



Invited Review

Factors Affecting Carcass and Meat Quality Characteristics in Goats

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ABSTRACT

Background/Aim: Goat meat has an important place in red meat production, especially in developing countries. Goat meat is characterized by a low intra-muscular and subcutaneous fat content and could be used as a nutritional alternative to other meat species. Recently, meat quality has become a primary focus for producers, and ultimately consumers. This review includes factors affecting carcass and meat quality characteristics in goats.

Conclusion: Both genetic and environmental factors affect carcass and meat quality characteristics in goats. Breed is a clear source of variation in carcass morphology related to fat quantity or meat quality. Gender has a marked influence on the fatness of the meat, with entire males being leaner than castrated males which are in turn, leaner than females. The age of kids has also an important effect on chemical composition and fatty acid profile of muscles. Generally, it has been determined that the percentage of moisture was decreased, whereas the percentage of fat was increased with increasing slaughter age in the studies carried out on the different goat breeds. Carcass and meat quality characteristics of goats are significantly influenced from production system. Different nutritional conditions can change fatness of carcass and fatty acid composition of muscle lipids. Pre-slaughter stress also negatively affects meat quality characteristics as cause to depletion of muscle glycogen reserves ante mortem and to increase in meat pH. All these factors should be taken into consideration to improve carcass and meat quality characteristics in goats.

Keywords: Goat, carcass, meat quality.

Keçilerde Karkas ve Et Kalite Özelliklerini Etkileyen Faktörler

ÖZET

Öz bilgi/Amaç: Keçi eti, özellikle gelişmekte olan ülkelerde kırmızı et üretiminde önemli bir yere sahiptir. Keçi eti, kas içi ve deri altı yağ içeriğinin az olması ile karakterizedir ve diğer türlerden elde edilen etlere alternatif olarak kullanılabilir. Son yıllarda et kalite, üreticiler ve tüketiciler için primer odak noktası olmuştur. Bu derleme, keçilerde karkas ve et kalitesini etkileyen faktörleri kapsamaktadır.

Sonuç: Keçilerde karkas ve et kalite özellikleri üzerinde hem genetik, hem çevresel faktörler etkilidir. Irk, yağ miktarı ve et kalitesi ile ilişkili olarak karkas morfolojisinde belirgin bir varyasyon kaynağıdır. Cinsiyet, etin yağlılığı üzerinde belirgin etkiye sahiptir, erkekler, kastre edilmiş erkeklerden, kastre edilmiş erkekler de dişilerden daha yağsızdır. Yaş da kasların kimyasal kompozisyonu ve yağ asidi profili üzerinde önemli etkiye sahiptir. Farklı keçi ırkları üzerinde yapılan çalışmalarda genellikle, yaşla birlikte etin rutubet miktarının azaldığı ve yağ miktarının arttığı belirlenmiştir. Keçilerin karkas ve et kalite özellikleri üretim sisteminden önemli düzeyde etkilenmektedir. Farklı besleme koşulları, karkasın yağlılığı ve kaslardaki yağ asidi kompozisyonunda değişikliğe sebep olabilir. Kesim öncesi stres de kas glikojen rezervlerinin kesim öncesinde tüketilmesine ve et pH'sında artışa neden olduğundan et kalitesini negatif olarak etkilemektedir. Keçilerde karkas ve et kalitesini artırmak için tüm bu faktörler dikkate alınmalıdır.

Anahtar kelimeler: Keçi, karkas, et kalite.

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Introduction

Goat meat has an important place in red meat production, especially in developing countries. There is potential for the development of goat meat market, since consumers prefer low-fat and high quality products (Carlucci et al. 1998). Goat meat is characterized by a low intra-muscular and subcutaneous fat content and could be used as a nutritional alternative to other meat species such as beef and chicken (Babiker et al. 1990, Johnson et al. 1995). Goat meat has a high percentage of protein and a low percentage of fat and it is also a good source of desirable fatty acids, since goats deposit higher PUFA (polyunsaturated fatty acids) than the other ruminants, which makes it attractive to consumers as a red meat alternative (Banskalieva et al., 2000).

Meat quality has become a primary focus for producers, and ultimately consumers (Newcom et al., 2004). Meat quality can be defined in terms of its physical and chemical characteristics, or in terms of consumer perception. (Casey and Webb 2010). Traditionally meat quality is either eating quality or processing quality, implying that quality is directly associated with usage. Eating quality comprises tenderness, flavour, juiciness, and being free of pathogens and toxins (Webb et al. 2005).

Consumer preferences for meat quality is difficult to define, the most important quality features of meat are fatty acid profiles and sensory characteristics (Bukala and Kedzior, 2001, Assan 2012). Previous studies have shown that consumer's perception on meat healthiness is related to its fat content and fatty acid composition (Fisher et al., 2000). Fat remains an important quality determinant of meat although the chemical and physical properties of fat usually have little influence on the commercial value of carcass, these properties do influence the eating and keeping quality of meat (Kempster et al, 1982, Assan, 2012). This review focuses on the factors affecting carcass and meat quality characteristics in goats.

Many factors such as breed, age, gender of animal, nutritional and environmental factors affect carcass and meat quality characteristics in goats.

Breed

Breed is a clear source of variation in carcass morphology related to fat quantity or meat quality (Guerrero et al. 2013). Breed exerts the most influence on items such as yield of carcass cuts, lean to fat ratio, intramuscular fat distribution or marbling, firmness of fat, and color, tenderness and juiciness of cooked meat. Some breeds begin to fatten at lighter weights and others at heavier weights. Breeds differ in the rate at which fat is deposited during the fattening stage (Tshabalala 2000). The carcass of some local or indigenous goat breeds may not be a high quality, because of little or no selection for meat characteristics (Mourad et al., 2001, Goetsch et al. 2011). Dhanda et al. (2003) also observed that significant differences among different goat breeds in terms of dressing percentage. Ozcan et al. (2010) determined that indigenous Gokceada kids had significantly lower values in terms of dressing percentage, muscle, bone, subcutaneous and intermuscular fat weights than Maltese and Saanen kids. However, Yilmaz et al. (2009) no significant differences observed among Hair and Saanen x Hair kids (F_1 and B_1) in terms of carcass characteristics.

Many authors reported that meat color characteristics were significantly affected by goat genotype (Dhanda et al. 2003, Santos et al. 2007, Yilmaz et al. 2009, Ekiz et al. 2010). Dhanda

et al. (2003) and Santos et al. (2007) significant differences observed in meat pH among genotypes due to the differences in response to preslaughter handling or differences in glycogen reserves. Kadim et al (2004) observed that there was some variation in cooking loss between genotypes probably due to the higher ultimate muscle pH observed in some breeds. The shear force values were not significantly changed among goat breeds (Dhanda et al., 2003).

Ekiz et al. (2010) reported that there were no significant differences among Gokceada, Saanen and Maltese kids in terms of sensory traits. Yilmaz et al (2009) also determined that Hair goat and Saanen x Hair goat kids had similar sensory traits such as tenderness, juiciness, flavor intensity and odor intensity.

Gender

Gender affects growth of body tissues and hence affects carcass composition. Gender has a marked influence on the fatness of the meat, with entire males being leaner than castrated males which are in turn, leaner than females (Tshabalala 2000; Watson 1994). Castration generally increases carcass fatness depending largely on plane of nutrition. Fat is deposited relatively more rapidly in carcass and non-carcass tissues by females than intact males, with wethers being intermediate (Goetsch et al. 2011, Ruvuna et al. 1992, Mahgoub et al. 2004, Abdullah and Musallam 2007). The relatively greater proportion of lean in the carcass of entire males is a favorable characteristic and may be explained by the anabolic effect of testicular hormones, which leads to greater muscular development (Tshabalala 2000). In the studies carried out related to the effect of gender on carcass composition in different goat breeds, it was determined that female kids had the higher percentage of subcutaneous, intermuscular and total fat in carcass than male kids (Peña et al. 2007, Toplu et al. 2013a).

The effects of gender on physical and nutritional meat quality characteristics have also been studied in different goat breeds. Bonvillani et al. (2010) reported that meat from female kids was the darker and redder, and showed a higher water-holding capacity and lower cooking loss and toughness than male kids. Santos et al. (2007) reported that female kids had the higher percentage of intramuscular fat than male kids. Toplu et al. (2013b) found that female kids had higher levels intramuscular fat content and the lower percentage of PUFA than male kids. Mahgoub et al. (2002) reported that male kids had the higher levels of C15:0, C18:2, C18:3, but the lower levels of C16:0, C17:0, C18:0 and C18:1 than female kids. In another studies related to the effect of castration on intramuscular fatty acid composition, Werdi Pratiwi et al (2006) determined that *longissimus thoracis* muscle from castrated Feral and Boer kids contained the higher percentages of UFA (unsaturated fatty acids) and MUFA (monounsaturated fatty acids), but the lower percentages of SFA (saturated fatty acids), PUFA and PUFA to SFA ratio than intact kids.

Age and Weight at Slaughter

Age is an important determinant of carcass and meat quality. Generally, the lean:bone ratio increase with age. Body composition of goats changes markedly during growth. (Tshabalala, 2000). Carcass characteristics such as dressing percentage, carcass conformation, carcass compactness have been reported to improve by increasing in slaughter age or body weight in different goat breeds (Goetsch et al. 2011,

Mourad et al. 2001, Toplu et al. 2013a). It was reported that carcass fatness increased, whereas the percentage of bone decreased with increasing slaughter weight of kids in many studies (Toplu et al., 2013a, Marichal et al. 2003, Dhanda et al. 2003, Peña et al. 2007, Zimerman et al. 2008).

Many studies related to effects of different slaughter weights on goat meat quality characteristics have been carried out in recent years. It has been reported that muscle color becomes darker red with increasing slaughter age as muscle pigment concentration increase (Toplu et al. 2013a, Dhanda et al. 1999). Several researchers reported that a^* (redness index) and chroma values increased and muscle color became darker red as slaughter age increased in different kid breeds (Toplu et al. 2013b, Marichal et al. 2003, Peña et al. 2009).

Toplu et al. (2013b) determined that pH decline on *M. longissimus dorsi* during 24 h post-slaughter increased by increasing slaughter age from 3 to 12 months of age in Turkish Hair goat kids. Finally the ultimate pH value of *M. longissimus dorsi* of the kids slaughtered at 12 months of age was lower than those of kids slaughtered at 3 and 6 months of ages. Dhanda et al. (2003) and Marichal et al. (2003) also the lower ultimate pH values obtained for carcasses of different goat breeds as slaughter age or slaughter weight increased.

Cooking loss increases with slaughter age due to denaturation of proteins, which results in structural change that cause fluid to be expelled (Offer and Knight 1988). Henckel et al. (2000) reported that a high rate of pH decline and a low ultimate pH results in muscle protein denaturation. A significant increase in cooking loss (Dhanda et al. 2003, Toplu et al. 2013b) and decrease in tenderness (Marichal et al. 2003, Werdi Pratiwi et al. 2007, Peña et al. 2009, Toplu et al. 2013b,) was observed by increasing slaughter age in different goat breeds.

The age of kids has also an important effect on chemical composition and fatty acid profile of muscles. Generally, it was determined that the percentage of moisture decreased, whereas the percentage of fat increased with slaughter age in the studies carried out on different goat breeds (Beserra et al. 2004, Werdi Pratiwi et al. 2007, Toplu et al. 2013b). Zygoiannis et al. (1992) reported that the composition of fat depots changed with a decreasing proportion of stearic acid, but increasing proportions of all other fatty acids with increasing age at slaughter of unweaned kids. Werdi Pratiwi et al. (2007) and Peña et al. (2009) also reported that total percentage SFA decreased, whereas total percentage UFA increased with increasing slaughter age/weight.

Production System

Carcass and meat quality traits of kids may be influenced from production system. Goat meat production can be carried out with different production systems and feeding planes and as results differences in growth rates; yield and carcass parameters between systems may be observed (Assan 2012; Vergara and Gallego, 1999). Confinement feeding with concentrate diets can affect various carcass characteristics as well as internal and carcass fat levels (Goetsch et al. 2011). Ryan et al. (2007) determined that the goats fed a diet with high energy resulted in heavier carcass weight, longer carcasses than grazed goats. Kamatara et al. (2013) also reported that the goats supplemented with non-molasses based concentrate and a molasses based concentrate had higher carcass weight than grazed goats. Daskiran et al. (2006) determined that the percentages of omental, intermuscular and subcutaneous fat

of intensively raised Norduz goats were significantly higher than those of extensively raised.

With regard to the production system on meat quality characteristics in goats, Ozcan et al. (2014) reported that Gokceada kids under an extensive production system had lower meat lightness, high scores in terms of kid odour intensity, flavour intensity and overall acceptability. Ryan et al. (2007) found that goats consuming diets with 50%, 70%, or 90% concentrate in confinement compared with rangeland grazing without concentrate supplementation had higher a^* (redness) and b^* (yellowness) of the *longissimus* muscle. Priolo et al. (2001) reported that the meat of animals finished on pasture is darker (higher redness) than the meat of animals finished with concentrates, associated to high final pH. Rodrigues et al. (2011) also determined that kids finished on pasture presented higher values of redness (a^*) compared with those of feedlot kids in their studies on Alpine, Anglobian X Alpine, Boer x Alpine crossbred kids.

The fatty acid composition of ruminant tissues is generally less affected by diet composition compared with non-ruminants. However, numerous studies showed that different nutritional conditions can change muscle lipid fatty acid composition (Banskalieva et al. 2000). It was reported that levels of saturated and monounsaturated fatty acids are greater in goats consuming concentrate in confinement compared with goats grazing rangeland (Goetsch 2011, Rhee et al., 2000; Ryan et al., 2007). Madruga et al. (2006) determined that goats raised in confinement regime contained significantly greater MUFA, higher ratio of MUFA/SFA and UFA/SFA than goats raised on field. They also reported that meat lipids from goats raised on fields showed a composition potentially beneficial for human health, accumulating more C18:2, C18:3 and C20:3 in comparison with goat confined.

Pre-Slaughter Conditions

During the pre-slaughter period, goats as the other farm animals can be exposed to different stressors including handling, loading and unloading, transportation, and feed deprivation (Kannan et al. 2000). Feed deprivation prior to slaughter makes the evisceration process easier during slaughter and thus preventing contamination of carcasses. However, feed withdrawal also results in reduction of live and carcass weights, which are of economic importance in meat animals. (Gregory 1998).

Pre-slaughter stress in goats also can greatly affects muscle metabolism and may negatively impact meat quality characteristics (Kannan et al. 2001). It has been reported that an increase in physiological stress and or physical activity in farm animals during transport and pre-slaughter handling leads to depletion of muscle glycogen reserves before slaughter, which may result in a higher ultimate meat pH, greater water-holding capacity, darker meat colour, and tougher meat (Gregory 1998). Pre-slaughter stress due to handling, transportation or lairage conditions causes a depletion of muscle glycogen reserves ante mortem and to an insufficient meat acidification post mortem, which leads to increase in meat pH (Miller 2002). The rate and extent of postmortem glycolysis and ultimate pH of the muscle are important factors that determine meat quality (Casey and Webb 2010). High ultimate pH values of goat meat suggest that goats are generally highly prone to stress. Ante mortem concentrations of glycolytic metabolites in muscles confirm this suggestion (Webb et al. 2005, Kannan et al. 2003,

Simela et al. 2004). Kadim et al. (2006) also determined that 2 h transport stress with high temperature prior to slaughter had a significant effect on meat quality characteristics in Batina, Dhofari and Jabal Akhdar goats ($P < 0.05$). They found that meat from transported goats had significantly higher ultimate pH, expressed juice, cooking loss percentage, shear force and redness index, but significantly lower lightness and yellowness index values.

Conclusion

Breed, age, gender of animal, nutritional and environmental factors, pre-slaughter handling and stress significantly affect carcass and meat quality characteristics in goats. All these factors should be taken into consideration to improve meat production and meat quality in goats. Improvement of management conditions and limiting of pre-slaughter stressful environment could contribute to improve carcass and meat quality characteristics in goats.

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