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Growth modelling of different ram breeds using computer tomography

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ABSTRACT

In this study the growth of rams of 3 different sheep breeds with extremely different growth patterns (Hungarian Merino, HM; American Suffolk, AS; and Dutch Texel, DT) were modelled. Two models (modified Gompertz and logistic) were fitted to experimental data generated from successive computer tomography (CT) measurements. In each breed the data fitted the Gompertz model with better precision (lower RSS values). However, the symmetric logistic function fitted the late maturing fat and long loin of the AS lambs more accurately. These models have consequently been validated to give *in vivo* predictions of market specific products and the optimal slaughter weight of each breed. Based on the results of the Gompertz model, medium sized sheep breeds with low growth capacity (e.g. HM) should be slaughtered when their live weight is between 21 and 33 kg at an age of 3–5 months. The large-sized, slow maturing breeds (AS) should be slaughtered between 27 and 45 kg, at a similar age to the HM lambs. The early maturing breed (DT) should not be reared older than 2–3.5 months of age, with a live weight varying between 24 and 36 kg.

1. Introduction

One of the most important goals in sheep breeding is to satisfy consumer demand – which nowadays is particularly health orientated. Therefore, to avoid increased fatness in farm animals, they should be fed to an ideal slaughter weight. The cumulated weight gain of young animals generally show a linear regression with time (Swatland, 1994), whereas the growth curve of live weight generally has a sigmoidal shape (Taylor, 1980). The growth curves of tissues have the same sigmoidal shape like live weight gain, but the rate and duration of the curves are different due to their specific function (Hammond, 1960). The different carcass regions also show sigmoid growth characteristics (Goliomytis et al., 2006). The end of the intensive stage of lean growth, as an optimum slaughter weight, can be easily determined by growth functions. Hence growth models with few parameters (e.g. the Gompertz, von Bertalanffy or Richards) have been used extensively for different animal species (Brody, 1945; Parks, 1982; López et al., 2000; Lewis et al., 2002; Renne et al., 2003; Lambe et al., 2006; Köhn et al., 2007). High genetic correlations have been recorded between the parameters of the growth curves, which may restrict the possibilities to change the shape of the growth curve, thus allowing early maturing and fast growing animal populations to be selected (Lambe et al., 2006).

Accurate analysis of the quantity and distribution of the main body tissues (Junkuszew and Ringdorfer, 2005; Lambe et al., 2007; Macfarlane et al., 2005) and meat regions (Kvame and Vangen, 2006; Navajas et al., 2007) can be achieved non-invasively using computer tomography (CT). The individual performance (growth capacity and age of maturation) of the test animals can be accurately estimated by CT measurements, together with growth modelling (Lewis et al., 2004). This combination provides new prospects in meat research. Little information is, however, available in the literature regarding the modelling of

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sheep growth, based on CT data – allowing *in vivo* evaluation of the carcass tissues and regions.

The aims of this study were to compare two models that describe the growth of 3 sheep breeds differing in growth capacities, to determine the ideal slaughter weight and time of each breed, and also to describe the growth rates of different carcass areas.

2. Materials and methods

2.1. Animals

The CT data were collected of 3 sheep breeds differing in their growth intensity (ADG) and duration. The breeds chosen were the American Suffolk (AS; $n = 10$), the Dutch Texel (DT; $n = 10$) and the Hungarian Merino (HM; $n = 10$). The intact rams were born as twins in 2002 and were reared under similar conditions and kept in a sheepfold in a mixed group for the entire observation period. The ram lambs were weaned at the age of 2 months and fed an *ad libitum* standardised concentrate diet, together with hay for the next 2 months (Székely et al., 2000). Following this 2-month period, the concentrate was reduced to 1 kg/animal/day until the end of the experiment.

2.2. Computer tomography (CT) procedure

Ram lambs ($n = 30$ in total) were CT scanned at 6 stages during their growth phase at the Health Sciences Centre of the University of Kaposvar. The body weights at scanning were 5–7 kg, 15–17 kg, 25–27 kg, 35–36 kg and 43–45 kg, respectively. At an age of 18–21 months a final scan was executed, providing estimates of final maturity regarding live weight or tissue weights – which were asymptotically approached, are the so-called 'asymptotic points'.

The CT scans were performed using a Siemens Somatom Plus 40 for the measurement stages 1–5, however, the 6th scan was performed using a Siemens Somatom Expert 4 spiral CT, due to the replacement of the equipment. For comparability the settings of the spiral CT were adjusted to those of the Plus 40 CT scanner. During the entire trial the settings were kept constant at a pixel resolution of 256×256 and 10 mm slice thickness (tube voltage: 120 kV; radiation dose: 660 mAs). The scanning procedures followed the CT examination protocol along with the animal hygienic regulations. All ram lambs were fasted for at least 12 h prior to scanning. However, for lambs in the 5–7 kg live weight category, the fasting time was reduced to 4 h. The lambs were weighed and then sedated with xylazine hydrochloride (Rometar 2%, Spofa Praha, Czech Republic; 0.3–0.4 mg/kg) 15 min prior to scanning. The immobilised lambs were then fixed in a prone position, within a cradle for the scans. The scans were recorded from the atlanto-occipitalis joint to the tarso-metatarsalis joint, covering the whole body, excluding the head. The slice distance was calculated by adapting the methodology as described by Romvári et al. (1996). Briefly, the method involved dividing the distance of the joints of shoulder and femur into 30 scans, thus the slice distance was increased from the initial 10 mm to 22 mm. Therefore the numbered identical scans of an individual lamb were positioned at the same anatomical position during the entire growth phase.

The area and tissue distribution was recorded using the CTPC programme (Berényi et al., 1991), based on the Hounsfield Units (1980). The respective thresholds were −200 to 0 for fat, 0 to +200 for lean and +600 to +1000 for bone. The internal organs, other non-carcass tissue and the cradle were removed by manual boundary settings in each cross-sectional image – leaving only the lean carcass, fat and bone. The volume data was derived using the Cavalieri method (Roberts et al., 1993), counting the area of different tissues. The volumes were then transformed into tissue weights using the values of Fullerton (1980), i.e. 0.93 g/cm^3 for fat, 1.05 g/cm^3 for lean and 1.55 g/cm^3 for bone. The following attributes were analysed: total live weight, weight of the carcass, fat, lean, long loin, short loin and leg derived from the CT measurements. Fig. 1 demonstrates the distribution of the carcass regions which is the reduced version of the official sheep cuts (Székely et al., 2000) and the manual boundary settings of the loin and the leg made by CTPC programme.

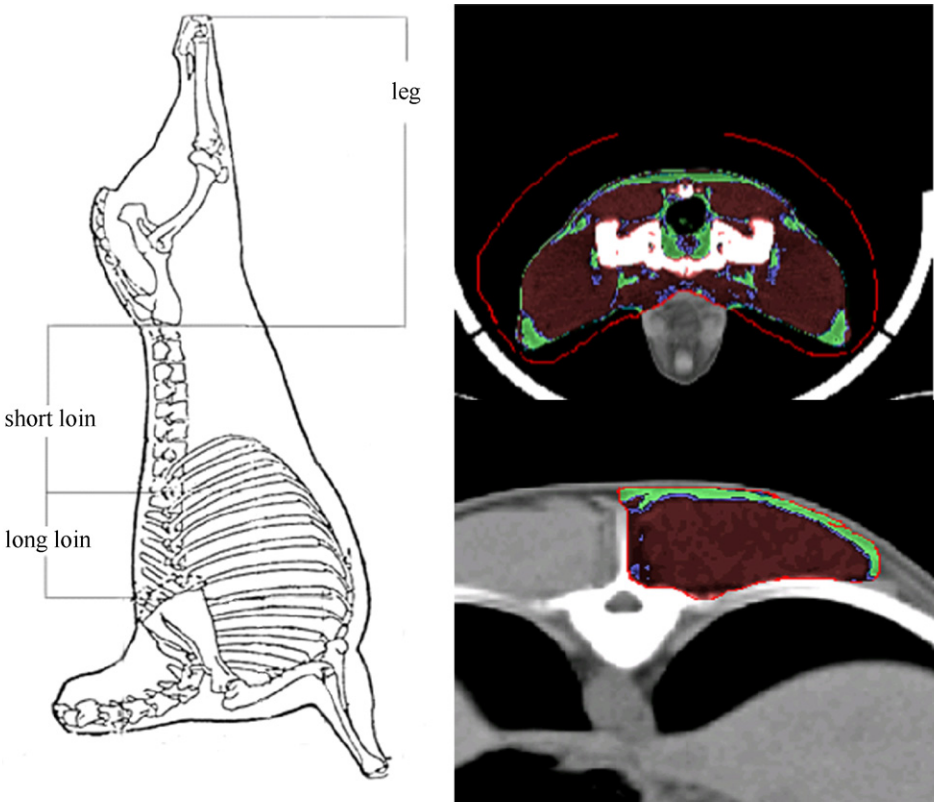

Fig. 1. Distribution of the lamb carcass regions (Székely et al., 2000) and the manual boundary settings of the loin and the leg made by CTPC programme.