ESTIMATING LAMB CARCASS COMPOSITION USING BIA

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Background

Most commercial lamb carcass classification schemes depend on visual assessment and/or tissue depth measurements taken by rulers or probes. An automated objective method of estimating lamb carcass composition would be likely to find favour in the industry provided it could be applied at line speed, was relatively low cost and was simple to operate. Bioelectrical impedance analysis (BIA) is a technique that has been shown to have potential for assessing carcass composition in cattle (Slanger and Marchello 1994), lamb (Berg et al. 1997; Tong et al. 2001) and pigs (Marchello et al. 1999) and could fulfil this role if it the electrode placement was automated . BIA works on the principle that muscle and fat have different electrical properties. The resistance and reactance of an alternating current passed between pairs of electrodes placed in the soft tissues of the carcass is therefore related to the proportion of these tissues encountered by the current.

Objectives

The objectives were to determine the precision with which BIA taken on hot and chilled carcasses can estimate carcass composition and to compare the precision achieved with two electrode configurations.

Methods

Twenty-four Suffolk-cross lambs were slaughtered at a pilot scale abattoir at the National Food Centre. After dressing and weighing, BIA resistance and reactance measurements were made with an RJL systems analyser (model 101A, RJL Systems, Detroit, MI, USA), using two electrode configurations. For the first (BIAS) configuration one electrode pair was placed just anterior to the scapula and the other was placed level with the last lumbar vertebra, in both cases 25mm to the left of the midline. For the second (BIAL) configuration the first pair of electrodes was left in place and the second pair was moved to the distal end of the flexor group of muscles of the left hind leg. In both cases the distance between the electrodes was recorded. The deep round temperature was recorded immediately prior to taking the BIA measurements. Carcass length was measured from the first rib to the anterior edge of the os pubis and the circumference of the hind was measured at the widest point. Following overnight chilling, the BIA measurements were repeated with the same electrode configurations as before. The deep round temperature was recorded. The depth of fat and muscle at the widest point of the longissimus muscle at the last rib were recorded. Each carcass was then carefully split down the midline and the left side was boned out. The boneless meat was minced and thoroughly mixed before a sample was taken to determine the fat content from which the Fat-free lean (FFL) weight and percentage were calculated. Multiple linear regression models were tested and optimised (minimum RSD) to estimate composition variables from carcass weight (hot or cold), carcass length, hind circumference and BIA resistance and reactance (deep round temperature and electrode separation included as possible co-predictors).

Results and discussion

The lambs ranged in carcass weight from 15.9 to 21.1 kg, which would be at the upper limit of the desirable variation in lambs destined for a specific market (Table 1). Carcass composition was relatively homogenous, with a fat free lean percentage varying from 59.8 to 65.2 % (c.v. = 2.7%) (Table 2). The carcass temperature when the BIA measurements were made on the hot carcasses ranged from 32 to 40 °C but, following chilling, there was little variation in carcass temperature. This may account for the fact that estimations of carcass composition from BIA measurements on cold carcasses were more accurate than those from hot carcasses (Tables 3 and 4) since Tong et al. (2001) showed that BIA measurements are temperature dependent. This should not be a major concern for the application of BIA as an on-line method in the slaughterhouse since there should be little variation in carcass temperature at a fixed point on the line. Hot carcass weight was a good estimator of total boneless meat weight with an RSD of 257 g (Table 3). As co-predictors with carcass weight, carcass length and hind circumference made a small further reduction in the RSD. BIA resistance and reactance measurements using the longer electrode separation were poor estimators of boneless meat weight (RSD = 984 g). With the shorter electrode separation, no significant model was found. This agrees with Berg et al. (1997) who reported relatively low correlations between individual BIA variables and estimates of carcass composition. Combining data from both electrode configurations resulted in a further reduction in the RSD. Models including BIA variables from a single electrode configuration with carcass weight were only slightly better than weight alone, but the best model included weight and BIA variables from both electrode configurations (RSD = 223 g). A similar pattern was seen for estimating fat-free lean weight. No significant model could be found for estimating either boneless meat % or FFL %. This is in contrast to Tong et al. (2001), who found that BIA measurements taken in lamb carcasses at 39°C explained 74% of the variation in saleable yield with an RSD of 1.95%. However, the sample of carcasses in that study was more variable (carcass weight range = 19.5 – 37.6). Furthermore, Tong et al. (2001) used a range of frequencies and the best model used BIA variables measured at 5 frequencies, whereas the equipment used here had a fixed frequency. BIA measurements taken on cold carcasses were better estimators of carcass composition (Table 4) than those taken on hot carcasses, which is in agreement with Berg et al. (1997) and Tong et al. (2001). The best models for boneless meat weight (RSD = 182 g) and percentage (RSD = 1.35%) and FFL weight (RSD = 222 g) and percentage (RSD = 1.16%) were obtained when variables from both electrode configurations were combined with carcass weight.

Table 1 Means, standard deviations and ranges for lamb carcass measurements

Trait	Live wt kg	Hot carcass wt kg	Carcass length cm	Hind circumference cm	Fat depth mm	Muscle depth mm	Hot carcass temp.	Cold carcass temp.
Mean	39.6	18.7	103	66.7	2.6	25.7	37.4	2.0
SD	1.89	1.29	2.02	2.09	1.3	2.2	2.15	0.14
Minimum	35.0	15.9	99	62.0	1.0	22.0	32.0	1.8
Maximum	43.0	21.1	107	70.0	5.0	29.0	40.1	2.3

Table 2 Means, standard deviations and ranges for lamb carcass composition

Trait	Boneless meat wt kg	Boneless meat %	Bone wt g	Bone %	Fat-free lean wt g	Fat-free lean %
Mean	14.5	82.7	3.0	17.3	10.9	62.1
SD	1.27	1.64	0.32	1.64	0.98	1.66
Minimum	11.5	79.2	2.45	14.5	9.3	59.8
Maximum	16.9	85.4	3.80	20.8	13.1	65.2

Table 3 Estimating carcass composition from BIA measurements taken on the hot carcass using two electrode positions (BIAS-= shoulder to anterior of loin; BIAL= shoulder to distal end of hind leg)

	Boneless meat wt g		Boneless meat %		Fat-free lean wt g		Fat-free lean %	
Model	R^2	RSD	R^2	RSD	R^2	RSD	R^2	RSD
Weight (W)	0.96	257	ns	-	0.90	320	ns	-
W + dimensions	0.97	241	ns	-	0.90	321	ns	-
BIAS	ns	-	ns	-	ns	-	ns	-
BIAL	0.48	984	ns	-	0.54	716	ns	-
BIAS + BIAL	0.69	826	ns	-	0.68	649	ns	-
W + BIAS	0.97	254	ns	-	0.92	304	ns	-
W + BIAL	0.97	247	ns	-	0.91	319	ns	-
W + BIAS +BIAL	0.98	223	ns	-	0.94	284	ns	-

Table 4 Estimating carcass composition from BIA measurements taken on the cold carcass using two electrode positions (BIAS-= shoulder to anterior of loin; BIAL= shoulder to distal end of hind leg)

	Boneless meat wt kg		Boneless meat %		Fat-free lean wt		Fat-free lean %	
Model	R^2	RSD	R^2	RSD	R^2	RSD	R^2	RSD
Weight (W)	0.97	243	ns	-	0.90	321	ns	-
W + tissue depths	0.97	225	0.44	1.35	0.94	251	0.33	1.42
BIAS	ns	-	ns	-	ns	-	0.52	1.26
BIAL	ns	-	ns	-	ns	-	ns	-
BIAS + BIAL	ns	-	ns	-	0.94	284	ns	-
W + BIAS	0.97	246	ns	-	0.95	257	0.52	1.26
W + BIAL	0.98	182	0.48	1.33	0.91	322	ns	-
W + BIAS +BIAL	0.98	182	0.50	1.35	0.96	222	0.60	1.16

Conclusions

BIA measurements were not as useful at estimating percentage composition of lamb carcasses as previously reported, possibly due to the lower variability of the sample used here. However, the weight range of the sample in this study was typical of a batch of lambs from a single producer. BIA resistance and reactance were better estimators of carcass composition when measured on chilled compared to hot carcasses. The longer electrode separation gave better estimates of FFL weight when BIA measurements were taken on hot carcasses, but the shorter electrode separation was more accurate for estimating FFL weight and percentage on cold carcasses.

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