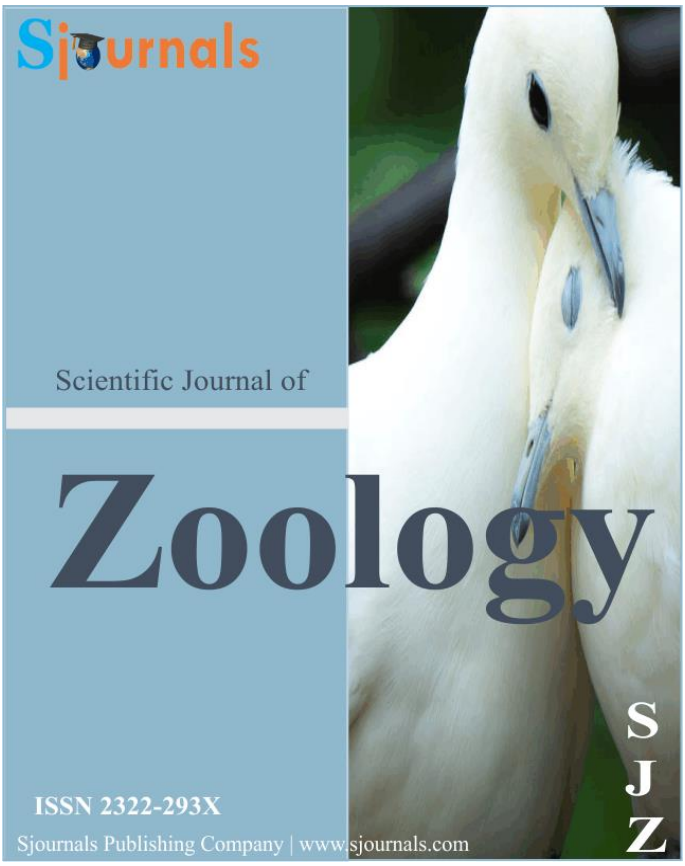

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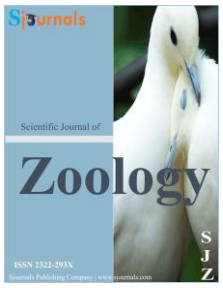

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Review article

Manipulating nutrition for ideal carcass and meat quality parameters in goat and sheep production

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ABSTRACT

Nutrition is an important component of the goat and sheep meat production systems and plays a vital role in promoting ideal carcass characteristics and meat quality properties. Goats and sheep diets can impact not merely growth performance but as well as carcass and meat properties that are acceptable to modern day consumers who have become sensitive to the quality of meat and meat products. Of significance, dietary composition can be manipulated towards acquiring desirable dressing percentage, carcass characteristics and meat quality properties in goats and sheep. It cannot be overemphasized that dressing percentage and meat yield directly respond to optimal dietary regime as a result manipulation of dietary constituencies especially energy and protein have been designed to produce acceptable carcass and meat properties. However, the existence of interactions of nutrition with other non-genetic factors in influencing carcass traits and meat quality properties in goats and sheep, cannot be overlooked. Apart from dietary composition influencing carcass yield and meat quality properties, overall dietary impact appears to vary with sex of animal, age and weight at slaughter. Optimal plane of nutrition will enhance goat and sheep performance, while inadequate dietary protein, energy, minerals and vitamins proportions have been interrelated to negative impact on carcass parameters and meat quality properties. It is important that the nutritional constituents be accurately balanced in order to attain

optimum dressing percentage, carcass yield and meat quality properties. Feed resources of every description have been fed for their nutritional value with different responses on their influence on carcass parameters and meat quality properties. Therefore, there are conspicuous differences of ration formulas on their impact on dressing percentage, carcass parameters, and meat quality properties. A balanced dietary composition become predictable critical component of which can impose a positive influence on carcass traits and meat quality properties. In order to get maximum response for carcass portions as a result of prescribed nutritional regime, animal should be slaughtered at an appropriate age and weight, and also sex to slaughter might need to be considered. The present review gives an insight of the impact of nutrition on dressing percentage, carcass characteristics and meat quality properties in goats and sheep.

1. Introduction

Nutrition is a major explanatory variable on distinctive carcass aspects and meat quality properties in goats and sheep (Montemayor et al., 2017; Boughalmi and Araba, 2016; Daskiran et al., 2010). Goat and sheep meat production, i.e. carcass characteristics and meat quality are dependent on genotype and non-genetic effects. Ranking amongst the latter, nutrition has been demonstrated to be the primary determinant of carcass and meat properties in many species (Wood et al., 2008; Webb et al., 2005). For the same reason, the effect of nutrition on carcass characteristics and meat quality attributes has been the subject of a considerable number of studies in goats and sheep meat production (Obeidat et al., 2020; Ekiz et al., 2019; Boughalmi and Araba, 2016; Adam et al., 2010). However, Tesema et al. (2018) demonstrated a genotype-nutrition interaction that existed with local Central Highlands goats' best performance displayed on grazing only, while Boer crosses predominantly performed well under supplementation. The dietary composition is regarded as an important quality determinant of meat (Damez and Clerjon, 2008) imparting the essential protein and vitamins for healthy eating by modern consumers (Grunert, 2006; Binnie et al., 2014). Manipulation of dietary constituencies into appropriate fractions especially energy and protein has been meant to support the production of acceptable carcass and meat properties. This entails that dietary composition becomes a predictable and critical component which can be modified to impact a positive appeal on dressing percentage, carcass traits and meat quality properties. It has been noted that interaction of nutrition with other factors exist in influencing dressing percentage, carcass and meat characteristics, and these factors are genotype (Anothaisinthawee et al., 2012; Santos-Silva et al., 2002), slaughter weight/age (Nayga et al., 2015; Şahin and Boztepe, 2010) and sex of kid/lamb (Santos et al., 2007; Valasco et al., 2000). The influence of nutrition on dressing percentage, carcass and meat quality properties in goats and sheep appear to vary with dietary composition, age and weight at slaughter. Therefore, the determination on nutrition and managing its interaction with other factors becomes paramount in attaining high quality kid/lamb carcass and meat. A diverse range of both conventional and/or commercial and non-classical feed resources have been utilized in goat and sheep nutrition with varying degree of animal performance responses in producing desirable carcass and meat. Concentrate supplementation reduces age to slaughter and increases carcass quality (Mtenga and Kitalyi, 1990). Fatty acids profiles in Rambouillet and Merino*Rambouillet lambs' carcasses were influenced by the type of diet (Rhee et al., 2003). Dietary intake and composition influenced goat carcass composition (Legesse and Abebe, 2008), while carcass fat, adipose tissue accretion appeared to be directly associated with nutrient availability (Brown et al., 2005) or energy density of the diet (Berg and Walter, 1983). Differentiated nature of feeding in intensive, semi-intensive and extensive production systems has influenced the comparative extent of meat production efficiency in goat and sheep (Akbas and Saatci, 2016; Karim et al., 2006). The purpose of the present review is to highlight the influence of nutrition on dressing percentage, carcass characteristics and meat quality properties in goats and sheep.

2. Goat and sheep nutrition influencing carcass parameters

The effect of diet on carcass weight was evidently observed in three genotypes of Bati, Hararghe highland and Short-eared Somali goats which was ascribable to improved feed intake and, accordingly, greater nutrient availability to support weight gain and tissue amplification (Tadesse et al., 2016). Indoor feeding system improved growth rate of kids resulting in heavier carcass in comparison with grazing kids (Alexandre et al., 2009). However, elevating dietary crude protein did not have an influence on carcass characteristics in intact male Tunisian goats (Atti et al., 2004). Goats fed cassava root sieviate-cassava leaf meal at fed different levels (0%, 20%, 40% and 60%) signalled that the diets were beneficial and influenced lean meat deposition across treatment groups (Jiwuba et al., 2018). Mushi et al. (2009) observed superior weights and carcass yields in goats fed high energy diets. Goonewardene et al. (2002) feeding a high-energy and protein concentrate mixture to wethers post-weaning brought about substantial betterment in weight gain, efficiency, carcass weight and rib-eye area in goats. This is inconformity with observations elsewhere where high protein feeding improved dressing percentage in Angora goats (Shahjalal et al., 1992). Feeding high energy and protein potentially enhances carcass characteristics such as rib-eye area (Saikia et al., 1996). Fekliye et al. (2018) working with Farta sheep observed that slaughter weight, empty body weight and hot carcass weight improved with increase in the level of supplementation of fed urea-treated rice straw supplemented with graded levels of dried Sesbania sesban leaves. Dressing percentage on slaughter BW basis and EBW basis followed a similar trend. Feeding protected soy bean meal carcass weights and overall meat production in Kacang goats improved, however retained protein to the meat conversion ratio was compromised. The explanation was due to high dry matter intake and on the other hand, the most efficient retained protein to the meat conversion ratio was reported when goats were fed 50% of formaldehyde-protected soya bean meal. In a similar study Wildeus et al. (2007) reported superior growth rate and dressing percentage as a result of Alfalfa feeding, however there was no effect on carcass characteristics, meanwhile gender group determined mostly carcass-fat level. Soybean meal improve Kacang goat productivity and carcass products as compared to fish meal (Kustantinah et al., 2016). Moore et al. (2002) observed that carcass yield was superior for goats fed soyhulls or wheat midds than with goats fed hay diet, with carcass yield from goats fed corn gluten feed being midmost. Ad libitum feeding of whole shelled corn for a longer duration resulted in most fat carcass cover, while reduced feeding duration experienced carcasses with equivalent fraction of carcass fat to alfalfa fed lambs (Joborek, 2016). In the same study lambs fed soya bean plus corn cobs as a plant protein source against alfalfa had poor carcasses which was ascribable to the large proportion (33%) of corn cobs in the soya bean meal based diet.

3. Goat and sheep nutrition influencing dressing percentage

Dressing percentage is an equally quantitative and qualitative determinant in assessment of performance of meat producing species (Sultana et al., 2010). The impact of nutrition on dressing percentage cannot be underestimated because determination of plane of nutrition may positively support both the quantity and quality of the goat meat as a final product (Geay et al., 2001). Supplementation would normally be expected to show a higher dressing percentage due to improved nutrition. Ascertaining the impact of optimum nutrition on dressing percentage, carcass yield and meat quality properties in goats and sheep, it has been reported that there is an interaction of nutritional effect with other various factors such as genotype, age at slaughter, weight at slaughter, animal health, etc. Dressing percentage in ideal meat type goats and sheep have been reported ranging from 49 to 55 (Shackelford et al., 2006; Burke and Apple, 2007) under various nutritional regimes. While elevated metabolisable energy in diets was associated with enhanced carcass weight and dressing percentage, increased dietary protein outcome had permitted decreased in the dressing percentage (meat cuts) (Mahgoub et al., 2005). Variation in dressing percentage is mainly due to greater difference in proportion of non-carcass components such as GIT and weight of digestive tract contents (Addisu et al., 2002; Dhanda et al., 1999) which is mainly influenced by genotype other than nutrition. In a similar study Safari et al. (2011) explained superior dressing percentage as plausibly concomitant to better development of muscle and fat tissue due to increased dry matter and crude protein intake in Small East African goats. Dressing percentage was increased with increase of fatness and this is related to provision of high dietary energy in lambs, had also more effect on live weight at slaughter and weights of internal organs and body fat (Sayed, 2009). These finding are consistent with Hosseini et al. (2008) who fed high energy diets to lambs and observed accelerated fat deposition than those fed a roughage diet. Ibrahim (1996) providing differed dietary energy levels, reported dressing percentage on hot carcass basis of 50.42, 48.8 and

44.16 % for kids fed on high, medium and low dietary energy levels. Devendera and Burns (1983) observed that dressing percentage was influenced by nutrition regime and other factors such as genotype, age and gender. In a similar study by Jiwuba et al. (2018) apart from nutrition, dressing percentage variation was attributed to age and slaughter weight of the goats.

Ekiz et al. (2019) working with Kivircik lambs observed that in concentrate based system lambs had superior cold carcass weight, cold dressing percentage, and produced fattier carcasses with reference to those of pasture based system. In a similar study, Borton et al. (2005) observed compromised dressing percentage on lambs finished on pasture than those provided with concentrates, and this was ascribable to enlarged digestive tract and reduced external fat cover as a result of forage finishing systems. On the other hand, Priolo et al. (2002) interpreted higher carcass weight in feedlot lambs fed concentrates relative to pasture-fed lambs by the diminished proportion of the gastro-alimentary tract in feedlot lambs. In a comparative study in Kheri lambs of intensive feeding with ad libitum concentrate supplementation versus extensive grazing, Karim et al. (2006) observed that dressing percentage was higher in former. Rapeseed oil supplementation improved dressing percentage, carcass and half carcass weights, which was attributable to high energy level, crude fat concentration in lamb diets and higher dry matter intake (Miltko et al., 2019). These results were in conformity with those reported by Peng et al. (2010), who observed beneficial effects of rapeseed oil supplementation to diet on dressing percentage and carcass weight. Dressing percentage had a propensity to be lower for goats fed the hay diet with reference to soyhull, corn gluten feed, or wheat midd diets (Moore et al., 2002). Shahjalal et al. (1992) increasing crude protein concentration of diets resulted in superior dressing percentage in wether goats. Borton et al. (2005) observed no difference in conformation scores between concentrate and forage-fed (grazed ryegrass) lambs, but lambs fed the concentrate performed better in carcasses as a result of greater hot carcass weight and fat and lean quality scores. Orchardgrass and ryegrass pasture grazing compromised lean muscle, fat, and bone, outcome with the lightest carcass weights in comparison with lambs grazing alfalfa or being fed a concentrate diet in the drylot (McClure et al., 1994). Shorland et al. (1970) working with sheep observed that lambs raised on white clover pastures produced lean and fat that had ideal flavor intensities during various weeks of grazing.

4. Goat and sheep nutrition influencing carcass fat and meat fatty acids profiles

Quite a number of non-genetic factors have been implicated in influencing the composition of fatty acids in their rank is nutrition (Lawrie, 2006). Nutrition is the major determinant of overall meat quality (Andersen et al., 2005) especially the fatty acids which have been a major concern by consumers in recent times, due to their influence on human health. For the same reason, the effect of nutrition on meat fatty acids has been the subject of a considerable number of studies in goats and sheep meat production (Dermirel et al., 2006; Rhee et al., 2003; Banskalieva et al., 2000; Cameron et al., 2000). Apart from nutrition, Wood et al. (1999) observed that fatty acids composition of edible tissues of sheep was also impacted by genotype. The consumer preference and perception of healthy meat has changed over the decades. Healthy meat concern has been associated with the presence of fat and the composition of fatty acids. This draws to the fact that the fat fraction is one of the primary component of goat and sheep meat that is greatly influenced by nutrition (Murphy et al., 1994). On the other hand, fat is the most easily susceptible tissue in the animal's body that can be easily modified by dietary composition (Ayo, 2002). Fat increases as energy density increases in a diet while malnutrition regresses fat fraction to a larger extent retarding muscle development (Kirk et al., 1994; Awet, 2007). Several authors observed an enhanced internal and carcass fat in goats as a result of increased intake of energy in diets (Goetsch et al., 2011; Zervas and Tsiplakou, 2011). Tesema et al. (2018) partly reported similar outcome in crossbred Boer where supplementation enhanced mesenteric fat as compared to grazing alone. High fat content has been ascribed to high dietary energy density (Jabbar and Anjum, 2008; Cameron et al., 2001). The reason for high fat content with high energy diet is that such diets elevate ruminal propionate production, which is a precursor of fat synthesis. Therefore, any reduction in carcass fatness might indicate a compromised several dietary factors especially energy source and density. Elsewhere, Werdi et al. (2007) observed that supplementation with concentrate feed compromised carcass fat fraction in grazing goats. However, it has been noted that higher fat fraction with supplementation may be a result of inappropriate balance of energy and protein for ideal tissue protein synthesis, consequently a larger proportion of energy being deposited as fat (Manso et al., 1998). The breed effect on carcass variation in meat products cannot be ignored because genotypes of lower growth rate potential, intend to experience higher percentage of intramuscular fat than fast-growing animals (Murphy et al., 1994). Carcass parameters for crossbred Boer goat

displayed a linear relationship with supplementation, where carcass parameters increased as the supplementation level increased exclusive of fat thickness (Tesema et al., 2018). In a similar study by Hango et al. (2007) observed that carcass weights increased as a result of supplementation in Small East African goats. These results were inconformity with Safari et al. (2009) who reported the same trend working with Small East African goats and their crosses with exotic Norwegian goats.

Profound effect of dietary sources on fatty acids profiles was clearly shown by Manfredini et al. (1988) working with goats. Inconformity with this result was different rations were accountable to for much of the differences in the fatty acids composition in sheep (Rhee et al., 2003). Miltko et al. (2019) supplementing of linseed oil to diets seems to reduce the concentration of SFA and increase the concentration of n-3 PUFA. The n-6/n-3 ratio is an important nutritional factor, and its value has been favorably decreased below 2, thereby achieving an important target related to human health. Due to these changes carcass fatty acid profile was improved, and so enhanced lamb meat healthy properties. Differential feeding of concentrates as compared to roughage has clearly shown the differences in the nature of fatty acid profiles, possibly due impact of activation of ruminal biohydragenation of dietary polyunsaturated fatty acids (Lanza et al., 2006). Depending on dietary source rumen degradation predominant triglycerides are hydrolyzed and the unsaturated fatty acids are hydrogenated (Doreau and Chillard, 1997). In this case the influence of dietary sources as it relates to fatty acids composition of the dietary fat with polyunsaturated fatty acids comprising a more negative impact on cellulytic rumen bacteria (Coppock and Wilks, 1991). Feeding of concentrates and milk replacers may alter the fraction of different fatty acids in internal or subcutaneous fat working with different goat breeds (Casey and van Niekerk, 1985). Elevating the fraction of n-3 fatty acids in ruminant's diets may modify the fatty acids composition of their muscle tissue which suggest that entirely not all dietary fatty acids are completely hydrogenated in the rumen (Scollan et al., 2001). Intramuscular fat of the pasture based system lambs had greater percentage of ∑PUFA and ∑n-3 pufa, and lower n-6/n-3 ratio in comparison with concentrate based systems (Ekiz et al., 2019). Jenkins (1993) proved that the greater part of dietary unsaturated fatty acids is hydrogenated in the rumen (Jenkins, 1993), where odd chain and branched chain fatty acid with an iso-or anteiso structure derived from lipids of rumen microorganism could be a substrate for the host animal (Bas et al., 2003). Evidence is now growing that n-6/n-3 ratio was much more affected by feeding than by genetics (Choi et al., 2000). Studying fatty acids composition of adipose tissues and muscles in kids, Bas et al. (1987) observed that fatty acids composition reflected their milk intake, while tissue fatty acids composition of mature goats mirrored the modifications of dietary contents in the rumen by bacteria which favored an amplification in total saturated fatty acids content (Sauvant et al., 1979). During lactation the fatty acid composition of adipose tissue of kids is entirely up to the fatty of milk fat (Kuhne et al., 1986).

5. Implications for goat and sheep nutrition on dressing percentage, carcass parameters and meat quality properties

Nutrition and genotype indifferently are the major determinants of dressing percentage, carcass parameters and meat quality properties in goats and sheep. In order to get desirable and/or ideal dressing percentage, carcass yield and meat quality properties as a result of prescribed nutritional regime, animals should be slaughtered at an appropriate age and weight, and also sex of animal might need to be considered. Dietary manipulation through establishing an appropriate energy and protein balance improves feed intake to support weight gain and tissue amplification, which translate into desirable dressing percentage, carcass parameters and meat quality properties in goats and sheep. The variation in the fraction of protein and energy in finishing diets on kid/lamb nutrition is reflected in the nature of carcass composition (fat, muscle and bone), lean meat yield and meat quality. Therefore, meat producers should refine their protein and energy levels in their finishing systems to achieve ideal dressing percentage, carcass measurements and meat quality attributes. Dressing percentage is an equally quantitative and economic determinant used to assess meat performance in goats and sheep, however, apart from nutrition, variation in dressing percentage is ascribable to age and weight at slaughter in goats and sheep. The interactions of nutrition and different factors such as age, weight and sex need to be understood in order to establish guidelines for nutritional management of goats and sheep to improve dressing percentage, carcass characteristics and meat quality properties. Superior dressing percentage is plausibly concomitant to better development of muscle and fat tissue due to increased dry matter and crude protein intake, while nutrition regime that promote reduced external fat cover and enlargement of digestive tract will result in compromised dressing percentage. Concentrate based system promote superior dressing percentage, carcass weight and composition and produce fattier carcasses as

compared to those raised in pasture based system. The improvement of dressing percentage, carcass and meat quality properties due to supplementation is associated with increased apparent digestibility which translate into ideal average daily gain, body weight change and feed conversion efficiency. Proper nutritional modification can impart desirable fatty acid profiles in order to enhanced goat and/or sheep meat healthy properties as preferred by consumers. The existence of specific fatty acids profiles has been a major health scare in red meat consumption. However, nutritional manipulation has been the approved way of imparting the desirable fatty acids.

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