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Prediction of carcass composition by impedance spectroscopy in lambs of similar weight

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Abstract

Previous research on impedance measurements for the prediction of carcass composition was predominantly carried out on animals that varied widely in body weight, breed, or sex. The high accuracy for the estimated lean or fat mass was mainly obtained by including the body weight in the regression equations. The objective of this study was the prediction of carcass composition in lambs of similar weight. We used 70 male German Merino Mutton lambs and 70 male German Blackheaded Mutton lambs with 35 and 45 kg live weight each. Impedance measurements with different electrode placements were carried out in vivo and on carcasses 20 min and 24 h postmortem. The carcass composition was ascertained by dissection of the left carcass side into lean, fat, and bone. R^2-values for prediction of lean mass by impedance and body weight ranged between 0.11 and 0.71 within breeds and weight groups and between 0.84 and 0.89 in the total material. Lean percentage was estimated with $R^2 = 0.18$–0.48 within breeds and weight groups. The corresponding values for the total material varied from 0.23 to 0.37. We conclude that the impedance method is not suitable for the prediction of lean or fat percentage, neither in lambs of similar weight nor in heterogeneous animals.

Keywords: Impedance; Carcass composition; Lamb

1. Introduction

Impedance spectroscopy gains increasing interest for the prediction of the body composition in humans and animals. For constant resistivity, the quotient L^2/Z (L = distance of the voltage electrodes, Z = impedance) theoretically allows the assessment of the frequency dependent volume of body compartments involved in current flow. This is the extracellular fluid at low frequencies and the total body water at high frequencies. The prediction of lean, fat or fat free mass becomes likely, because these compartments are highly correlated with the water content.

In livestock, the mass of lean or fat was commonly estimated by impedance, body weight, and electrode distance as independent variables in regression equations (Hegarty, McPhee, Oddy, Thomas, & Ward, 1998; Marchello, McLennan, Dhuyvetter, & Slanger, 1999a; Swantek, Marchello, Tilton, & Crenshaw, 1999). A high accuracy resulted from consideration of only the body weight, especially if it exhibited a high variability, because the tissue masses increased with body weight. The impedance method was scarcely investigated in animals of similar body weight. In order to investigate the significance of the impedance for body composition we applied this method in lamb groups of definite weight,

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breed, and sex. In practice, the carcass quality of such homogeneous groups must be evaluated, e.g., in breeding systems with a weight dependent performance test. Contrary to other authors, who commonly measured the impedance in the frequency domain, we used the time domain impedance, which allow a high speed of measurement and simpler technical equipment (Altmann, Pliquett, Suess, & von Borell, 2004). Furthermore, we tested different electrode placements and the repeatability. The results of this work should also allow conclusions for the suitability of the impedance method for carcass grading. Within the European Union, the carcass grading system for pigs is based on lean percentage, for beef and sheep on the body conformation and fat content as well as fat distribution. Therefore, the carcass dissection into tissues was choosen as a reference method for impedance measurements.

2. Materials and methods

2.1. Animals

The protocol for this study was approved by the Animal Care Committee of the veterinary district office. We used 70 male lambs of German Mutton Merino (MM) and 70 male German Blackheaded Mutton lambs (BM). The lambs of each breed were divided into two groups: 35 lambs of 34–36 kg and 35 lambs of 44–46 kg live weight. They were weaned at three months of age and fed with concentrates (10.2 mJ NE/kg) and hay ad libitum. The animals were weighed weekly and feed-deprived for 24 h, when they reached the final weight. The lambs were slaughtered according to normal industrial procedures immediately after the in vivo impedance measurements.

2.2. Impedance measurements

Time domain based impedance measurements were used in this experiment. We demonstrated in further studies (Altmann et al., 2004), that this method is adequate for the commonly used measurements in the frequency domain. It is more practicable for a great number of animals due to simplicity and high speed of measurement.

2.2.1. Technical setup

A continuously running square wave oscillator supplied an offset free current with an amplitude of ±100 μA into the outer electrodes (current electrodes) of the four-electrode interface. The voltage appearing at the inner electrodes (voltage electrodes) was monitored using a high impedance differential probe. Both, the current and the voltage were traced by a digital oscilloscope THS720 (Tektronix, Bracknell, UK). The traces were stored in a laptop-computer for further processing. In order to avoid additional noise and parasitic oscillations, one of the outer electrodes carried the current amplifier while the other outer electrode had an internal pull down resistor of 1 kΩ. The inner electrodes were both attached to a FET-input buffer amplifier. All coaxial connections to the impedance measurement device were matched to 50 Ω. Syringe needles with 0.3 mm diameter and a length of 3 mm (ventral electrode placement) or 25 mm (dorsal electrode placement) were used as electrodes for in vivo measurements, while 0.95 mm – needles with a length of 35 mm were used for the carcasses.

2.2.2. Electrode placements for in vivo measurements

The in vivo measurements were done after 24 h feed withdrawal with electrode placements in three different ways (Fig. 1). *Dorsal*: Current electrodes 3 cm from the dorsal midline at the first coccygeal vertebra and 5 cm cranial from the tip of the shoulder blade. Voltage electrodes 3 cm from the dorsal midline 5 cm cranial of first coccygeal vertebra and at the tip of the shoulder blade. The lamb was fixed in a box and the head was arrested. *Ventral I*: Current electrodes near the right ossa carpi and near the left tuberositas tibiae, voltage electrodes in the right armpit and beside the left teat. The lamb lay on its back and the extremities were restrained. *Ventral II*: Contralateral to ventral I.

2.2.3. Electrode placements for carcass measurements

Measurements on the whole carcass were done 20 min and 24 h postmortem with the following electrode placements. *Dorsal*: The same as in vivo. *Ventral I*: Current electrodes in the right M. flexor digitorum close to the carpal condyle and the left M. semimembranosus close to the tuberositas tibiae, voltage electrodes in the right

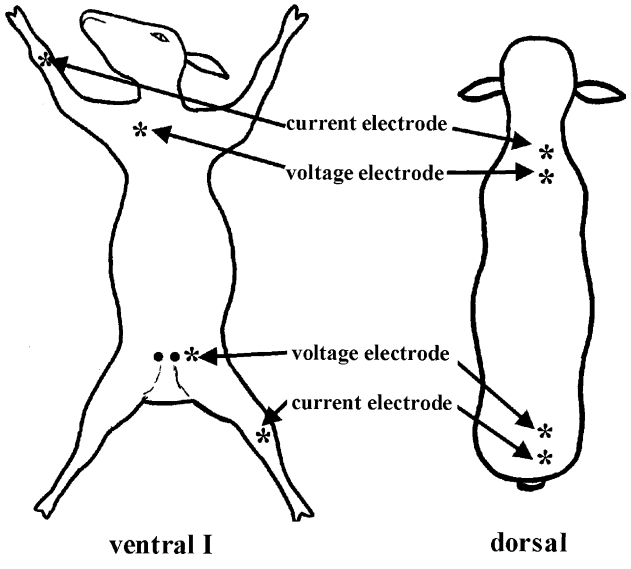

Fig. 1. Ventral and dorsal electrode placements in vivo.