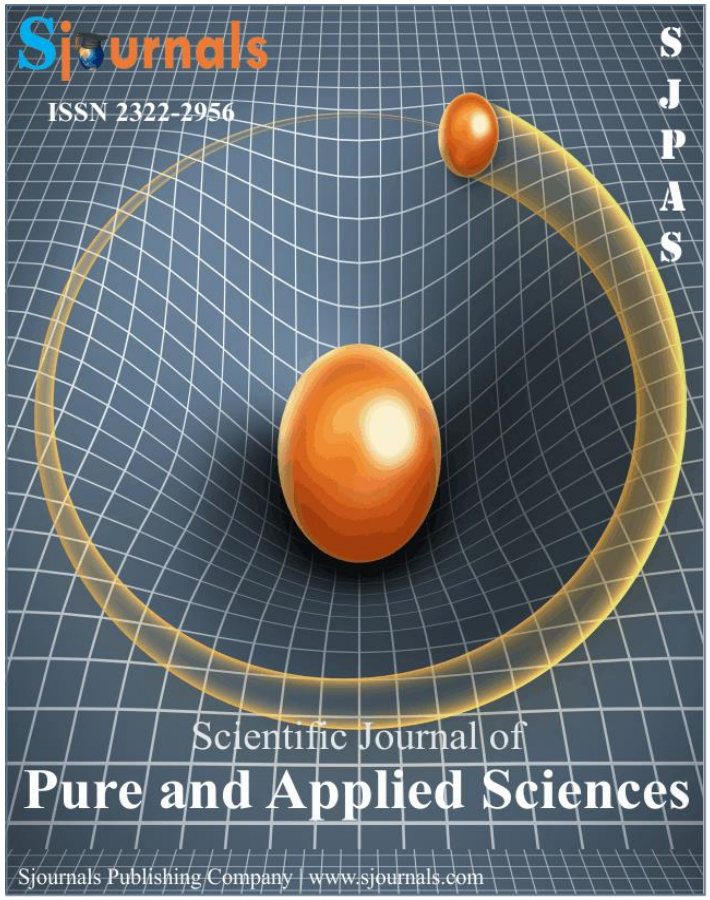
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Review article

Systematic crossbreeding and its impact on carcass parameters and associated meat quality properties in goats and sheep

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ABSTRACT

The major focus of any commercial goat and sheep enterprise is to maximize on carcass and meat production and obviously realizing substantial gain in profits. In modern goat and sheep meat production, crossbreeding has become an admissible and accelerated strategy to produce carcasses that ensure the point of departure for leaner meat, in addition to consumer acceptable carcass properties. It has become a norm that genetic manipulation for desired carcass and meat quality in small ruminants can be achieved through crossbreeding. There is considerable individual, maternal and paternal heteroses for carcass and meat quality properties in goat/ sheep crosses. In this regard, crossing of genetic distant goat/sheep breeds fortifies the degree of manifestation of carcass and meat quality performance results. In practice noticeable commercial gains have been achieved in improving carcass and meat quality properties through crossing indigenous and exotic goats'/sheep breeds, especially in low input production systems. It should be noted that the inconsistency on end results on the impact of crossbreeding on carcass and meat quality parameters is due to various non-genetic factors that are experienced in different production systems. Carcass and meat value is influenced by a significant number of different factors where the uttermost importance are genotype, nutrition, sex, age and weight at slaughter and management. In this case, comparability of results of crossbreeding on carcass and meat quality performance in different production systems have been debatable and complicated, due to the fact that in certain cases crossbred animals are slaughtered at the same age and varied sex, and/or different age and same sex, possibly differing in weight at slaughter. The differentiated nutritional management in extensive versus intensive production systems is critical in determining the quality carcass and/or meat in crossbred goat and sheep. Consumers have been the major prescribers of the intended form of carcass and meat quality proponents' world over, especially in developed countries. In this regard crossbreeding has been strategically used to customise meat production to the needs of various production systems, in terms of carcass and meat attributes seem acceptable by different host markets and consumers' expectations. However, it has been acknowledged that not necessarily every crossing is adapted for breeding to guarantee comparable desired carcass and meat quality parameters, hence different combination of two-breed and to a lesser extent three-breed crossing of selected populations of goats and sheep have been used to carter for the needs of different production systems and markets. Against this background, the application of any systematic crossbreeding strategy should take into account the appropriate breed combination by selecting right population to fulfill efficient goat/sheep meat production. Crossbreeding capitalize on genetic distance through utilizing superior specialized maternal and paternal breeds/lines for the purpose of maximizing their superiority, diluting their flaws for improved performance in carcass and meat quality parameters. Basically, crossbreeding is not one size fits all, in conformity with expanded genetic diversity of goat and sheep breeds and differential production systems, no one combination of specific breeds will work for multiple production systems. The purpose of the present review is to give an insight on the impact of crossbreeding on carcass and meat quality parameters in goats and sheep.

1. Introduction

For decades, crossbreeding has been extensively put into practice to efficiently improve carcass and meat quality properties in goats and sheep and its impact in this respect is well documented world over (Arrigoni et al., 2019; Claffey et al., 2018; Putra et al., 2017). Goat and sheep producers should generally prioritise the production of desirable carcasses (Abdelkareem et al., 2010) and high-quality meat (Webb et al., 2005) which are essential components of a viable meat production enterprise (Medeiros et al., 2012). In addition to growth performance, carcass and meat quality characteristics in crossbreds are among the important characteristics that have driven the gain in profitability in commercial meat production entities (Abuelfatah et al., 2013). As demonstrated by Carson et al. (1999) crossbreds of any breed apart from their superior growth performance, will take shorter term to reach targeted slaughter and carcass weights in comparison with straight breds. Therefore, exploitation of crossing becomes functional to maximize the combined potentiality of carcass and meat parameters of different goat/sheep breeds to produce consumer admissible products. The rapid and more simplified way of improving the growth, carcass and meat quality in kids/lambs comprise utilizing commercial crossing with the meat type breeds (Koutná et al., 2016; Yilmaz et al., 2010). Cameron et al. (2001) reported that genetic manipulation for desired biochemical and physical meat properties in small ruminants was achievable through crossbreeding. This is based on the fact that breed differences in carcass and meat parameters exist, which can be exploited to derive acceptable carcass and meat parameters through different breed combination (Hoffman et al., 2003). Providing proof on the impact of crossing in goats, Browning Jr et al. (2012) reported substantial individual heterosis for live, carcass, and primal weights ranging from 5 to 9%, while dressing %, proportional boneless meat yield and primal weight proportions had low individual heterosis of less than 2%. Carcass and meat production efficiency in sheep was enhanced by the use of prolific ewes, and the crossbred ewes derived from mating local breed to meat-type rams (Boujenane and Kansari, 2002). Herold et al. (2007) demonstrated that crossing specialised meat, dairy and fibre goat breeds produced vital crossbreds with desirable efficiency in unfavourable conditions while producing comparable meat and carcass performance. Fat cover on the loin muscles was greater of Scottish Blackface as compared with Texel cross Scottish Blackface ram and wether lambs (Claffey et al., 2018). The outcome of crossing Mahali with Damascus goat breeds improved growth rates in the kids, in addition to carcass as a result of improved slaughter weights (Ahtash et al., 2010). Reports on the impact of crossbreeding on carcass and meat quality parameters, in some cases are inconsistent because they are production system dependent. Non-genetic factors and their interactions such as plane of nutrition, age and weight at slaughter, castration, sex of animal etc. have influenced the variation in crossbreeding results on carcass and meat parameters in goats and sheep. Absolutely not every crossing gives similar desirable results hence the choice of compatible breed combination is a very critical component in driving the best performance out of crossbreeding systems. The purpose of the present review is to give an insight on the impact of crossbreeding on carcass and meat quality parameters in goats and sheep.

2. Systematic crossbreeding systems in goats and sheep

Crossbreeding taps from the diverse and vast genetic pool that gives a sound foundation for rapid strategy for improving carcass and meat quality traits in goats and sheep. This makes crossbreeding a vital tool to improve growth performance and some carcass and meat traits in goats and sheep. Heterosis effects were studied and estimates were important and positive for some carcass traits, namely carcass yield, width, shape and internal fatness (Dhanda, 2001). Crossbreeding, the mating of two or more genotypes of the same species is a widely admissible strategy used in commercial meat production because of the performance advantages it has to offer to goat/sheep producers (Atashi and Izadifar, 2012). For goat and sheep meat industry to remain competitive and viable should thrive to produce meat products that are consistent in quality and value (Montossi et al. 2013). A variety of factors influence the quality value of meat and its carcasses, while genotype, nutrition and management belong to the most important determinants (Zonabend König et al., 2017; Koutná et al., 2016; Asizua et al., 2014; Kuchtík and Dobeš, 2006). Exploitation of different goat and sheep genotypes to improve carcass and meat properties can be strategically used in straight breeding and crossbreeding. Current trends in small ruminants' production has focused on crossbreeding as an important source for increasing meat production efficiency (Shrestha and Fahmy, 2007). As demonstrated by Carson et al. (1999) crossbreds of any breed apart from their superior growth performance, will take shorter term to reach targeted slaughter and carcass weights in comparison with straightbreds. Therefore, exploitation of crossbreeding becomes functional to maximize the combined potentiality of carcass and meat parameters of different goat and sheep breeds to produce consumer admissible products. Systematic crossbreeding mode of production takes advantage of heterosis which is driven from utilization of breed diversity in goats and sheep to increase animal performance comparable to purebred flocks (Petrovic et al., 2011; Fathala et al., 2014). There is no single specialized goat and/or sheep breed that has finally met all the intended carcass and meat quality properties of diversified market demands and consumer expectations. In this respect the role of systematic crossing has been to take advantage of best performance parameters by mating two or more goats/sheep breeds where the crosses are enhanced in growth, carcass and meat quality properties. Crossing different breeds of goat/sheep have not only targeted combining specialized meat breeds, but also with other groups bred for other purposes such as wool and dairy goat/sheep breeds, which have high maturity; high feed efficiency and meat productivity. Yilmaz et al. (2009) improved carcass and meat quality parameters by crossing Saanen (dairy)×Hair Goat under an intensive production system. Successful goat/sheep crossbreeding ventures have been dependent on the genetic distance of breed utilized. The crosses of exotic and local goat/sheep breed in Africa have performed well in meat production. However, the limitation has been matching the crossbred performance with management and nutritional demand of animals. Crossbreds have failed to produce to their maximum due to scarcity of feed resources and associated poor management, especially in smallholder animal agriculture. On the other hand, the fail to choose appropriate breeds to use in a crossbreeding systems, will compromise breed complementarity, maternal and individual heterosis. In attempt to go round this challenge, Boujenane and Kansari (2002) worked with prolific ewes, and the crossbred ewes derived from mating local breed to meat-type rams resulting in greater improvement in meat performance in sheep. However, not every crossing is suitable for breeding to obtain the desired objective but also the application of two-breed system and three-breed crossing of selected populations of goat/sheep. The most common used systematic crossbreeding systems are terminal crossing and rotational crossing or crisscrossing. In rotational crossing utilizes two or more goat/sheep breeds in a rotation where rams/bucks are mostly purebreds. The ewes/does to which the rams/bucks are mated are purebred only for the first generation of mating. Rotational crossing utilising two breeds translates into potential heterosis in the first generation (F1), half in the second (first back-cross) then variable ratios, and three quarter in following generations. As a result of the fact that all females are crossbred after the first generation, there are known benefit of maternal heterosis for traits. Terminal crossing is the continuous production of F1 which are then slaughtered. Choice of two purebreds are used regularly to produce only first generation crosses (F1s). The F1 generation shows the whole of any heterosis which is acquired as a result of crossing the two breeds. This takes into account the relative role of the additive genetic and heterotic effects, and to the balance of the population which can be sustained as crosses.

3. Goat and sheep meat characteristics

Inclination of consumers to sheep and goats' meat, is probably driven by the desirable organoleptic quality, nutritional value, and palatability (Montossi et al., 2013). World over, the prime target of the meat industry is to produce acceptable sound carcass and high value meat with desirable properties consistence with the demands of different markets. The motivation of buying meat by modern consumers has been based on a plethora of factors such as eating quality, sensory properties and meat. Texture (appearance) (Grunert et al., 2004). However, feasibility of magnitude of quality differ dependent on the perception or expectations of consumers (Monte et al., 2007). Failure to provide the expectations of the modern consumers with appropriate products is the major challenge which has resulted in collapse on goat/sheep meat production ventures. In attempt to improve meat production one of the option to improve carcass and meat quality properties, more acceptable cuts were a focus on crossbreeding. Branched chain fatty acids possibly impart the typical sheep and goat species flavor (Ha and Lindsay, 1990). Webb (2014) pointed out that the phenotypic parameters and production potential of goats are extremely inconsistent, with consequential influence on carcass and meat quality. Goat meat has nutritional merits over other red meats due to its low fat content, elevated levels of protein, high iron and unsaturated fatty acids (Pratiwi et al., 2007; Madruga, 2004). The nature of protein in goat meat is of high biological index of approximately 60.4 and digestibility coefficient of 97% (Casey et al., 2003). Goat carcass fat measure is generally low, and fat deposition occurs much later in the growth process compared with other domesticated ruminants (Webb, 2014) and comparably low carcass fat content in goats has a bearing on the transformation of muscle to meat and subsequently meat quality (Webb et al., 2005). A low consumption of saturated fat and increased polyunsaturated (PUFA) to saturated fatty acid proportion is related to a minimised risk of human coronary heart disease (Simopoulos, 2008). Beyond, meat from young goats qualifies for edible portion of potential value, which can be a source in the production of healthy meat. The properties of young goat meat of low intramuscular fat content and a high level of protein and mineral elements (Kesava Rao et al., 2003, Pieniaklendzion et al., 2003, Sen et al., 2004; Sikora and Borys, 2006; Brzostowski et al., 2008) draws its healthy desirable meat properties for human consumptions.

Sheep meat has a lot of beneficial properties for human nutrition, is a source of proteins and essential amino acids, and has low concentration of lipids and saturated fat (Alves et al., 2014). Despite fat and meat colour being vital determinants of meat value to consumers (Ripoll et al., 2008; Calnan et al., 2016), and eating quality (Jeleníková et al., 2008), in recent years the quantity and the quality of fat of meat are also important because they affect consumer health (Martemucci and D'Alessandro, 2013). The meat of young animals is acceptable in terms of flavor, color and smell. Producers have focus on slaughtering young flock to meet the consumers' requirements, with a short life between birth and slaughter compared to other ruminants. Thus, producers need to properly plan and execute their production system through choice of production systems, considering suitable breeds, nutrition and climate (Macedo et al., 2000; Osório et al., 2012). Sen et al. (2004) proved distinctively lower shear forces of 7.42 kg/cm2 in goats and 3.74 kg/cm2 in sheep with goats having also tougher meat in sensory evaluation.

4. Crossbreeding impact on carcass and meat quality parameters in goats

There has been an attempt to develop diversified and location specific goat meat breeds, however despite the within breed intense selection to improve carcass and meat characteristics, in no way has any breed been flawless in stipulation of desirable carcass and meat quality acceptable to diverse consumers' expectations. It is now agreeable that there is lack of consistency in developed breeds to demonstrate possession of all of the carcass and meat quality attributes imperative to produce efficiently in diverse production systems and markets (Shrestha and Fahmy, 2007). In this regard crossbreeding has been strategically used to circumvent the needs of various production systems, in terms of carcass and meat attributes seem acceptable by different host markets and consumers' expectations. Crossbreeding now has become an admissible strategy to realise carcasses meat parameters that ensure the point of departure for leaner, but additional consumer acceptable carcass and meat quality properties. Crossbreeding has the prospects of improving viability and efficiency of goat meat production by increasing the performance potential of the kids produced (Yilmaz et al., 2010). In other meat species, such as rabbits (Assan, 2017) and pigs (Weschenfelder et al., 2013), exploitation of crossbreeding has been used effectively as a strategy to accelerate the improving carcass and meat parameters. Carcasses of meat animals are composed primarily of Muscle, fat and bone ratios are the major constituency of carcasses of meat animals, of these muscle is the most important part contributing to the edible human potion (Cloete et al., 2004). Carson et al. (1999) proved that it's not just crossbreeding as such that will provide benefits on carcass improvement, but the alternative breeds used to produce the crossbred progeny. Among the meat developed goat breeds.

Joshevska et al. (2016) working with domestic Balkan and Alpine crosses reported that crossbred kids had higher carcass weight and dressing percentage and weight of all analyzed internal organs than kids from domestic Balkan breed. The effects of breed in crosses was a major component that contribute to improved carcass traits and more desirable meat quality in this study. Spanish goats and their crossbreds' derivative from Boer, crossbreds' kids resulted in improved live weights and carcass than their parental breeds (Oman et al., 1999). In a similar study, Oman et al. (2000), reported lighter slaughter weights and hot carcass weights than other crosses on an age dependent slaughter, while carcass parameters were a bit shorter than those of other genotypes. However, leg circumferences of purebred Angora goats were smaller than those of crossbred Boer x Spanish- and Spanish x Angora-goats. Comparable carcasses ranging from 12.7 to 13.8 kg, resulting in non-significantly different carcass yields of 49 to 46%) were observed for four crossbred genotypes, but ½ Boer + ½ SPRD and ½ Anglo Nubian + ½ SPRD goats had higher carcass yields than the pure-bred Boer and ¾ Boer + ¼ SPRD goat (Medeiros et al. 2012). This indicates that Anglo Nubians and Boers have proved as some of the best goat breeds for utilization in crossbreeding to improve meat production efficiency. Also working with Anglo-Nubian goats Al-Ojaili (1995) reported increased goat meat efficiency in crossing of Dhofari with Anglo-Nubian in Oman. The outcome of crossing Mahali with Damascus goat breeds improved growth rates in kids, in addition to carcass as a result of improved slaughter weights (Ahtash et al., 2010). However, it was suggested that studies to ascertain performance of crosses in different production systems is worthwhile, because there is variation in performance of the same goat breeds crosses in different production systems. Crossbreds have a tendency of perform highly on high plane of nutrition that has a bearing on their carcasses and meat quality. The same crosses have featured differently in extensive versus intensive production environment mainly being influenced by nutritional management. Crosses kept on range are more likely to limit their fat content which might be desirable for certain segments of consumer preference. In comparison of crosses of Mahali*Damascus versus Mahali*Morca Granada, the former had superior live weight, slaughter weight and dressing percentage than the latter. The entails a Mahali* Damascus should be the choice for a two breed meat production efficiency as reflected the crossbred potentiality. The average dressing percentage for crossbreds was 50.1% for three quarter Damascus with one quarter Mahali goat. The probable reason for differences in purebreds and crossbreds was the differences of the stomach and intestine at slaughter (Van Niekerk and Casey, 1998).

Misra (1983) assessed kids of the Black Bengal, Jamunapari and beetle breeds and their crosses and observed that large breeds had potential advantage for enhancing meat production in small and medium goat breeds in India. Mai et al. (1993) working with different breeds (Black-Bengal, Barbari and Anglo-Nubian, and Barbari Black Bengal) and their crosses, the crossbred kids remained intermediate in carcass parameters as compared with kids of their purebred parents. Deducing from reports from Herold et al. (2007) one outstanding, and often ignored impact of crossbreeding is the tendency for crossbreeding to influence birth weight. Birth weight differences in crossbred will have profound influence on a few carcass parameters. Therefore, probably higher birth weight in kids/lambs might have high chances of superior carcass performance especially in some valuable parts. Related to birth weight, Villete and Theriez (1981) observe that the carcass derived from low birth weight lambs had more fat and less bone. In higher birth weight lambs, chemical composition of the carcass in addition to that of the body weight exhibited a higher and lower, fat and water, respectively.

The crossing of exotic Boer and Anglo Nubian breeds with the local SPRD resulted in a goat meat of high quality. Border Leicester x Merino crosses carcases experienced as much as 3.2% less saleable meat yield than the Texel cross genotypes which commensurate to 760g less meat in a 23.7 kg male carcase. The extent of the dissimilarity widened as the carcasses became heavier (Hopkins et al., 2013). Medeiros et al. (2012) working with pure-bred Boer and ½ Anglo Nubian + ½ SPRD goats stood out, with values of 48.1 and 48.6 g.100 g-1, respectively, indicating more succulent meat. Saanen x Angora-crossbreds had significant lower proportion of muscle content of the carcass than purebred Saanen, Boer and Feral goats or crossbreds (Herold et al., 2007). Carcass weight superiority of Boer × Spanish first progeny kids over purebred Spanish kids was also partly due to high concentrate rations, however sire breed did not alter boneless lean proportions (Oman et al., 1999; 2000). Gadiyaram et al. (2008), studying the effect of electrical stimulation post-mortem on the meat quality of male Boer × Spanish × Kiko goats, reported SF values of 4.6 and 3.8 kgf.cm-1 at 1 and 4 days' post-mortem, respectively. Sen et al. (2004) found values of 4.2 kgf.cm-2 and 7.42 kgf.cm-2 in the meat of crossbred Boer and native goats, respectively, in India.

The meatiness and the fatness are prominent parameters that determine the carcass value (Dvalishvili et al., 2015). Fat deposition between breeds and their crosses is more associated with different locations of fat deposit (Putra et al., 2017). Herold et al. (2007) working with crosses from specialised meat, dairy and fibre goat breeds, crossbreds had higher scores of meatiness, while differences in fat cover did not exist between crossbreds and purebreds. Yilmaz et al. (2010) working on hair goat and Saanen x hair goat crossbred kids produced rather light (6.49-7.29 kg) carcasses with very low level fatness in intensive fattening after weaning. These results might explain the ineffectiveness of intensive fattening on these genotypes in given environmental conditions. Weight of fat around stomach and intestines did not differ amongst crossbreds, this ranged from 550-793.8 gm for purebreds (Mahali, Damascus, Morcia-Granada), 650-975 gm for half bred contemporaries and 762.5-987.5 gm on three quarter crossing groups (Abdelkareem et al., 2010). This was in conformity with result by Pralomkarm et al. (1995) who also reported no significant variation in stomach and intestine fat in pure and crossbred kids. Working with Johnson (2000) reported that purebred Cashmere and Boer x Cashmere kid carcasses were superior in subcutaneous and intermuscular fat than carcasses of Boer x feral kids. Chevon carcasses of Boer x Angora-crossbreds had enhanced subcutaneous fat thickness as compared to other genotypes (Dhanda et al., 1999). Prime cuts from purebreds Angora carcasses were among the fattest, similarly Spanish x Angora-crossbreds (Oman et al., 2000). Gutierrez et al. (2005) showed an enhanced fat deposition in Rambouillet x Pelibuey as compared to Pelibuey purebred. The superiority of weight around the kidneys in goats is ascribable to differences in weight at slaughter (Treacher et al., 1987). Kidney-pelvic fat percentage in Boer and Spanish sired F1 kids lacked total internal fat that differed from F1 kids of other sire breeds (Menezes et al., 2009) or purebred kids from local sire breeds (Cameron et al., 2001). Gibb et al. (1993) using Saanen maternal lines observe that Boer-sired kids manifested less internal fat than Saanen-sired kids. Boer, Saanen, and feral-sired kids bred from feral dams were not different in kidney-pelvic fat percentage and percent total internal fat, while Boer-sired F1 kids from Angora mothers deposited less pelvic fat percentage and consequently total internal fat than Saanen-sired F1 kids from Angora does (Dhanda et al., 2003). Salvatori et al. (2004) observed the fatty acid palmitoleic acid proportions in the semimembranosus muscle of lambs varied between the crosses French Ile x Pagliarola and Gentile di Puglia x Sopravissana. However, no variation was note in the Longissimus lumborum and gluteobiceps muscles. Medeiros et al. (2012) Shear force (Kgf.cm-2) was similar (9.4; 10.2 and 9.1) among the three groups (pure-bred Boer, ¾ Boer + ¼ SPRD and ½ Anglo Nubian + ½ SPRD goats, respectively) and higher than that of the ½ Boer + ½ SPRD goats (7.4). Medeiros et al. (2012) crossing of SPRD goats, a native genetic group with low genetic aptitude for meat production, with breeds selected for meat production, such as Boer and Anglo Nubian, can improve the sensory attributes of goat meat. Monte et al. (2007) observe that goat meat from Anglo Nubian* Boer crossbreds, when assessed had lower hardness than SPRD goat meat.

5. Crossbreeding impact on carcass and meat quality parameters in sheep

Crossbreeding enhanced pre-slaughter weight, hot carcass weight, slaughter weight and cold carcass than the purebred lambs (Dvalishvili et al., 2015). The hot carcass weight of crossbred lambs outclassed their purebred counterparts by 2.8 kg, consequently, the proportion of muscle to bone was considerable higher by 13%. Zonabend, König et al. (2017) in a study working with Red Maasai and Dorper sheep and their crosses, the crossbreds were of higher rank to the two parent breeds for live weight, conformation, carcass traits. Individual heterosis effects founded on the 50 % crosses were estimated reasonably high at 6.5 % and 12% for live traits and carcass weight, respectively. In a similar study, Abdullah et al. (2011) assessing Awassi sheep and their crosses with Charollais and Romanov sheep reported that hot and cold carcass weights and dressing% differed considerably with (F_1 Charollais-Awassi) crosses, characterised by higher values than purebred Awassi sheep, while the (F_1 Romanov-Awassi) crosses had transitional values. The same authors concluded that the crossbreds Awassi with either Charollais or Romanov yielded higher meat yield and quality, at the same time (B_1 Awassi-Romanov-Awassi) progeny gave midway values in the absence of any adverse effects on meat quality. Hot carcass and cold carcass weight in a crossbreeding study showed breed effect was very important, with purebred Merino demonstrating lower weights compared to both Dorset and White Suffolk crossbred lambs (Flake et al., 2015). Burke et al. (2003) reported differentiated meat yield within Dorper, St. Croix, Romanov, Katadin, and the Dorper x Romanov x St. Croix cross. The observation was in conformity with Gutierrez et al. (2005) who worked with Pelibuey, Suffolk x Pelibuey, and Rambouillet x Pelibuey breeds.

Texel cross Scottish Blackface lambs displayed higher dressing percentage in respect of purebred Scottish Blackface, predictably wether lambs had greater dressing percentage compared with rams (Claffey et al., 2018). Dressing percentage for first generation kids sired by Boer buck bred to Saanen does were greater than for pure bred Saanen kid contemporaries (Gibb et al., 1993). Tsegay et al. (2013) working with crosses between Dorper and Blackhead Ogaden, showed that Dorper crosses disctinctly had the highest dressing percentage. Dressing percentage founded on the hot carcass weight, displayed no variation between crossbred (R × A) and purebred Romanov lambs (Dvalishvili et al., 2015). In Texel cross Scottish Blackface lambs, Speijers et al. (2009), reported a 2.5 percentage increase in dressing percentage in favor of the crosses as compared with purebred Texel lambs, while also an increased dressing percentage in wether lambs compared with ram lambs. The lower dressing percentage in ram lambs was partly attributable to the weight of the testes and heavier horns, particularly in Scotish Black ram lambs, which outright contributing to final slaughter weight unlike carcass weight. Apart from dressing percentage variation separating crossbred ram and wether lambs may be ascribable to the heavier liver, lungs, and heart in ram lambs compared with wether lambs (Morgan and Owen, 1973). Zonabend König et al. (2017) in a study working with Red Maasai and Dorper sheep and their crosses, the dressing percentage, effects of individual heterosis appeared negligible, this entails crossbred groups results pertaining dressing percentage likewise comparable with to Red Maasai than to Dorper. The superior effects of the crosses indicate one prime reason why crossbreeding between Red Maasai and Dorper has become very common mode of production in sheep. The low maintenance of local sheep and ability to adapt to harsh environmental conditions suffice to exploit crossbreeding in sheep production. The local dams have good mothering ability as a result their use as dam lines to faster growing crosses of exotic breeds rams may be an acceptable production system. Overall the results suggest that there are not likely to be large benefits from crossbreeding for tenderness or eating quality traits and in fact selection within say Terminal breeds for traits like muscling need to be carefully monitored so as not to have a detrimental effect on sensory traits (Hopkins et al., 2005). There was a considerable variation in meat quality properties for *M. semitendinosus* with pure Awassi possessing greater cooking loss%, and hue angle values but lower redness values than their crosses with Charollais and Romanov (Abdullah et al., 2011). In the same study lightness values for *M. semitendinosus* were greater for Awassi-Romanov-Awassi) crosses and (Awassi) purebreds, with no agreement between (Awassi) and Awassi-Charollais-Awassi) genotypes. Hernández-Cruz, (2009) working with (Pelibuey x Katadin x BlackBelly) and (Rambouillet x Criollo) crosses of lambs fattened on a high plane of nutrition to attain 40kg body weight at ten months of age, it was observed that protein content in meat derived from neck and loin were higher in former than later, while moisture in muscle was higher in later than former group.

Crossbreeding improved carcass traits by virtue of cut down in body fat in the fatty tailed sheep breeds (Farid, 1991). Gutierrez et al. (2005) reported elevated fat proportion in Rambouillet x Pelibuey than in purebred Pelibuey. There were no differences in meat quality measures of visceral mass fat and carcass fat mass between purebred and crossbred Romanov male lambs (7/8 Romanov:1/8 Argali) (Dvalishvili et al., 2015). Fat cover on the loin muscles was greater of Scottish Blackface as compared with Texel cross Scottish Blackface ram and wether lambs (Claffey et al., 2018). In this study the animals were fed concentrates and were slaughtered at different ages. The implication of this suggests that crossbreeding is a potential strategy in improving lamb meat production, however sex of animal will influence the end results. Ram lambs' finishers may be a potential choice to increase growth rates and food conversion efficiency, and produce an even more necessary carcass than do wether lambs. In the same study loin muscle and fat components were dependent on sex, where females demonstrated lower muscle proportions and higher fat proportions as compared to males. The differences reported in fat cover between sheep breeds could be explained by the early maturation of lambs and increased deposition of adipose tissue at a lighter weight compared with the later maturing breeds. Crosses of a higher mature weight potential, growing toward maturity, will be less fat at any given weight compared with an animal of lower mature weight potential. Mainly, because these are at a lower proportion of their mature weight, thus are still utilizing the energy for growth and muscle development instead of lay down fat (Wood et al., 1980). Crossbred ram lambs produced carcasses which resulted in an ideal fat score of 3.07, while wether lambs yielded carcasses with an excessively high mean fat score of 3.91. The leaner carcasses produced by ram lambs compared with wether lambs is consistent with the reports of Lee et al. (1990) and Hopkins et al. (1991). High carcass fat cover is an undesirable attribute for processors. Variation in dressing %, yield grade and REA were determined by the sire breed in the crossbreeding application, with Dorset and White Suffolk sired progeny having elevated values as compared to the Merino, which showed lower fat thickness compared to other sire breeds. No difference existed in body wall thickness or GR fat score (Flakemore et al., 2015). It has been established that dressing percentage increases with age of lambs (Ghanekar et al., 1972) and this influence is dependent in increase in body weight (Basuthakur et al., 1980). Dvalishvili et al. (2015) working with Romanov ewes with crossbred Argali Romanov rams improved muscle tissue by 15% and intramuscular fat appreciated by 57%, while bone proportion did not differ in carcasses of either purebred and crossbred Romanov lambs. Merinos had lower sensory scores than Border Leicester x Merino (BLM) lambs for two different muscles, which may have reflected a slower rate of pH decline in the Merino lambs (Hopkins et al., 2005).

6. Implications

Crossbreeding is an efficient and quick mode of improving carcass and meat quality properties in goats and sheep. Comparability of results of crossbreeding on carcass and meat quality performance in different production systems have been debatable and complicated, due to the fact that performance results are taken from crossbred animals might be slaughtered at the same age and varied sex, but differing in their slaughter weight. Absolutely not every goat/sheep breed combination will give desirable results on carcass and meat quality properties in crossbreeding. Choice of compatible or suitable goat/sheep breeds combinations are very critical component in driving the best performance results out of crossbreeding. There is substantial individual, maternal and paternal heteroses for carcass and meat quality properties in goat/ sheep crosses. In pursuance of improved goat/sheep meat production efficiency, systematic crossbreeding should be intentionally configured taking into consideration the strong points and weaknesses of the paternal and maternal goat/sheep breeds/lines being used. There are potential sire goat/sheep breeds that can improve carcass and meat quality properties, and also alternate dam breed has an influence on the extent of improvement of carcass and meat quality properties in goats and sheep. The comparable potentiality of sires/paternal lines in crossbreeding for improved carcass and meat quality properties becomes more apparent when assessed subject to controlled nutritional conditions and using invariable dam breeds. Differences of flock management practices and conditions despite using similar mode of crossbreeding will influence carcass and meat quality properties differently, hence comparative assessment of breed effects in crossbreeding on goat and sheep carcass traits and meat quality traits in contradicting production systems would be worthwhile. Non-genetic factors and their interactions such as plane of nutrition, age and weight at slaughter, castration, sex of animal etc. are the sources of the differential performance results in goat/sheep crossbreeding. Crossing genetic distant goat/sheep breeds fortifies the degree of manifestation of carcass and meat quality performance results. Considerable commercial gains have been achieved in improving carcass and meat quality properties through crossing indigenous and exotic goats/sheep breeds in Africa.

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