knowledge to precision of breeding, management and marketing decisions (Leeds *et al*., 2008).

To the best of our knowledge no researches on determination of *Longissimus dorsi* muscle measurements by ultrasonography have been conducted on Egyptian sheep. This study was designed to evaluate the accuracy of ultrasound to predict carcass composition in live lambs. The relationship between ultrasound and carcass traits was also investigated.

## MATERIALS AND METHODS

**Experimental animals and management:** Animals used were 45 Barki, Ossimi and Rahmani fat-tail ram-lambs (15 of each), aged 12 months, raised at the Small Ruminants Farm of Cairo University during the period from 2010 to 2011. Management and feeding of the ram-lambs were already described (Agamy *et al*., 2013).

### Experimental procedure and data collection

***In vivo* measurements (Ultrasound measurements):** The ultrasound measurements were performed *in vivo* using a real-time, B mode 8 MHz linear array ultrasound scanner (Model: Scanner 100 LC, Pie Medical Company, Maastricht, Netherlands). Each lamb was measured monthly from weaning (4 months) up to 12 months of age for depth, width and area of eye muscle (*Longissimus dorsi*) and thickness of fat covering at the $12^{th}$ and $13^{th}$ ribs area using an ultrasonic scan. Ultrasound was scanned by the same experienced and well-trained technician (Bedhiaf and Djemali, 2006; Silva *et al*., 2006, 2007; Teixeira *et al*., 2006; Sahin *et al*., 2008; Esquivelzeta *et al*., 2012). Identical procedures were applied to the three breeds. The lambs were manually immobilized, an experienced assistant restrained the lamb by keeping a gentle pressure with the left hand under the jaw to prevent forward movement and placing the right arm around lamb's back to stop backward movement. All real-time ultrasound images were taken transversal to the vertebral column at the left side of the lamb in one anatomical location, at the thoracic region between the $12^{th}$ and $13^{th}$ ribs.

The transducer was placed between the $12^{th}$ and $13^{th}$ ribs lateral and perpendicular to the vertebral column and parallel to the rib covering all the *Longissimus dorsi* muscle to obtain the measurements. Acoustic gel was used to provide better contact between the probe and the skin after wool was removed by shearing on the measurement area. The right placement for scanning was determined by palpating the left side of the lamb. Pressure on the transducer head was kept to a minimum to avoid compression of both fat and muscle. After capturing the scan image, subcutaneous backfat thickness (UFT), depth (ULMD), width (ULMW) and area (ULMA) of *Longissimus dorsi* muscle were measured using the electronic callipers of the scanner. The ULMD and ULMW were obtained with the straight option of the ultrasound whereas ULMA was calculated with the freehand selection tool. Note that ULMD and ULMW were the maximum height and width of the thoracic muscle, whereas UFT was evaluated over the maximum muscle depth (Fig. 1) (Esquivelzeta *et al*., 2012).

***Ex vivo* measurements (Carcass evaluation):** One day before slaughtering, ultrasound measurements were recorded. All ram-lambs were slaughtered at the experimental abattoir of Faculty of Agriculture, Cairo University, Giza, Egypt, after 18 h fasting. Ram-lambs were slaughtered according to the Muslim (halal) tradition by severing the throat and major blood vessels in the neck at the allanto-occipital joint. Each carcass was deskinned and decapitated. Carcasses were weighed hot (about 1 h after slaughtering). Fat-tail was removed from ram-lambs carcasses and weighed. Each dressed carcass of 7 Barki, 8 Ossimi and 7 Rahmani was then longitudinally split into approximately two equal halves. The left side of carcass was then cooled at 4°C for 24 h. The chilled half of each carcass was weighed and divided into six cuts (Fig. 2)

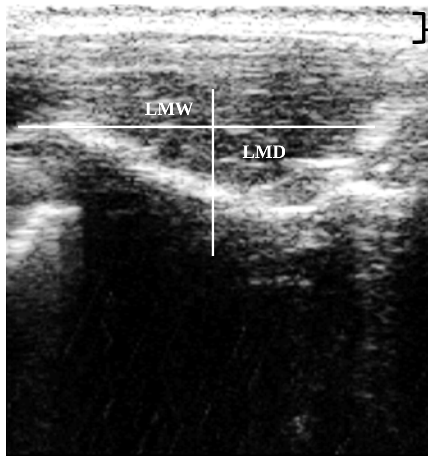


Fig. 1: Example of image of a real time ultrasound of backfat thickness (UFT), *Longissimus dorsi* muscle depth (LMD) and width (LMW) between 12$^{th}$ and 13$^{th}$ ribs

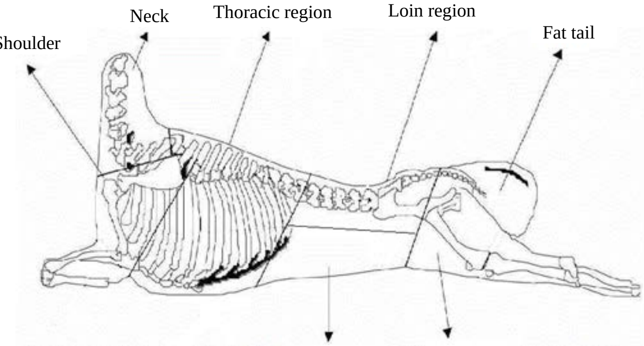


Fig. 2: Lamb carcass wholesale cuts and tail fat

according to Atti and Ben Hamouda (2004) and Abdel-Moneim (2009a,b). Each cut was then completely dissected into bone, fat (subcutaneous and intermuscular) and trimmed meat (including the nerves and connective tissue) and were weighed separately. Dressing percentage, based on pre-slaughter body weight, was calculated. Body weight at slaughtering (12 months of age) averaged, 34.1 kg ± 0.25, 34.8 kg ± 0.29 and 34.4 kg ± 0.24 for Barki, Ossimi and Rahmani ram-lambs, respectively. The composition of the whole carcasses was estimated from the composition of the dissected side as follows: (1) Total trimmed meat = constant×weight of trimmed meat from left carcass, (2) Total dissected fat = constant×weight of dissected fat from left carcass, (3) Total bone = constant×weight of bone from left carcass and constant = carcass (whole) without Fat-tail weight/left half carcass weight (Awgichew, 2000). The weights of the total bones, trimmed meat and trimmed fat were expressed as proportion of the hot carcass weight, slaughter weight and empty body weight.

The left sides of best end of neck of all carcasses were ribbed at the 11$^{th}$ and 13$^{th}$ and chilled for 24 h. Total tissue depth at the 11$^{th}$ and 13$^{th}$ ribs, subcutaneous backfat thickness, depth and width of eye muscle (*Longissimus dorsi*) were measured on carcass cut surface with callipers at the same anatomical point/location where measurements were taken on live animal using ultrasonic.

The *Longissimus dorsi* area was determined by tracing the outer perimeter of *Longissimus dorsi* on acetate sheet and the circumference of the eye muscle was measured in $cm^2$ afterwards using a digital planimeter.

Indicator cut (the ribs cut at $11^{th}$ and $13^{th}$ ribs) was dissected into its components of bone, lean and fat tissues to measure its physical components and prepared *Longissimus dorsi* meat samples to chemical analysis by removing fat and tendons around the muscle.

**Statistical analyses of data:** Data were analysed by least squares procedure of General Linear Model (GLM) using SAS statistical package (SAS, 2004), with the slaughter weight as the covariate. Duncan's Multiple Range Test was used to detect significant differences among means. Simple correlation coefficients between ultrasound and carcass measurements, within each breed were calculated and tested for significance. For each breed, to predict carcass composition traits based on ultrasound measurements and body weight, the stepwise procedure was used to select the variable for prediction equations. This procedure did not include variables with a $p>0.05$ as suggested by Dıaz *et al.* (2004) and Marshall *et al.* (2005). The coefficient of determination ($R^2$) assessed the accuracy of the equations. Probability values <0.05 were taken as a significant level.

## RESULTS AND DISCUSSION

Pre-slaughter ultrasound and carcass measurements of Barki, Ossimi and Rahmani ram-lambs, in addition to levels of significance are presented in Table 1.

**Ultrasound measurements:** Our results showed no significant differences in ultrasound measurements at the $12^{th}$ and $13^{th}$ ribs of the three studied breeds (Table 1). The average values for backfat thickness (UFT), area (ULMA), width (ULMW) and depth (ULMD) of *Longissimus dorsi* muscle were, respectively 2.79-3.22 mm, 14.60-16.08 $cm^2$, 3.99-4.23 and 2.01-2.21 cm. Linear regression coefficients of backfat thickness, area and depth of *Longissimus dorsi* muscle with body weight were positive and significant ($p<0.01$). However, *Longissimus dorsi* measurements were generally accepted to express meat quality in sheep (Leeds *et al.*, 2007; Orman *et al.*, 2008; Sahin *et al.*, 2008; Esquivelzeta *et al.*, 2012).

Table 1: Values of ultrasound and carcass measurements of *Longissimus dorsi* at $12^{th}$ and $13^{th}$ rib as affected by breed and body weight of Egyptian ram-lambs

| *In vivo* and *ex vivo* measurements | Barki | | Ossimi | | Rahmani | | | Reg. on body weight (kg) | |
|---|---|---|---|---|---|---|---|---|---|
| | $\bar{x}$ | S.E | $\bar{x}$ | S.E | $\bar{x}$ | S.E | p | b | S.E |
| **Ultrasound measurements** | | | | | | | | | |
| Backfat thickness (mm) | $3.17^a$ | 0.19 | $3.22^a$ | 0.20 | $2.79^a$ | 0.18 | ns | 0.08** | 0.02 |
| *L. dorsi* area ($cm^2$) | $16.05^a$ | 0.57 | $14.60^a$ | 0.62 | $16.08^a$ | 0.53 | ns | 0.15** | 0.05 |
| *L. dorsi* width (cm) | $4.23^a$ | 0.17 | $3.99^a$ | 0.18 | $4.04^a$ | 0.15 | ns | 0.01 | 0.01 |
| *L. dorsi* depth (cm) | $2.21^a$ | 0.08 | $2.01^a$ | 0.08 | $2.21^a$ | 0.07 | ns | 0.02** | 0.01 |
| **Carcass measurements** | | | | | | | | | |
| Backfat thickness (mm) | $3.07^a$ | 0.40 | $3.37^a$ | 0.46 | $2.35^a$ | 0.37 | ns | 0.12** | 0.04 |
| *L. muscle* area ($cm^2$) | $14.90^b$ | 0.54 | $13.77^b$ | 0.62 | $16.70^a$ | 0.50 | ** | 0.21** | 0.05 |
| *L. muscle* width (cm) | $5.03^a$ | 0.13 | $5.13^a$ | 0.14 | $5.34^a$ | 0.12 | ns | 0.03* | 0.01 |
| *L. muscle* depth (cm) | $3.22^{ab}$ | 0.10 | $2.91^b$ | 0.11 | $3.31^a$ | 0.09 | * | 0.04** | 0.01 |
| **Carcass components (kg)** | | | | | | | | | |
| Dissected fat | $3.28^a$ | 0.30 | $3.50^a$ | 0.28 | $2.36^b$ | 0.26 | * | 0.11** | 0.04 |
| Fat-tail | $1.21^c$ | 0.17 | $2.56^a$ | 0.19 | $1.98^b$ | 0.16 | ** | 0.09** | 0.02 |
| Trimmed meat | $12.77^a$ | 0.49 | $11.64^a$ | 0.46 | $12.49^a$ | 0.43 | ns | 0.37** | 0.06 |
| Bone | $3.74^a$ | 0.12 | $3.65^a$ | 0.11 | $3.85^a$ | 0.11 | ns | 0.08** | 0.02 |

Among breeds, means of each trait not followed by the same letter differ significantly from each other ($p<0.05$). p: *$p<0.05$, **$p<0.01$, $\bar{x}$: Least square means, SE: Standard errors, b: Regression coefficient, ns: Non significant

Carcass backfat thickness and width of *Longissimus dorsi* muscle were not significantly different among Barki, Ossimi and Rahmani breeds. While *Longissimus dorsi* muscle area (p<0.01) and depth (p<0.05) were significantly higher in Rahmani (Table 1). On the contrary, Abdel-Moneim (2009a) and El-Asheeri and Hafez (2009) found that breed of carcass had no significant effect on area of eye muscle in Barki, Ossimi and Rahmani lambs. On the other hand, positive and significant linear regression coefficients of backfat thickness as well as *Longissimus dorsi* muscle measurements on body weight were observed (Table 1). Additionally, Ossimi and Barki breed had significantly (p<0.05) more dissected fat in their carcasses than that of Rahmani. Fat-tail weight was least for Barki, medium for Rahmani and highest for Ossimi, differences were significant (p<0.01). However, no significant differences in either trimmed meat or bone weight of whole carcass were found among the three breeds. In view of the obtained results, it can be concluded that the increase in slaughter weight might cause a significant increase of backfat as well as *Longissimus dorsi* muscle measurements. These results are supported by many authors on different sheep breeds (Macit, 2002; Shaker *et al*., 2002; Abdullah and Qudsieh, 2008; Orman *et al*., 2008).

**Relationship between ultrasound and carcass measurements of Egyptian ram-lambs:** Simple correlation coefficients among ultrasound and carcass measurements at $12^{th}$ and $13^{th}$ rib for Barki, Ossimi and Rahmani ram-lambs are shown in Table 2, 3 and 4. Body weight of Barki was positively and significantly correlated with ultrasound backfat thickness and *Longissimus dorsi* muscle width (r = 0.72 and 0.55, respectively, Table 2). However, only ultrasound backfat thickness of Ossimi was positively and significantly correlated (r = 0.61) with body weight but negatively correlated with ultrasound *Longissimus dorsi* muscle width (Table 3). Meanwhile, positive and significant correlation coefficients were found between body weight of Rahmani ram-lambs, all ultrasound and carcass measurements (Table 4). This agrees with the results presented by other authors (Macit, 2002; Shaker *et al*., 2002; Abdullah and Qudsieh, 2008; Orman *et al*., 2008). Orman *et al*. (2008) reported that *Longissimus dorsi* muscle area increased with increasing live weight in Awassi but this increase was not significant. Abdullah and Qudsieh (2008) recorded increase in carcass backfat thickness with increase in live weight of Awassi lambs (weighing from 30-40 kg). On the other hand, carcass backfat thickness was not changed with increase in live weight of fat-tailed Morkaraman lambs (weighing from 40-45 kg). In view of the obtained results it can be concluded that the increase in slaughter weight causes a significant increase of ultrasound and carcass backfat thickness.

Table 2: Correlation coefficients between ultrasound and carcass measurements of Barki ram-lambs at $12^{th}$ and $13^{th}$ rib

| | Ultrasound | | | | Carcass | | | |
|---|---|---|---|---|---|---|---|---|
| | | *Longissimus dorsi* muscle | | | | *Longissimus dorsi* muscle | | |
| Traits | Backfat thickness | Width | Depth | Area | Backfat thickness | Width | Depth | Area |
| Body weight | 0.72** | 0.55* | 0.28 | 0.28 | 0.48 | 0.25 | 0.45 | 0.34 |
| **Ultrasound** | | | | | | | | |
| Backfat thickness | | 0.62* | 0.53* | 0.53* | 0.35 | -0.11 | 0.44 | 0.28 |
| *L. dorsi* width | | | 0.72** | 0.72** | 0.07 | 0.21 | 0.50 | 0.54* |
| *L. dorsi* depth | | | | 0.99** | 0.21 | 0.20 | 0.70** | 0.55* |
| *L. dorsi* area | | | | | 0.20 | 0.20 | 0.70** | 0.55* |
| **Carcass** | | | | | | | | |
| Backfat thickness | | | | | | 0.34 | 0.34 | 0.27 |
| *L. dorsi* width | | | | | | | 0.55* | 0.79** |
| *L. dorsi* depth | | | | | | | | 0.85** |

*p<0.05, **p<0.01

Table 3: Correlation coefficients between ultrasound and carcass measurements of Ossimi ram-lambs at 12th and 13th rib

| | Ultrasound | | | | Carcass | | | |
|---|---|---|---|---|---|---|---|---|
| | | *Longissimus dorsi* muscle | | | | *Longissimus dorsi* muscle | | |
| Traits | Backfat thickness | Width | Depth | Area | Backfat thickness | Width | Depth | Area |
| Body weight | 0.61* | -0.58* | 0.12 | 0.12 | 0.50 | 0.29 | 0.44 | 0.56 |
| **Ultrasound** | | | | | | | | |
| Backfat thickness | | -0.31 | 0.06 | 0.05 | 0.34 | 0.01 | 0.03 | 0.22 |
| *L. dorsi* width | | | 0.23 | 0.23 | -0.44 | 0.21 | -0.18 | -0.18 |
| *L. dorsi* depth | | | | 0.99** | 0.37 | 0.29 | 0.50 | 0.06 |
| *L. dorsi* area | | | | | 0.37 | 0.29 | 0.50 | 0.06 |
| **Carcass** | | | | | | | | |
| Backfat thickness | | | | | | 0.10 | -0.07 | -0.14 |
| *L. dorsi* width | | | | | | | 0.49 | 0.53 |
| *L. dorsi* depth | | | | | | | | 0.78** |

*p<0.05, **p<0.01

Table 4: Correlation coefficients between ultrasound and carcass measurements of Rahmani ram-lambs at 12th and 13th rib

| | Ultrasound | | | | Carcass | | | |
|---|---|---|---|---|---|---|---|---|
| | | *Longissimus dorsi* muscle | | | | *Longissimus dorsi* muscle | | |
| Traits | Backfat thickness | Width | Depth | Area | Backfat thickness | Width | Depth | Area |
| Body weight | 0.58* | 0.66** | 0.66** | 0.66** | 0.68** | 0.55* | 0.67** | 0.64* |
| **Ultrasound** | | | | | | | | |
| Backfat thickness | | 0.31 | 0.31 | 0.31 | 0.62* | 0.74** | 0.32 | 0.40 |
| *L. dorsi* width | | | 0.78** | 0.78** | 0.23 | 0.42 | 0.52* | 0.92** |
| *L. dorsi* depth | | | | 0.99** | 0.54* | 0.36 | 0.67** | 0.83** |
| *L. dorsi* area | | | | | 0.54* | 0.36 | 0.67** | 0.83** |
| **Carcass** | | | | | | | | |
| Backfat thickness | | | | | | 0.66** | 0.36 | 0.38 |
| *L. dorsi* width | | | | | | | 0.25 | 0.55* |
| *L. dorsi* depth | | | | | | | | 0.52* |

*p<0.05, **p<0.01

Additionally, Abdullah and Qudsieh (2008) reported that, carcass *Longissimus dorsi* muscle depth increased with increasing slaughter weight from 20-30 kg and from 30-40 kg in Awassi lambs. On the other hand, Shaker *et al*. (2002) showed that carcass *Longissimus dorsi* muscle depth was not changed with increasing slaughter weight of lambs in Awassi and its crosses (from 41-44 kg or 44 -52 kg). According to Shaker *et al*. (2002), the difference of carcass *Longissimus dorsi* muscle width was significant for Awassi lambs weighing 44 and 52 kg, while it was not for lambs weighing 41-44 kg.

Positive but non-significant correlations between ultrasound backfat thickness and carcass backfat thickness could be observed in Barki and Ossimi (r = 0.34-0.35) ram-lambs (Table 2 and 3), while it was significant (r = 0.62) in Rahmani ram-lambs (Table 4). The obtained correlation coefficients are less than those previously reported for Akkaraman lambs (r = 0.77) by Sahin *et al*. (2008), Manchego lambs (r = 0.90 and 0.92 for 25 and 35 kg, respectively) by Fernandez *et al*. (1998) and Manchego, Merino and in Ile de France×Merino lambs (r = 0.74) by Fernandez *et al*. (1997). In the meantime, the obtained correlation coefficients are larger than those previously reported for Barbarine lambs (r = 0.43) by Bedhiaf and Djemali (2006) and Churra Galega Bragancana lambs (r = 0.32) by Teixeira *et al*. (2006).

Likewise high and significant (p<0.01) correlation coefficients were found between ultrasound *Longissimus dorsi* muscle depth and carcass *Longissimus dorsi* muscle depth in Barki and Rahmani lambs (r = 0.70 and 0.67, respectively) (Table 2 and 4). Similar significant correlation coefficient (r = 0.60) was observed by Sahin *et al*. (2008) in Akkaraman lambs. Lower values were

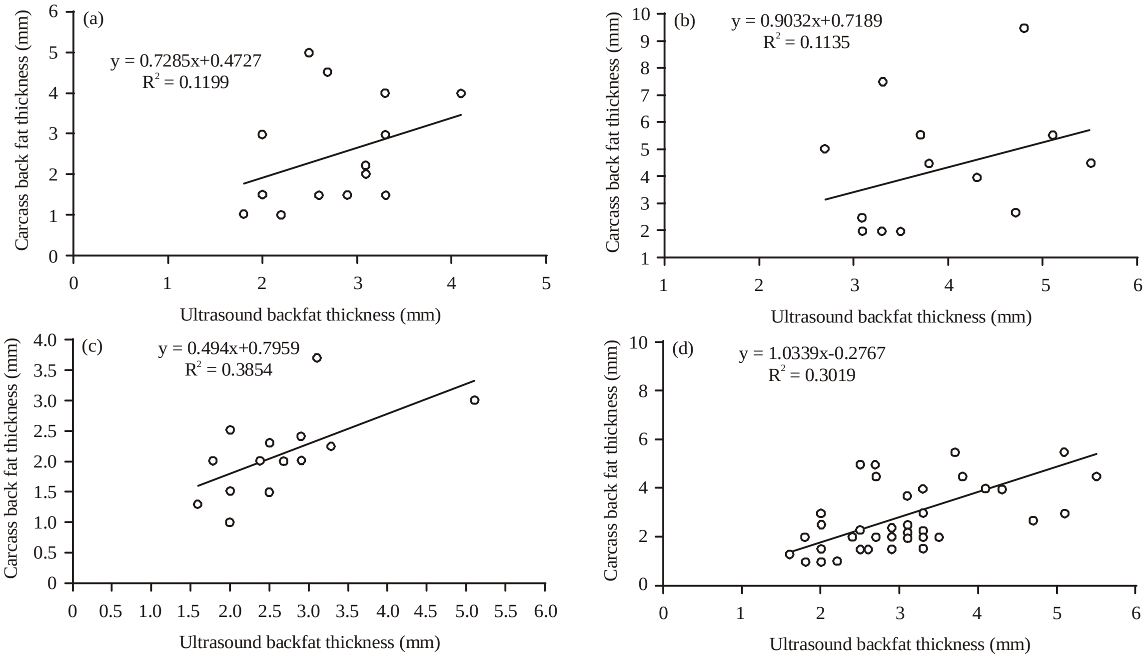


Fig. 3(a-d): Linear regression of ultrasound backfat thickness against direct carcass backfat thickness at 12th and 13th rib of (a) Barki, (b) Ossimi, (c) Rahmani and (d) Egyptian ram-lambs

reported in Barbarine lamb (r = 0.53) by Bedhiaf and Djemali (2006) and Manchego, Merino and Ile de France×Merino lambs (r = 0.56) by Fernandez *et al.* (1997).

It was noticed (Table 2-4) that correlation coefficients between ultrasound *Longissimus dorsi* muscle area and carcass *Longissimus dorsi* muscle area were positive and significant in Barki and Rahmani (0.55 and 0.83, respectively) and non-significant in Ossimi ram-lambs. Similar correlation coefficients were reported by Sahin *et al.* (2008) (r = 0.82) in Akkaraman lambs, Leeds *et al.* (2007) (r = 0.75) for offspring from four sire breeds, Milerski and Jandasek (2002) (r = 0.65) for crossbred lambs and Fernandez *et al.* (1997) in Manchego, Merino and Ile de France×Merino lambs (r = 0.88).

**Prediction equations of carcass components from ultrasound measurements:** To evaluate the performance of *in vivo* ultrasound measurements of backfat thickness and *Longissimus dorsi* muscle traits, prediction equations were established. Figure 3a-d presented prediction equations of carcass backfat thickness of Barki, Ossimi and Rahmani ram-lambs from ultrasound backfat thickness. Figure 3a and b showed non-significant equations to predict carcass backfat thickness based on ultrasound backfat thickness in Barki and Ossimi ram-lambs. Meanwhile, the accuracy of the equation in Rahmani ram-lambs was 0.39 (Table 5 and Fig. 3c). Irrespective of breed effect, the accuracy of prediction equation of carcass backfat thickness in Egyptian ram-lambs was 0.30 (Table 5 and Fig. 3d).

It is clear from the results of the present study that using ultrasound *Longissimus dorsi* muscle width to predict carcass *Longissimus dorsi* muscle width was non-significant in the three studied breeds (Fig. 4a-d). On the other hand, using ultrasound *Longissimus dorsi* muscle depth to predict carcass *Longissimus dorsi* muscle depth was significant in Barki (0.49) and Rahmani (0.45) (Table 6 and Fig. 5a and c) but it was non-significant in Ossimi ram-lambs (Fig. 5b). Irrespective

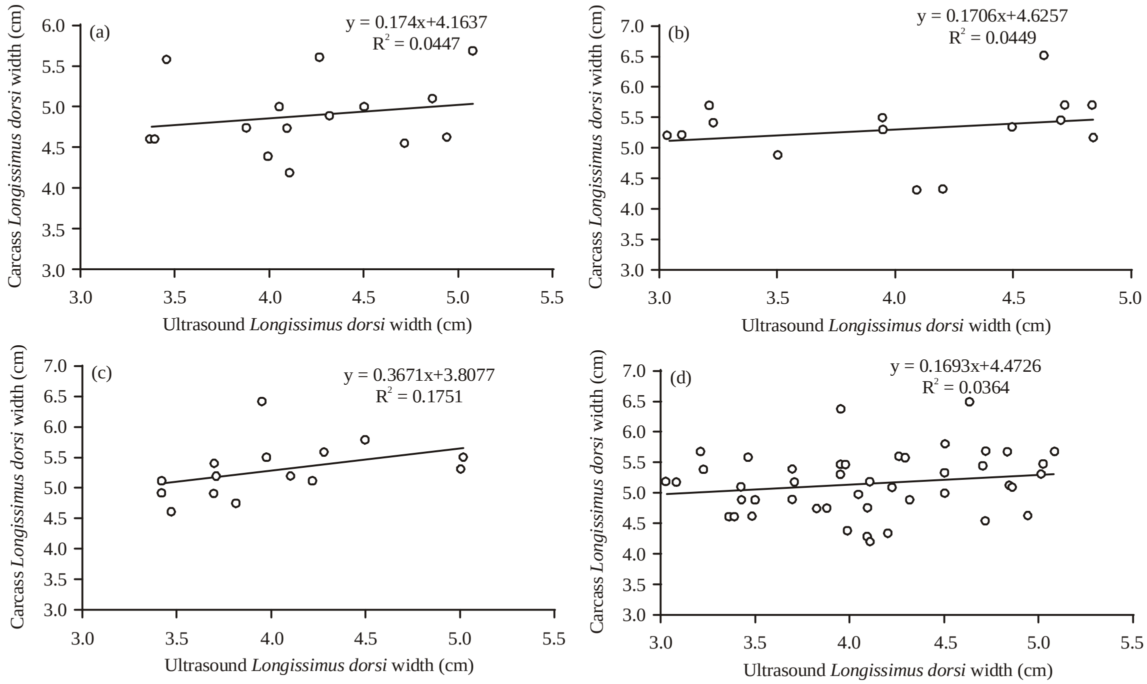


Fig. 4(a-d): Linear regression of ultrasound width of *Longissimus dorsi* against direct carcass width of *Longissimus dorsi* at the thoracic level (12$^{th}$ and 13$^{th}$ rib) of (a) Barki, (b) Ossimi, (c) Rahmani and (d) Egyptian ram-lambs

Table 5: Prediction equations for calculating carcass backfat thickness from ultrasound backfat thickness at 12$^{th}$ and 13$^{th}$ rib of Egyptian ram-lambs

| Breeds | Variable | p | $R^2$ | S.E |
|---|---|---|---|---|
| **Rahmani** | | | | |
| CFT = 0. 0.79587+0.49397 UFT (mm) | UFT | * | 0.39 | 0.17 |
| **All breeds** | | | | |
| CFT = -0.27666+1.03394 UFT (mm) | UFT | ** | 0.30 | 0.24 |

*p<0.05, **p<0.01, CFT: Carcass backfat, UFT: Ultrasound backfat thickness, $R^2$ = Determination coefficient

of breed effect, the accuracy of prediction equation of carcass *Longissimus dorsi* muscle depth in Egyptian ram-lambs decreased $R^2$ to 0.39 (Table 6 and Fig. 5d).

Using ultrasound *Longissimus dorsi* muscle area to predict carcass *Longissimus dorsi* muscle area was significant in both Barki ($R^2$ = 0.31) and Rahmani ($R^2$ =0.68) (Table 7 and Fig. 5a and c) and insignificant in Ossimi ram-lambs (Fig. 5b). Irrespective of breed effect, the accuracy of prediction equation of carcass *Longissimus dorsi* muscle area in Egyptian ram-lambs was 0.30 (Table 7 and Fig. 5d).

It could be noticed (Table 8) that the prediction equation including only body weight to predict total carcass trimmed meat weight for Ossimi carcasses had accuracy of 0.63. In Rahmani ram-lambs, ultrasound *Longissimus dorsi* muscle width was the only variable in the equation to predict total carcass trimmed meat weight with accuracy of 0.85. However, no variables reached a significant level to predict total trimmed meat weight in Barki lambs.

On the other hand, irrespective of breed, body weight contributed 66% of the total variation in total trimmed meat weight of the Egyptian ram-lambs. Whereas, ultrasound *Longissimus dorsi* muscle area came next and scored a partial determination of 16% increasing the model's $R^2$ to 82% (Table 8).

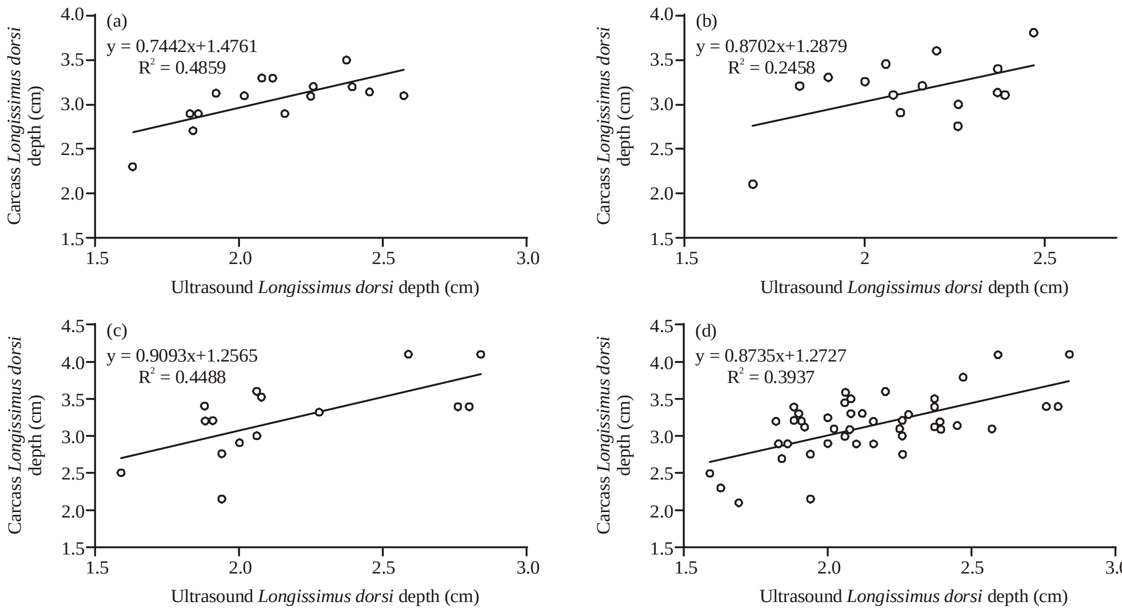


Fig. 5(a-d): Linear regression of ultrasound depth of *Longissimus dorsi* against direct carcass depth of *Longissimus dorsi* at the thoracic level (12th and 13th rib) of (a) Barki, (b) Ossimi, (c) Rahmani and (d) Egyptian ram-lambs

Table 6: Prediction equations for calculating carcass depth of *Longissimus dorsi* from ultrasound depth of *Longissimus dorsi* at 12th and 13th rib of Egyptian ram-lambs

| Breeds | Variable | p | $R^2$ | S.E |
|---|---|---|---|---|
| **Barki** | | | | |
| CLMD = 1.47610+0.74420 ULMD (cm) | ULMD | ** | 0.49 | 0.21 |
| **Rahmani** | | | | |
| CLMD = 1.25647+0.90932 ULMD (cm) | ULMD | ** | 0.45 | 0.28 |
| **All breeds** | | | | |
| CLMD = 1.27265+0.87347 ULMD (cm) | ULMD | ** | 0.39 | 0.17 |

**p<0.01, CLMD: Carcass depth of *Longissimus dorsi*, ULMD: Ultrasound depth of *Longissimus dorsi*, $R^2$ = Determination coefficient

Table 7: Prediction equations for calculating carcass area of *Longissimus dorsi* from ultrasound area of *Longissimus dorsi* at 12th and 13th rib of Egyptian ram-lambs

| Breeds | Variable | p | $R^2$ | S.E |
|---|---|---|---|---|
| **Barki** | | | | |
| CLMA = 5.37819+0.55603 ULMA ($cm^2$) | ULMA | * | 0.31 | 0.23 |
| **Rahmani** | | | | |
| CLMA = 4.76404+0.72829 ULMA ($cm^2$) | ULMA | ** | 0.68 | 0.14 |
| **All breeds** | | | | |
| CLMA = 5.79169+0.60256 ULMA ($cm^2$) | ULMA | ** | 0.30 | 0.14 |

*p<0.05, **p<0.01, CLMA: Carcass area of *Longissimus dorsi*, ULMA: Ultrasound area of *Longissimus dorsi*, $R^2$ = Determination coefficient

Table 8: Prediction equations for calculating total trimmed meat from ultrasound measurements and body weight of Egyptian ram-lambs

| Breeds | Step | Variable | p | $R^2$ | S.E |
|---|---|---|---|---|---|
| **Ossimi** | 1 | BW | * | 0.63 | 0.09 |
| Total trimmed meat = -0.41+0.30 BW (kg) | | | | | |
| **Rahmani** | 1 | ULMW | ** | 0.85 | 0.67 |
| Total trimmed meat = - 2.41+3.52 ULMW (cm) | | | | | |
| **All breeds** | 1 | BW | ** | 0.66 | 0.04 |
| Total trimmed meat = -4.03+0.26 BW+0.36 ULMA ($cm^2$) | 2 | ULMA | ** | 0.82 | 0.09 |

BW: Body weight, ULMW: Ultrasound *Longissimus dorsi* muscle width, ULMA: Ultrasound *Longissimus dorsi* muscle area, *p<0.05, **p<0.01, $R^2$ = Determination coefficient

Table 9: Prediction equations for calculating total dissected carcass fat from ultrasound measurements and body weight of Egyptian ram-lambs

| Breeds | Step | Variable | p | $R^2$ | S.E |
|---|---|---|---|---|---|
| **Barki** | | | | | |
| Total dissected carcass fat = 0.70+0.73 UFT (mm) | 1 | UFT | * | 0.69 | 0.22 |
| **Rahmani** | | | | | |
| Total dissected carcass fat = 0.83+0.48 UFT (mm) | 1 | UFT | * | 0.70 | 0.14 |
| **All breeds** | | | | | |
| Total dissected carcass fat = -2.26+0.13 BW (kg) | 1 | BW | ** | 0.39 | 0.04 |

UFT: Ultrasound backfat thickness, *p<0.05, **p<0.01, BW: Body weight, $R^2$ = Determination coefficient

Table 10: Prediction equations for calculating total bone from ultrasound measurements and body weight of Egyptian ram-lambs

| Breeds | Step | Variable | p | $R^2$ | S.E |
|---|---|---|---|---|---|
| **Ossimi** | | | | | |
| Total bone = 0.01+0.09 BW (kg) | 1 | BW | * | 0.52 | 0.03 |
| **Rahmani** | | | | | |
| Total bone = 0.90+0.07 BW (kg) | 1 | BW | ** | 0.81 | 0.02 |
| **All breeds** | | | | | |
| Total bone = 0.78+0.07 BW (kg) | 1 | BW | ** | 0.63 | 0.01 |

*p<0.05, **p< 0.01, BW: Body weight, $R^2$ = Determination coefficient

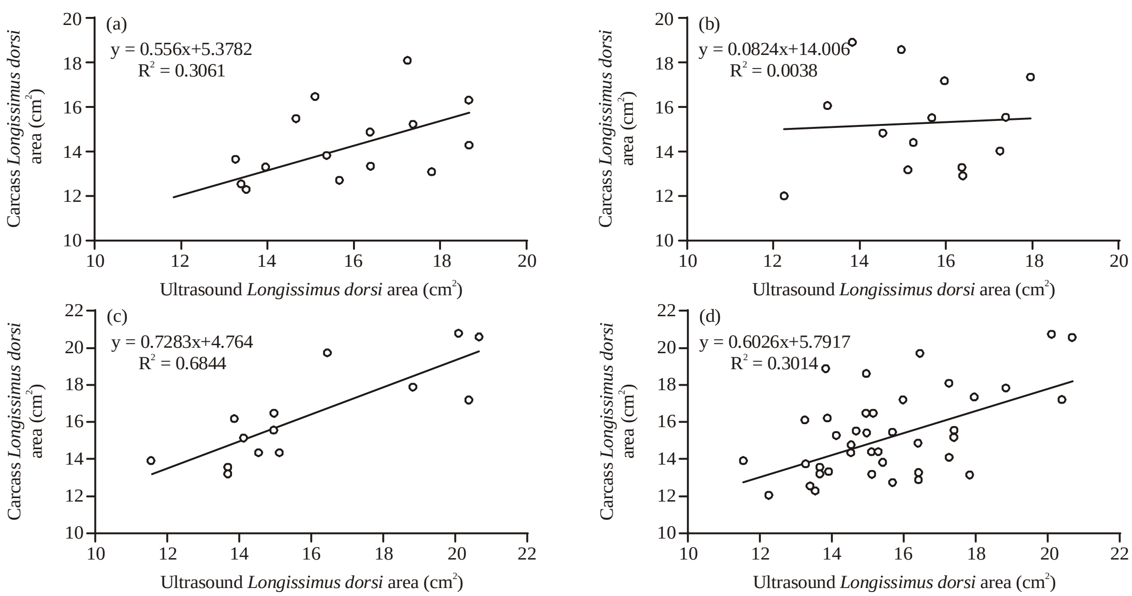


Fig. 6(a-d): Linear regression of ultrasound area of *Longissimus dorsi* against direct carcass area of *Longissimus dorsi* at the thoracic level (12th and 13th rib) of (a) Barki, (b) Ossimi, (c) Rahmani and (d) Egyptian ram-lambs

Results in Table 9 show that only ultrasound backfat thickness could be included to predict total dissected carcass fat weight of Barki ($R^2 = 0.69$) and Rahmani ($R^2 = 0.70$) carcasses. Regardless of breed, the equation including only body weight could predict total dissected carcass fat weight of Egyptian ram-lambs with an accuracy of 0.39.

Data in Table 10 revealed that ultrasound measurements could not be used to predict bone weight in Egyptian ram-lambs. Body weight was the domain variable in the equations of predicting bone weight in Ossimi and Rahmani ram-lambs with an accuracy of 0.52 and 0.81, respectively. When the effect of breed was ignored, body weight was the domain variable in the equations of Egyptian ram-lambs with an accuracy of 63%. In the meantime, it could be noticed that no variables reached significant level to predict total carcass bone weight in carcasses of Barki lambs (Fig. 6).

## CONCLUSION

In view of the obtained results it can be concluded that the increase in slaughter weight might cause a significant increase of backfat thickness as well as *Longissimus dorsi* muscle measurements. In the meantime, our study revealed that backfat thickness, *Longissimus dorsi* depth and area are progressively increased as body weight increases. Additionally, it was noticed that ultrasound measurements could be used for accurate prediction of carcass components in Egyptian ram-lambs.

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