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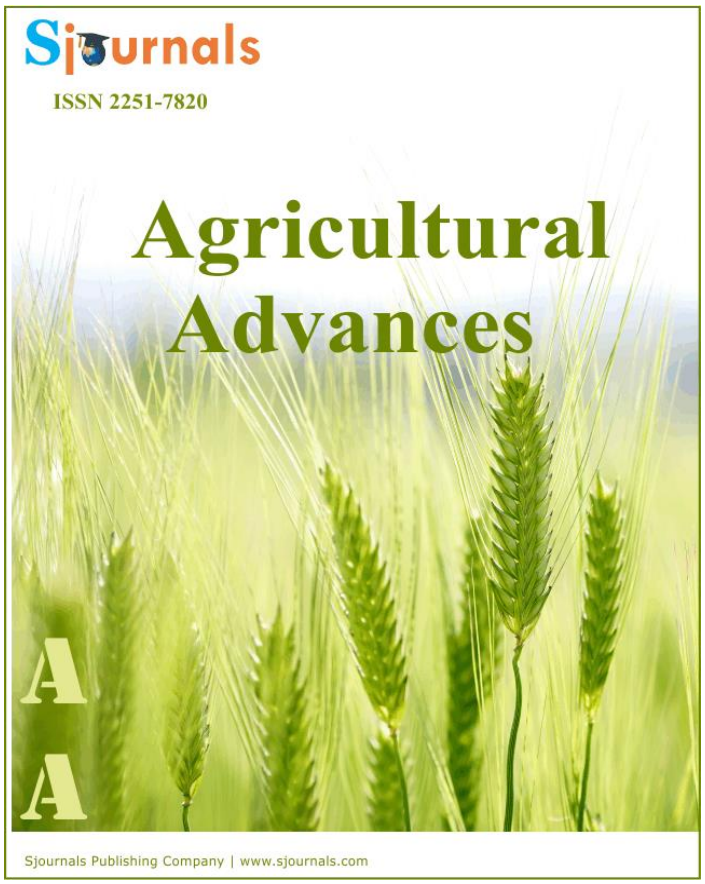

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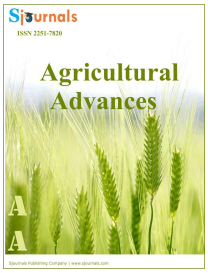

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Review article

Weaning age/time based model influencing performance in goats and sheep meat production

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ABSTRACT

Weaning is an essential animal husbandry intervention which has been associated with nutritional stress that interferes with both animal's behavioral and physiological responses consequently influencing post weaning growth performance in goats and sheep production. The timing of weaning and/or weaning age of kids/lambs becomes critical in determination of flock performance with the intention of maximizing meat productivity and improving profitability. There are two possibilities that exist in deciding on weaning age of kids/lambs, thus early and late weaning, however, the decision on when to wean is dependent mainly on the production environment and purpose, as well as the dam welfare. Age at weaning differ greatly in sheep and goats, therefrom 14 days to natural weaning, and exceeding four months of age. In sheep production effective early weaning has been practiced untimely at 14 days; in goats' kids have been weaned early successfully at 28 days. Early weaning is considered traditionally weaning ahead of the 90 days of age; 60 days is most widely used; age thereafter qualifies for late weaning. The age at weaning greatly influences post weaning animal performance, however if not timed properly it would impact negatively also on *weaner survival rates.* Weaning itself is a very stressful procedure and subjecting kids/lambs to further stress which directly impinge on the kid/lamb's immunity consequently increasing their susceptibility to diseases and reduced weight gain. There is need for age of weaning to balance the potential positive impacts on the ewes/does to rebreed, with potential negative impacts on the kid/lamb growth performance and survivability. Early weaning has become an effective

husbandry practice especially in advanced goat and sheep production systems, which focuses on shortened female breeding reproductive cycle, while enhancing meat productivity through increased frequency of kidding/lambing. It is important to consider weaning age in relation to nutritional strategies which provide adequate time for diet transition which is intended not to compromise feed utilization and feed conversion efficiency in kids/lambs consequently reducing growth performance. The effectiveness of weaning age and anticipated live weight gains post-weaning is dependent on nutritional management especially concentrate supplementation which may promote performance and productivity in pastured based systems. Late weaning is probably convenient for less prolific goat and sheep breeds and genotypes not selected for their growth potential. It should be acknowledged that there is interaction between weaning age with other factors such as nutrition, sex and weight of animal. Some of the goat and sheep producers worldwide have shifted to use of weight based weaning model, similar age but with different weights, heavier lambs have superior development efficiency during lactation. The present review gives an insight on the consequences of early and late weaning on animal's post weaning performance in small ruminants.

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1. Introduction

Weaning age is an important factor of influence on post weaning performance in goats and sheep meat production. Goat and sheep meat production systems around the world are extremely diverse, as a result practiced of age at weaning varies dependent on degree of sophistication of production systems. In intensive goat and sheep production systems, weaning as of late has evolved into early and later weaning, and also certain segments of goats and sheep producers have adopted the weight based weaning model. Weaning kids/ lambs when they are 60-90 days' old has been the standard procedure for most goat and sheep producers. One of the many studies cited the most economical and productive weaning ages as between 35-40 days, however, the optimum age at weaning was prescribed as 2 months of age (Zapasnikiene, 2010). Early weaning at 45 to 60 days of age is a common management practice, Abdel-Fattah et al. (2013) and Bath et al. (1978) suggested weaning age of 75-90 days, after birth in sheep. However, the decision on weaning age varies depending on the production conditions (Kashani and Bahari, 2017). Singh et al. (1991) reported that weaning age of Black Bengal goat was three months which was inconformity with results by Islam et al. (2009) working with the same breed of goat. Sex greatly influenced live weight and average daily gain under early and late weaning ages (Abdel-Fattah et al., 2013). Late weaning will favour a longer lactation length of the ewes/does as a result adversely affecting the dam's productive life in the long term. On the other hand, delayed weaning becomes a costly strategy and also its adversity on the development of a functional reticulo-rumen due to delayed stimulation of solid feed (Lu and Potchoiba, 1988). Average weight gain was important between sexes, but no resemblance was exhibited between weaned and unweaned lambs at the ages of 38 to 40dys (Sañudo et al., 1998). Nagpal et al. (1995) reported a weaning age × feeding system interaction which seemed to have influenced body weights, average daily gain and pre-slaughter weight. Hanan and Ellamei (2013) observed that fat deposition was influenced by age at weaning, where early weaning promoted greater fat deposition in the tail, while late weaning promoted fat deposition in intestinal region. The present review gives an insight on the consequences of early and late weaning on animal's post weaning performance in small ruminants.

2. Weaning age influencing kid/lamb performance parameters

2.1. Conversion

2.1.1. Liveweight

Hassan (2017) studied the effects of weaning age on Ossimi lambs on growth performance, and observed that early weaning of lambs at 56 days of age, resulted in the improvement of liveweight, TWG and average daily gain, with reference to those lambs weaned at 84 and 112 days. This also applied to TFI, DFI, FCR and EFE which were superior in early weaners than late weaners. In this study it was concluded that Ossimi sheep should be weaned early at 56 days in order to benefit from heavier liveweight, TWG and average daily gain. Ossimi breeds are known for their low milking capacity to nurse their young ones to their full potential hence early weaning will facilitate lambs to adjust to forage consumption and creep feeding at an early age. Maternal viability and efficiency of raising lambs to promote lambs' growth potential during the suckling period is an important trait associated with successful pre-weaning, because there is a positive correlation with maternal milking capacity in this phase (Al-Saigh and Al-Najjar, 1999). Previously, studying Lori lambs, the superior feed conversion ratio was attained at 60-day weaning age, while the least feed conversion ratio was exhibited in the 120 days weaning age (Nikkhah and Moghadam, 1975). Cañeque et al. (2001) concluded that feed conversion ratio would be reduced in case of lower weaning age, however, this trend seemed to differ in intensified and more intrinsic by widening the length in suckling duration of lamb (Kirton et al., 1982). Kashani and Bahari (2017) working with Romanov*Zel crossbred sheep reported that weaning at 45-day of age may provoke decreased feed conversion efficiency, while 75-day weaning age had superior average daily gains. Similar resulted were reported by Kordkoy et al. (2009) on age of male lambs in feedlot conditions.

2.1.2. Dain gain

Average weight gain was important between sexes, but no resemblance was exhibited between weaned and unweaned lambs at the ages of 38 to 40 days (Sañudo et al., 1998). The sex differences in performance of weaned males and female lambs might be related to hormonal profiles. In a study sex-dependent variation on early weaning at 5 weeks of age, Cieslak et al. (2015) observed that there was lower cortisol secretion in male lambs as compared with the greater cortisol secretion in female lambs at 16 weeks of age. Early weaning results in the sexually dimorphic stress reaction that is more potent and long-lasting in female in contrast to male lambs. In female lambs, the stress reaction of early weaning is strong and long-lasting. Lambs weaned with older ages, after an extended suckling period had a compromised post-weaning performance as compared to those weaned earlier (Selaive-Villarroel et al., 2008). Poli et al. (2008) and Ribeiro et al. (2009) observed that early weaning exhibited low yields and productivity for lambs raised entirely on pasture. This reduced performance was explained by alteration of animal's nutritional status and metabolic profiles which impinged on growth performance. It was proposed that accompanying early weaning there should be a provision of concentrated supplementation in order to improve performance in lambs based on pasture. Milk replacing intake in suckling kids/lambs greatly influence feed intake and the daily weight gain between different weaning times (Joz et al., 2007), while feed intake tends to be increased with advanced weaning age (2009). The development physiology of the digestive systems has been the fundamental basis of timing of weaning for kid/lambs. Despite the weaning age or how to manage it and the development of the rumen, especially gastric degradability which is dependent on the type of feed intake has been the major focus on weaning time (Kashani and Bahari, 2017). The advances in goat and sheep production environment coupled with increase in demand for quality mutton and chevon in developing countries producers have been forced to adopted accelerated forms of meat production, which has favoured the use of early weaning in small ruminants. The early weaning based model of production has taken cognisance of kid/lambs' gastrointestinal development physiology which is an important component in feed utilization at an early stage of growth. Through compensatory growth early weaners have exhibited potential of fast growth, at the same time early weaning gives enough dams to recover their body condition ready to conceive for the next reproductive cycle, and all this will result in a shorter generation interval enhance lifetime performance of individual dams. Time evolution of pre-rumination to rumination, which principally accompany the volatile fatty acids has been considered an important process in kid/lamb nutrient utilization at this stage. This takes into account that feed form and type as it influences the rumen growth and development (Sharifi and Khadem, 2012). On the other hand, Abdel-Fattah et al. (2013) noted that early weaning was a relative concept, in actual terms early weaning kids/lambs are separated from their dams at around 14 days, however in most cases before 90 days. Predominantly, sixty (60) days has been exploited as weaning age in intensively managed sheep operations. Early weaning (between 40 and 60 days of age for lambs) may be a strategy to increase productivity and enable ewes to have a greater period to rest and recover their body condition. Weaning grazing lambs earlier than 45 days of age is not advised, as these lambs will suffer large growth setbacks, whereas 60 day old lambs are much more capable

of making a relatively seamless weaning transition. Weaning depressed average daily gain by 92 g/d and wean and suckled lambs experienced 113 g/d and 205 g/d, respectively (Fernandes et al., 2012). In the same study early weaning enhanced adverse metabolic profiles resulting into compromised performance in lambs. This means it might not be proposed as single strategy to rear lambs on pasture. On the other hand, supplementation with concentrates had a comparable effect to suckling on lamb performance and metabolic profiles, and it a feasible option to improve the nutritional condition of early weaned lambs. The age at weaning along with nutritional status succeeding weaning did not adversely influence growth and milk yield, therefore early weaning might be a feasible mechanism to effectively curtail the cost of the rearing period in goat kids (Panzuti et al., 2018). Fernandes et al. (2014) working with Suffolk lambs concluded that early weaning fortified with enhanced nutritional regime in the post-weaning period is an effective means in finishing lambs for the market. Diets with high protein and energy content are suitable for lambs weaned on pasture, while high concentrate would ensure improved feed intake after weaning. It has been noted that sometimes apart from enhancing weight gain, unweaned lambs have produced heavier carcasses with higher yields and higher fat content than the systems where lambs are weaned. In a comparative study of weaned and unweaned lambs slaughtered at a weight range of 32 to 34 kg, the carcasses weight and yield were superior for unweaned with reference to weaned ones (Fernandes et al., 2008; Ribeiro et al., 2009). One of the many studies cited the most economical and productive weaning ages as between 35-40 days, however, the optimum age at weaning was prescribed as 2 months of age (Zapasnikiene, 2010). Weaning age is crucial for the success of early-weaning which has become a major animal husbandry intervention for improved efficiency and profitability of intensive sheep production system (Chai et al., 2015). Early weaning has been a common husbandry practice especially in advanced goat and sheep production systems, which focuses on shortened female breeding reproductive cycle and enhanced meat productivity through increased frequency of kidding/lambing. For early weaning kids/lambs can be weaned at the age of 21 to 35 days of age. Wang et al. (2019) reported that early weaning reduced average daily gain however without any adverse effects on the lambs' immunity hence weaning at 21 days of age was concluded to have a negative impact on lambs' performance. Successful early weaning is dependent on the lamb's ability to utilize solid food. Rumen development is therefore the most important physiological factor to consider. Lambs will begin to nibble at hay and grain at a very young age, at least by the time they are a week old. Although they won't consume significant amounts of feed until three weeks of age, the small amounts are very important for establishing rumen function and the habit of eating. Early weaning of Sahiwal calves and offering them solid feed or using milk replacer reduced pre-weaning feeding costs, however, this practice resulted in poor weight gains at weaning (Bhatti et al., 2012).

Advanced weaning age or late weaning in Lori enhance daily weight gain and final weight (Yarahmadi et al., 2006). In a previous study on late weaning at (56, 112 and 168 days), Pretorius (1966), reported that growth was profoundly reduced at 56 days, but only for the first two weeks after weaning. The 56 days of age at weaning was however was within the recommended age range by Castillo et al. (1973) who subscribe to best weaning age as being between 75 and 90 days of age. The nonconformity of the weaning age to this age range might be explained by the interactions of weaning age by other factors such as nutritional status, weight at weaning, and sex of animal. Selaive-Villarroel et al. (2008) observed that weaning lambs at different ages (60, 75 and 90 days) did not influence post weaning growth, and a similar result was reported by Cañeque et al. (2001). Apart from early weaning between 40 and 60 days of age in lambs being an effective option to enhance meat productivity, it also provides an extended period for dams to rest and recover their body condition. This is very crucial for the dams to breed in the next cycle, and conceptions rates tend to be high. However, accompanying this scenario should be quality nutrition on the part of dams, especially with pasture based systems. Although with early-weaned lambs reared mainly on pasture the resultant carcasses have been not desirably appealing in meat market (Fernandes et al., 2008; Ribeiro et al., 2009; Fernandes et al., 2011). The comparable post weaning growth of weaners at different ages could be explained by the fact that at the ages of 60, 75 and 90, there is no differences in terms of ruminal digestive system development, as a result all groups were capable of utilizing solid feed at the same rate. Also in respect of dams' milk, the milk yield is marginal especially after 2 months of suckling with minimum contribution to lamb nutrition (Karim et al., 2000). Therefore, it has been suggested that under semi-arid tropical production conditions, weaning lambs at 60 days is feasible on condition that they are provided with quality nutrition to promote growth. Lower weaning age of 35 days have been reported by Müller et al. (2006) in intensive production systems. This is sufficing to suggest early weaning can be effective in small ruminant production as long as it is accompanied with adequate nutrition. It is also important to mention that the advancement in production systems has made early weaning as a viable option. On the other hand, where facilities are limiting and nutrition is

lacking early weaning might have posed a lot of challenges for both the lamb and dam, lamb growth might be compromised and lack of nutrition to the dam may adversely affect the preceding breeding cycle. Freitas et al. (2005) working with Santa Inês hair breed reported average daily gain of 143 g and 150 g for lambs weaned at 56 and 98 days, respectively, however the lambs where slaughtered at 126 days. Elsewhere, in a similar study by Müller et al. (2006) reported average daily gain of 182 g and 183g in lambs weaned at 35 and 42 days and slaughtered with 28kg of liveweight. The studies take note of the influence of duration between that act of weaning and when the animals will be slaughtered, might influence performance parameters. This implies producers might decide to delay slaughter although the kids/lambs were weaned early, or the other way round, and this has some implications on performance on similar age at weaning but differences in slaughter duration. In this scenario the major parameter of influence is the weight of the animal at that specific slaughter time, that will determine that animal performance not the age at weaning. There was an interaction of weaning age and weight at weaning, hence similar age but with different weights, where heavier lambs had the superior development efficiency during lactation, determined by dam's milk yield and length of lactation period and also influenced by age and body condition of the ewe at lambing (Godfrey et al., 1997; Ploumi and Emmanouilidis, 1999). This study provides an insight on the importance of weaning weight as a possible determination of weaning weight as opposed to weaning age. On age at weaning and sex dependent weaning performance, early-weaned lambs outclassed late weaned between 5th and the 8th month (fattening period) on body weight gain, by about 2.64 and 0.98 kg for male and female lambs, respectively (Abdel-Fattah et al., 2013). In the same study late weaned lambs exposed to suckling duration of up to 4 months, had inferior post-weaning performance as compared to early weaners (2 months of age). The conclusion in this study was that sex greatly influenced live weight and average daily gain under early and late weaning ages. Combellas (1981) reported partly similar results performance was lower at 56 days however this was followed by compensatory recovery to comparative weights by 20 weeks. Something interesting was the resemblance of weight gains between the group weaned at 56 and 84 days. This was squarely ascribable to the low breed milking capacity as from the 8th week of lactation (Combellas, 1980). It can be urged that despite the effect of weaning age the genotypes' ability to produce sufficient milk for sustaining its young ones might directly influence growth performance in sheep and goats after weaning. This might indirectly also relate to parity order, where milk production will tend to increase as parity order increases hence might have an impact of the performance of weaned kid/lambs. It will be also sufficing to assume that well fed dams milking ability can counteract the effect of early weaning. Despite sufficient pasture availability for foraging, early-weaned lambs exhibited poor growth response due to selective grazing strategy (Poli et al., 2009). Post-weaning stress (Napolitano et al., 2008) and greater susceptibility to parasites (Miller and Horohov, 2006) were also contributing factors for this poor performance. It has been noted that post weaning stress compromises immunity of kids/lambs, which makes animals susceptible to diarrhoea and other diseases.

Weaning individual lambs at 35 days, apart from providing appropriate option for raising triplets, it can also promote desirable carcass quality as a result of reduced fat level in triplets (Gallo and Davies, 1991). Elsewhere, early weaning in Barki lambs displayed significant effects on liveweight and greatly influenced average daily gain and growth rate as compared with late weaning. On the other hand, early weaned lambs had superior carcass weight (7.44%) and tailed hot carcass weight (20.04%) (Hanan and Ellamei, 2013). Various carcass parameters such as pre-slaughter weight, hot carcass weight, dressing percentage, loin eye area, and decreased bone percentage, were improved by weaning male kids in three breeds in India, however these were under intensive feeding management (Nagpal et al., 1995). In addition, weaning age × feeding system interaction seemed to have influenced body weights, average daily gain and pre-slaughter weight in the same study. Desirable carcasses have been attained when lambs were slaughtered at a body weight of 36 kg and at the age of between 90 and 120 days of age (Monteiro et al., 2009). Superior lamb carcass yield and compactness index were attained at a weaning age of 62, while dam supplementation and weaning age were not important on dam reproductive efficiency (Bôas et al., 2003). Santhoshkumar et al. (2018) working with Mecheri lambs weaned at different ages of 90, 75 and 60 days, observed that different weaning age did not influence pre-slaughter weight, hot carcass weight, dressing percentage, loin eye area and carcass measurements.

Sañudo et al. (1998) working with weaned (38 to 40dys) and unweaned lambs, observed that subcutaneous fat was superior of unsaturated in weaned lambs. However, in intramuscular fat composition differed in polyunsaturated fatty acids (higher in unweaned), but total unsaturated or saturated, were comparable. In the same study dressing percentage in unweaned surpassed lambs weaned at 38 to 40dys, while alongside the meat quality properties, weaned lambs possessed redder meat against unweaned lambs as indicated by color and heam

pigment levels. Hanan and Ellamei (2013) observed that fat deposition was influenced by age at weaning, where early weaning promoted greater fat deposition in the tail, while late weaning promoted fat deposition in intestinal region. However, all internal organs weights were comparable in early and late weaning lambs. Sensory attributes for meat from early weaned lambs, was characteristically tender however showing dryness and deprived of flavour, this tendency was ascribed to low content of visible fat (Jagusch et al., 1970). Concentrate supplementation is costly, consequently in order to sustain high lamb production through early weaning there is need to provide good-quality pasture to reduce cost of production. There was slightly lower live-weight gain in the midst of an early weaning study which was an indication that early weaning might retards at some point post weaning growth performance hence it would be important to compensate this derailment in a projected future to maximise production. The contemporaries' lambs weaned at 4 and 5 weeks performed poorly than their suckled lambs' counterparts. This might be a problem emanating from nutritional deficiency of early weaned lambs, which can be corrected by feeding high-quality pasture or forage. Lambs weight before weaning is greatly dependent on the dams' milk rather than the genetics (Kashani and Bahari, 2017). Therefore, it is effective to choose a kind of ewe which produces more milk because it may improve weaning weight. There should be a synchrony of milk feeding and weaning time for goat kids, this means kids can be weaned earlier than the traditional weaning age of 3 months. This entails kids could be favourably weaned at 9 kg of body weight, 8 weeks of age or from the moment when at least 30 g/day of solid feed are consumed feed (Lu and Potchoiba, 1988). This is done in order to minimize weaning shock which is the major source of underperformance of lamb's post weaning period. It has been noted that restriction in milk feeding promotes solid feed consumption by kids/lambs as a result translating into weight gain. Therefore, early weaning is feasible other than economical with the condition that solid feed intake can be encouraged. This point to the fact that case of delayed weaning becomes a costly strategy and also its adversity on the development of a functional reticulo-rumen due to delayed stimulation of solid feed. The difference in weaning weight in various seasons time is due to the environment factor impact mention like temperature as well as the other factor such as nutrition, disease and management. The success of early weaning is dependent on the provision of kids/lambs drinking water and quality and sufficient dry feed. On one hand, early weaning should give enough recovery time for dams to return to breeding condition earlier, which is paramount for accelerated kidding/lambing systems.

3. Implications

Due to the intensity and advances in goat and sheep production systems, especially in nutritional technologies and livestock farm infrastructure development, coupled with increase in demand for quality mutton and chevon world over, early weaning has been adopted as an effective means of efficient meat production and profitability. In early weaning producers have focused on shortened female reproductive cycle, while enhancing meat productivity through increased frequency of kidding/lambing. The effectiveness of weaning age and anticipated post-weaning live weight gains are dependent on nutritional management especially concentrate supplementation which may promote animal performance in extensive pastured based systems. Therefore, perfecting feeding strategies, early weaning will permit an increase in the overall meat performance through higher performance in growth and survival of kids. It should be noted that there is substantial interaction between weaning age, sex of animal and dietary status on growth performance and survival of kid/lambs. In early weaning an essential balance should be modelled between promotion of kid/lambs growth performance without compromising the reproductive capacity of the dams due to frequency of kidding/lambing. It is important to consider weaning age in kids/lambs in relation to nutritional strategy which provide adequate time for solid feed transition, because impairment in this process will compromise feed conversion and utilization efficiency consequently reducing growth performance in kids/lambs. Early weaning has featured well for prolific goats and sheep breeds and genotypes bred for high genetic potential for growth. Hyper prolific modern ewes/does have a high reproductive potential, which needs to be optimized according to the environmental and management conditions where they are utilized. On the other hand, knowledge on the effects of performance losses related to early weaning age is necessary to determine the productivity and healthy implication of this practice on kids/lambs in a commercial goat and sheep meat production system. Since kids are the most vulnerable component of any flock, improvements that will bring about positive changes in the growth and survival of kids/lambs, early weaning is bound to increase productivity and economic returns. In conclusion, is age based weaning better than weight based model, there has been a slight shift in implementation of weaning process based on weight than age.

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