Meat Science 96 (2014) 247–255

Contents lists available at ScienceDirect

Meat Science

journal homepage: www.elsevier.com/locate/meatsci

Use of serial ultrasound measures in the study of growth- and breed-related changes of ultrasonic measurements and relationship with carcass measurements in lean cattle breeds

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ARTICLE INFO

Article history:
Received 10 January 2013
Received in revised form 5 July 2013
Accepted 11 July 2013

Keywords:
Beef
Gluteus medius depth
Marbling
Rib fat thickness
Rump fat depth
Ultrasonography

ABSTRACT

The growth and breed-related changes of rib and rump characteristics in lean beef cattle and the ability of ultrasound to predict carcass traits were investigated. Three hundred bulls from three breeds were scanned monthly (6–7 times) using real-time ultrasound with final scans taken <7 days prior to harvest. The rib and rump ultrasound measurements, except intramuscular fat content, increased ($P < 0.05$) with live weight. Breed affected most of traits. The 12th rib ultrasound measurements showed a weak to high positive correlation (0.131 to 0.976, $P > 0.05$ to $P < 0.001$) with 12th rib measurements in the carcass. Regression equations developed with the ultrasound measurements, explained 97% of the variation in *longissimus* muscle area, 88% of the variation in fat thickness and 57% of the variation in intramuscular fat content. When last ultrasound scan measurements were excluded from prediction equations, the R^2 significantly decreased. Ultrasound measures "*in vivo*" are viable options for assessing carcass attributes of lean cattle.

1. Introduction

Consumer demands for beef have changed overtime with quality now considered the top priority. The improvement of carcass and meat quality is vital to beef industry because both domestic and international markets are placing increased emphasis on product quality. Ultrasonography is considered a viable, reliable and acceptable cost-effective technique (Houghton & Turlington, 1992) to provide precise, fast and accurate determinations of beef carcass composition (Lambe et al., 2010). In beef, the use of real-time ultrasound has followed different strategies and objectives. In general, serial measurements have been made to understand the evolution of the parameters of interest (Silva, Leme, Pereira & Putrino, 2003; Lambe et al., 2010), to estimate carcass attributes on live animals (Brethour, 2000), to determine the most appropriate measures in predicting (Greiner, Rouse, Wilson, Cundiff, & Wheeler, 2003b; Bergen, Miller, Mandell, & Robertson, 2005; Aass, Gresham, & Klemtsdal, 2006; Aass, Fristedt, & Gresham, 2009), and to predict optimal slaughter endpoints (Crews & Kemp, 2001; Wall, Rouse, Wilson, Tait, & Busby, 2004) with an acceptable degree of accuracy.

Ultrasound technology is a well-established method used in both cattle breeding programs and production which has been described in several publications (Bergen, McKinnon, Christensen, Kohle, & Belanger, 1997; Crews & Kemp, 2001; Herring & Kemp, 2001; McNeil & Northcutt, 2008; Silva, Leme, Pereira, et al., 2003; Tarouco, Lobato, Tarouco, & Massia, 2005; Baker, Tedeschi, Fox, Henning, & Ketchen, 2006). However, these beef production systems are characterized by genotypes with different degrees of maturity and/or higher intramuscular fat levels than in most European markets, where beef production is based mainly on intact males and moderate feeding to produce leaner carcasses. Few studies have reported ultrasonic measurements from light carcasses of ruminants produced in Mediterranean systems, in which animals are slaughtered earlier and at much lighter weights than in the USA or northern Europe. Thus, the applicability of commercial ultrasound technology for carcass and meat predictions in low intramuscular fat cattle populations (<2–3%) is not well documented and needs further exploration before the technology can be introduced in breeding schemes for

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http://dx.doi.org/10.1016/j.meatsci.2013.07.012

these populations and beef markets (Aass et al., 2006, 2009). In addition, this technology would allow farmers to predict optimal times of slaughter.

Beef from yearling bulls from different local breeds and their crosses make up approximately 50% of the total production in Spain (MAPA, 2003). Beef production in south-western Spain is based mainly on semi-extensive systems with pure breeds (e.g., Retinta, Limousine and Charolais) or their crosses (MAPA, 2003). The Retinta breed is the most important autochthonous beef breed in south-western Spain. Retinta is an early maturing beef breed, producing characteristics large, low-muscled lean carcasses. Charolais and Limousine are well known as late maturing beef breeds, producing highly muscled lean carcasses. After weaning (6–8 months of age), calves are generally fed with concentrate in free stanchion barns until about 12–14 months of age and 500–550 kg live weight. This combination of genotypes and breeding system leads to low-fat beef, as demanded by Spanish consumers. The use of local beef breeds, reared under traditional systems and commercialized under labels of origin (i.e., protected geographical indication) or quality trademarks, has become very important in Spain in recent years.

This study was conducted to: 1) understand the evolution of rib (i.e., fat thickness, *longissimus dorsi* area, marbling or intramuscular fat content) and rump (i.e., fat thickness and *gluteus medius* depth) traits during the finishing phase in three lean beef breeds (i.e., Charolais, Limousine and Retinta), and 2) to develop ultrasound-derived prediction equations for these variables. Also, this technology could provide information about which is the best time to scan feedlot bulls from lean cattle breeds.

2. Material and methods

2.1. Animals

Three-hundred bulls, raised following the typical beef production systems of south-western Spain, were selected at a commercial feedlot during two consecutive years (2009 and 2010). Breeds used included two highly-selected French beef breeds (CH, Charolais and LI, Limousine) and a medium-sized Spanish beef breed (RE, Retinta). The calves were reared in a semi-extensive regime, linked to the "dehesa" (*Quercus ilex rotundifolia* and *Quercus suber* open woodlands) until weaning. After weaning, at around 7–8 months of age, all cattle were transported to the feedlot facilities COVAP (Córdoba, south-western Spain). At the start of the finishing phase, bulls were randomly allotted to one of 12 pens (10 × 10 m, 25 head per pen) with straw bedding. The animals were considered a representative sample of breeds, sex and ages commonly slaughtered in the area. Bulls were then raised following feeding and handling conditions according to Spanish rules and regulations for animal care (EU Council Directive 86/609/EEC). Bulls were fed a specific medium-energy diet based on concentrated meal (Table 1) and wheat straw, both *ad libitum*. After a 14 day adjustment period, the young bulls were offered a grower diet for the first 90 days after which they were adapted to a medium-energy finishing diet.

Table 1
Ingredients and chemical composition of growing and finishing diets.

	Grower	Finisher
Ingredients		
Barley meal (g/kg)	341.0	324.1
Maize meal (g/kg)	310.0	350.0
Whole soybean (g/kg)	22.5	86.4
Canola (g/kg)	18.3	–
Corn gluten feed (g/kg)	160.0	170.0
Wheat bran (g/kg)	72.3	–
Palm oil (g/kg)	37.4	33.1
Mineral–vitamin (g/kg)	38.5	36.4
Chemical composition		
DM (%)	89.1	88.9
Crude protein (g/kg DM)	133.5	139.0
Crude fibre (g/kg DM)	47.4	42.9
Ash (g/kg DM)	56.9	58.1
ME (MJ/kg DM)	11.6	11.7

DM: Dry matter; ME: Metabolizable energy.

2.2. Ultrasound equipment and measurements

Carcass traits were estimated by capture of ultrasonic images. To obtain the ultrasound images, cattle were immobilized and restrained by the head in a squeeze chute and the image sites were determined by physical palpation to accurately ascertain the scanning sites. The animals were held manually avoiding any abnormal situation that could stress the animal, and they were only scanned in a relaxed posture, permitting accurate measurements. Ultrasound images were measured over the skin without shearing or clipping of hair. Vegetable oil tempered at 25–30 °C was used as a coupling agent to allow a better acoustic contact surface between the probe and the skin. Ultrasound measurements were taken at 30 ± 5 days on feed (approximately 250 days old), and then serially every 30 to 35 days throughout the finishing phase by a certified ultrasound technician (who was also responsible for image analysis) using an Aquila Pro (Esaote Pie Medical) diagnostic real-time ultrasound with a 18 cm 3.5 Mhz linear array transducer (ASP-18). The last scan was taken within seven days prior to slaughter. Bulls were individually weighed after each scan. The measurements collected on live animal were, as described by Wall et al. (2004) and Bergen et al. (2005): *longissimus dorsi* muscle (LD) area at a point between the 12th and 13th rib (UREA), subcutaneous fat thickness (UFT) between the 12th and 13th rib over the LD at a point ¾ the length ventrally of the ribeye, intramuscular fat content or marbling (UIMF), measured in the longitudinal image of the LD directly over the 12th and 13th rib, as well as rump fat thickness (URFT) at the junction of the *biceps femoris* and *gluteus medius* (GM) muscles between the *ischium* and *illium* (Greiner, Rouse, Wilson, Cundiff, & Wheeler, 2003a). The GM depth (UGMD) was measured immediately below the juncture of the GM and the *biceps femoris* muscle between the hook and pin bones with the transducer placed approximately 2.5 cm dorsal to the hook bone and parallel to the backbone. Each animal was scanned once for UREA, UFT, URFT and UGMD, and four independent scans were collected for UIMF. To insure the independency between images, the probe was removed between consecutive images and hide re-oiled before the probe was placed in correct position. The UIMF, URFT and UGMD images were collected without a stand-off pad. Data from the first to the seventh scan are expressed as $UREA_1$ to $UREA_7$, UFT_1 to UFT_7, $URFT_1$ to $URFT_7$, $UGMD_1$ to $UGMD_7$, $UIMF_1$ to $UIMF_7$. Also, UREA, UFT, URFT, UGMD and UIMF were expressed as values per 100 kg live weight (WREA, WFT, WRFT, WGMD, WIMF) using the formula presented by Turner, Pelton, and Cross (1990):

$$WREA = (UREA * 100/Slaughter\ weight)$$

2.3. Carcass traits

Once 80% of bulls in any pen reached of 60–65% of live weight at maturity (540–580 kg for CH and LI; 500–525 kg for RE, depending local market preferences), they were transported to an officially approved slaughterhouse (COVAP) within 20 km of the feedlot, and kept for 12 h in collective boxes with access to water. At slaughter, animals were stunned, exsanguinated and dressed following commercial procedures. Carcasses were weighed immediately after slaughter (HCW) and approximately 24 h *postmortem* (CCW). Just before the carcasses were halved and placed in the cooler (at 2–4 °C), a licensed technician graded carcasses for conformation and fatness according to the European beef grading system (EU Regulation No 1208/81, 1026/91, 2237/91). Carcasses were classified using the SEUROP classification scales for conformation (from S = superior musculature to P = poor musculature; this