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The quality of meat and edible by-products from kids with different inheritance of Boer goat

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ABSTRACT

The purpose of this study was to investigate the influence of the Boer breed on the quality characteristics of the three muscles: *m. longissimus*, *m. semimembranosus*, *m. supraspinatus* and five edible by-products: the tongue, liver, lung, heart and kidneys. The purpose of the study also included investigating the differences between the indicated points of measurement (understood as the particular muscles and organs). The presented research was undertaken to increase the available information on the physicochemical traits of goat meat and organs. The study was conducted on the samples of muscles and organs obtained from 72 male kids divided into four breed groups: the Polish White Improved (WI) and three crossbred groups having various shares of Boer (B) genes (1/4B3/4WI, 1/2B1/2WI and 3/4B1/4WI). No influence of genotype was found for: the edible by-products share in kid body weight, $pH_{1,24,48,72}$, and electrical conductivity $EC_{1,24,48,72}$ measurements and the chemical composition of muscles and organs. However, the extraction fat content in the *m. longissimus*, *m. semimembranosus*, the liver and the kidney was affected by the genotype. The measurements of the water holding capacity (WHC) and thermal drip (TD) for *m. supraspinatus* and *m. longissimus* showed a genotype effect. The colour (L^*) of all muscles was also shown. All the analysed points of measurement differed significantly considering the values of their physiochemical traits. The correlations between pH_{24} and EC_{24} with the following measurements of pH_{48}, pH_{72}, and EC_{48}, EC_{72} and other carcass quality indicators, were low or quite low. The relationship between $pH_{24,48,72}$ and $EC_{48,72}$, on the other hand, had a moderate significance.

1. Introduction

Chevon, Capretto or Cabrito are different names for goat meat; one of the most commonly consumed red meat in the world (Biswas et al., 2007; Ozcan et al., 2014). The main reason for the popularity of goat meat is that goats have few environmental needs. These traits make goat breeding and farming possible in all latitudes (Atay et al., 2011; Madruga and Bressan, 2011; Ozcan et al., 2014; Pieniak-Lendzion et al., 2009; Webb et al., 2005). The world's goat population was around one billion in 2013 (FAOSTAT, 2013). The largest number of goats is concentrated in the developing countries like Asia and Africa. These countries account for 93% of the world goat population (FAOSTAT, 2013). In the developing countries, goats are used for many purposes like milk, meat, fibre or skin (Anaeto et al., 2010; Dubeuf et al., 2004). Goat meat is known from lower fat and cholesterol content, and lower saturated fatty acid levels compared to other red meats (USDA, 1989). Therefore, the goat meat is considered to be the perfect substitute for pork or beef

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in a healthy diet (Pieniak-Lendzion et al., 2010; Stanišić et al., 2012; Webb et al., 2005). The Boer goat is popular in crossbreeding due to large mature size and potentially high growth rates (Mahgoub et al., 2012). Boer crossbreds, if fed correctly, show an increased: growth potential (Malan, 2000), body weight at slaughter, carcass weight, dressing percentage (Stanisz et al., 2009), muscularity (Blackburn and Gollin, 2009) and weight of primal cuts (Cameron et al., 2001). Moreover, the Boer crossbred offspring shows an improved carcass conformation over the straightbred kids (Browning and Leite-Browning, 2011; Merlos-Brito et al., 2000; Oman et al., 1999, 2000).

At slaughter, not only the meat is obtained but also the edible by-products (Dalmás et al., 2011; Goldstrand, 1988). These by-products are commonly used in production of such traditional foods as *morcilla de Burgos* in Spain, *cavourmas* in Greece, *morcella de Assar*, goat *sarapatel* and bovine liver *pâté* in Portugal or goat *pâté* and *buchada* in Brazil (Aristoy and Toldrá, 2011; Madruga et al., 2007). As recent research has indicated, by-products are an important source of essential nutrients (Dalmás et al., 2011; Stanisz et al., 2009). The livestock industry may increase profitability by converting as much edible by-products as possible into food products. The use of by-products would also reduce the cost of waste management and the negative environmental impact (Brasil et al., 2014).

The objective of the presented study was to increase the available information about the physicochemical traits of the meat and edible by-products of Boer crossbreds. Our research hypothesis assumes that muscles and edible by-products of the presented genotypes have different physiochemical traits due to the varied amounts of Boer genes.

2. Materials and methods

Investigations were conducted on samples of muscles and edible by-products obtained from 72 male kids. Four groups ($n = 18$) of kids had been formed according to an orthogonal data design: the Polish White Improved (WI) and three groups of crossbreds with various shares of Boer (B) genes. The latter three crossbred groups were the progeny of three B sires imported from Germany. The crossbred groups were arranged as follows: 1/4B3/4WI, 1/2B1/2WI and 3/4B1/4WI. As the dams were not milked at all, the dams were suckled until the kids (all born as twins) reached 20 kg of body weight. When the kids were 14-day-old they were additionally fed rolled oats as well as a concentrated mix composed of crushed wheat and barley grain, wheat middlings, post-extractive rapeseed meal (15.8% crude protein, 6.9 MJ ME/kg) and meadow hay ad libitum. During the suckling period, dams were fed farm-produced feeds in accordance with the INRA system standards for goats suckling twins (1993). The mean age of the goat kids at slaughter was: 95, 87, 76 and 72 days for WI, 1/4B3/4 WI, 1/2B1/2WI and 3/4B1/4WI, respectively. The slaughter weight of all kids was 20 kg. After slaughter, all the investigated internal organs were weighed to a 1 g accuracy. Secondly, each of the analysed internal organs was expressed as the percentage of body live weight. The evaluation of kid meat and organ quality was based on measurements of the: *m. supraspinatus* (*m. supr.*), *m. longissimus* (*m. long.*) and *m. semimembranosus* (*m. semim.*) collected from carcasses after a 24-h, 2–4 °C chilling period. The heart (after removal of fat tissue), tongue, lung and kidney samples were also collected. Acidity (pH) and electrical conductivity (EC, mS/cm) were measured 45 min after slaughter (pH_1, EC_1), 24 h (pH_{24}, EC_{24}), 48 h (pH_{48}, EC_{48}) and 72 h (pH_{72}, EC_{72}) after slaughter. Acidity was evaluated using a combination glass calomel electrode. Electrical conductivity was evaluated with an LF-STAR apparatus (Matthäus, Germany). For the duration of the research all the collected samples were kept at 4 °C. Twenty-four hours after slaughter, the tristimulus CIE values: L^* (lightness), a^* (redness), b^* (yellowness) were used to express the colour of the freshly cut cross-section surface of *m. long.* (behind the last thoracic vertebrae), *m. supr.* and *m. semim.* (in the widest part). The colour space parameters were measured by the reflectance method using a Minolta Colorimeter CR-200b, with an illuminant C, a 2° observer, and 30 mm-diameter aperture size at one point (the samples had a uniform appearance). To determine water content, the samples were dried at 105 °C to a constant weight (PN-ISO 1442, 2000). Crude fat was determined according to Soxhlet (PN-ISO 1444, 2000), total protein according to Kjeldahl (PN-A-04018, 1975), thermal drip (TD) after Honikel (1998) and water holding capacity (WHC) after Pohja and Niinivaara (1957).

The effect of genotype on the weight and percentage of the tongue, heart, lungs, liver and kidneys in the pre-slaughter body weight was calculated using the ANOVA of SAS ver. 9.1 software package (SAS, 2001).

$$Y_{ij} = \mu + p_i + e_{ij}$$

where μ is the mean, p_i the genotype effect ($i = 1, 2, 3, 4$) and e_{ij} the random error.

The effect of genotype and eight measurement points[1] (eight points: *m. supr.*, *m. long.*, *m. semim.*, tongue, heart, lungs, liver and kidneys), on the pH, electrical conductivity (EC) and chemical composition (dry matter, total protein, extracted fat), was calculated. The effect of genotype and three measurement points[2] (three points: *m. supr.*, *m. long.*, *m. semim*) on the water holding capacity, thermal drip and meat colour (L^*, a^*, b^*) was also calculated. Both statistical calculations were made by means of a two-way ANOVA, SAS ver. 9.1 software package (SAS, 2001).

$$Y_{ijk} = \mu + p_i + t_j + (pt)_{ij} + e_{ijk}$$

where μ is the mean value, p_i the genotype effect ($i = 1, 2, 3, 4$), t_j the point of measurement effect ($j = 1, 2, 3, 4, 5, 6, 7, 8$)[1] or ($j = 1, 2, 3$)[2], $(pt)_{ij}$ the interaction of factors and e_{ijk} the random error.

Since the calculated interactions between the genotype effect and the point of measurement effect were found to be non-significant, they were not presented in the tables. The Pearson correlation coefficients were calculated (SAS, 2001) from among the carcass quality traits.

3. Results

3.1. The effect of Boer inheritance on the physical characteristics of meat

No significant differences between WI kids and kids crossbred with the B breed were found for organ weight and the organ percentage in goat kids' live weight (Table 1). The successive measurements of pH and EC (Table 2) made on groups of kids at 45 min, 24, 48 and 72 h after slaughter, also did not differ ($P > 0.05$). For this reason, the scheme of pH and EC changes for different genotypes was not presented. However, most of the observed pH and EC differences between the examined muscles and organs were significant or highly significant. After a 24-h chilling, the pH of the analysed muscles decreased, and ranged from 5.50 to 5.70. Another decline in the pH value was recorded 48 h after slaughter, whereas 72 h after slaughter, the pH increased. In the heart and kidneys, an increase in the pH value was recorded in all the analysed intervals. The liver was characterised with a pH decline until 48 h after slaughter, and then a rise 72 h after slaughter. For the tongue and lungs, the pH dropped in the first 24 h of the measurements, and then increased in the following intervals. The results of the presented study indicated that the correlations between pH_1 and the following measurements of pH, and EC, and other studied meat quality indicators, were low (Table 6). However, high correlations ($P < 0.001$) were found for the pH 24 h after slaughter. The pH_{24} value was positively correlated with the pH_{48} (0.808), pH_{72} (0.766) and L^* (0.306).