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Review article

The significance of genotype and some non genetic factors in influencing productive traits, carcass and meat quality properties in pig production

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Growth rate, carcass and meat quality properties are vital factors influencing the cost of fattener production and viability in pig production enterprises. These factors are related to genetic potential and various environmental factors, where the overall efficiency of production depends on the successful interaction of these two factors. There has been a distinctive association of genetics and individual levels of various non genetic factors such as nutrition, management, litter size, parity etc with different production parameters, carcass and meat quality properties in pig production. Whilst genetics is a major influence on these traits, there are a large number of non genetic factors that impinge on maximizing production, hence the need to manipulate them to improve the final product, which is pork. The preceding review gives insight on the role of genetics and non genetic factors on production traits, carcass and meat quality properties in pig production. An examination of the impacts of pre-slaughter stressors on pig carcass and meat quality should be considered in corrective strategies for remediating and preventing pre-slaughter stress which result in poor carcass quality. Some suggestions to guarantee appropriate pre slaughter conditions and obtain the best meat quality are reviewed. The discussion concludes that a holistic approach which give emphasis on understanding both genetic and non genetic factors which influence production will give maximum benefits in pork production. In addition appropriate preslaughter animal handling issues should be part of the strategies to improve meat quality in pig production.

1. Introduction

Worldover, pork markets have been characterized by rapid changes in consumer trends and taste pertaining to meat consumption which have forced pork producers need to meet consumer demand and preferences for their product quality. The targeted pig productive traits, carcass and meat quality properties are ultimately determined by the producer in the light of market requirements and prices but are also affected by biological variables, assuming that products with desired quality attributes must be conducive to better health and safety. The compelling goals for pork producsers have been shifted to two main goals of improving the efficiency of production and the end product quality. The startegies in this effort may take in the form of improve management, nutrition and environment and improve genetic quality. This is on the background that whilst genetics is vital in pig production, a number of non genetic factors affect productive traits, carcass and meat quality properties, through indirectly obscuring the recognition of genetic potential of individual animals. It has been noted that varying the level of non genetic factors had significant differences in the nature of corresponding productive traits, carcass and meat quality properties in animal production (Assan, 2013). Therefore, an understanding of both the genetics and non genetic factors which influence productive, carcass and meat quality traits will direct changes in the breeding and management programs to minimise influences which reduce meat production efficiency.

The role of different non genetic factors has been the subject of extensive number of studies in an attempt to improve pig production and overall meat quality (Adebambo, 1986; Ellis et al., 1999; Dzama et al., 1999; Wood et al., 2004; Apple et al., 2009). This is on the understanding that both genetic and non genetic factors will influence pork production. The role of the pig producer is generally to take the end result of genetic improvement and manage animals in a manner to maximize expression of their genetic potential. The review alludes to the complexity of the genetic and non genetic influences on productive traits, carcass and meat quality properties as the end product in pig production.

2. Pig improvement strategies and the effects of genotype on productive traits and pork quality properties

Breed or genotype is considered one of the most important distinguishing factor influencing the final perception of meat products (Hoffmann et al., 2005). The genetic variation within pig breeds, expressed as the heritability, can be estimated for the various growth and carcass traits (Hermesch et al., 2000; Chen et al., 2002; Lee and Kim, 2004). The existence of sufficient genetic variation makes genetic improvement for many growth and carcass traits in pig breed possible through effective selection methods. Therefore, genetic improvement through growth and carcass traits in pigs would be possible enough from the estimates of heritability in growth and carcass traits. Pig breeding is currently accomplished with estimated breeding values or expected progeny differences to improve growth rate and carcass traits. However, an optimum selection strategy would be improved with carcass and growth traits in balance. Therefore, it is important to investigate the relationship between growth and carcass traits to determine if undesirable genetic correlations exist between them (Hoque et al., 2007). In commercial pork production, selection and crossbreeding have been employed to achieve the highest level of performance. If a metric character is determined by an effectively infinite number of loci, selection cannot cause any permanent change in the genetic variance but will cause a temporary change which is rapidly reversed when selection ceases (Bulmer, 1971). The characterization of breeds for major traits contributing to weaner production is essential for making decisions in both purebreeding and crossbreeding programmes. Such characterization will allow maximum exploitation of heterosis and additive genetic differences between breeds. Pig breeds have experienced intense selection pressures for the development of desirable productive, carcass and meat quality traits. This has resulted in a large diversity of pig breeds that display variation in many phenotypic traits, such as coat colour, muscle composition, early maturity, growth rate, body size, reproduction, and behaviour. One of the targets in pig selection programs is to increase the size and number of litters produced per sow before culling. Although selection for lifetime productivity is impractical today, the knowledge and data accumulated from successful breeding programs for litter size may help make it the selection objective of the future (McLaren and Bovey, 1992).

Crossbreeding is an important tool of commercial pork production systems because of improvement in efficiency from heterosis and potential to exploit differences between pig breeds. Systematic crossbreeding aimed at utilization of general and specific combining abilities of different pig genotypes on productive traits, carcass and meat quality properties has had considerable success invigorating interest in commercial pork production (Hale and Bondari, 1986; Sanchez et al., 2007). Elsewhere crossbreeding in pigs was cited as an effective way to use to enhance reproductive efficiency of the index line (Petry and Johnson, 2004). In terminal crossbreeding systems in which all offspring are market animals takes the greatest advantage of differences in strengths of lines or breeds. Pork producers should consider lines that have superior genetic merit for reproduction provide females and lines that are superior for production traits and meat quality provide males. The resultant animals for marketing and slaughter then have high genetic potential for production and the sow herd has high merit for reproductive traits. Several studies have shown large differences between pig breeds and potential for exploitation of heterosis (Jungst and Kuhlers, 1984; Yen, et al., 1987). Considerable variation exist among pig breeds on productive traits, carcass and meat quality properties (Miller et al., 1990; Hoffman et al., 2003; Kouba et al., 2003;) and knowledge of variation in carcass properties, fatty acid profiles, sensory characteristics of different genotypes and their crosses in different management system can be used to identify optimal breeds combinations and crossbreeding systems for existing markets. The potential for genetic improvement of reproductive performance in pigs through cross breeding is great. Improvement can be achieved by increased commercial use of F1 hybrid females produced by crossing lines with excellent reproductive performance and by selection within nucleus populations of these lines for improved reproduction as well a for growth and carcass characteristics (McLaren and Bovey, 1992). Hybrid vigour on the other hand, has the most significant benefit in maternal performance and factors affecting fertility in boars.

Comparing the merits and demerits of crossbred pigs over indigenous and exotic pigs with respect to growth and economic feasibility of rearing pigs. A clear breed difference was noticed with respect to carcass traits such as carcass weight, carcass length, back fat thickness and loin eye area except dressing percentage in different levels of protein (Ramakrishnan, 2013). The differences between males and females in terms of growth are well known but are more relevant in relation to carcass weight and fatness and increase in litter size is associated with lower body weight of piglets at birth. However, the birth weight of piglets is not related only to the litter size (Leenhouwers et al., 1999); it depends on several factors such as genotype (Ritter et al., 1992; Falkenberg and Hammer, 1994; Leenhouwers et al., 1999), folicular development (Egerszegi et al., 2001), parity (Quiniou et al., 2002) and placental size (Biensen et al., 1999). The greater proportion of Pietrain genetics in the selection resulted in leaner carcasses, but also in pigs being more difficult to handle. Crossbreeding appeared to have a greater impact on animal welfare and meat quality than vehicle type, but trailer type may emphasize these negative genotype-related defects (Weschenfelder et al., 2013).

The role in genotype in pork production is generally to take the end result of a genetic improvement program and manage animals in a manner to maximize expression of their genetic potential. Carcass quality was similar in Duroc and Large White pigs, whereas lower carcass quality was observed in Landrace, while increased slaughter weight was accoumpanied by lower carcas quality in the three breeds. The interaction between breed and slaughter weight for muscle characteristics and pork quality were mostly non significant (Potokar et al., 1998). The genotype of both the mother and the foetus play a vital role in determining the birth weight, while the consequent litter weights basically depend, beside the foetuses genotype, on the suckled milk from the dam (Abdel- Azeem, 2006). In India, Pandey et al (1996) found that local sows produced low litter size especially mated to local boars. This was explained by the higher embryonic or foetal mortality resulting from small body size of the piglets. The differences in productivity traits in pig production may be attributed to the effect of genotype besides of the non genetic factors (Ncube et al., 2003). Selecting sires on the basis of their lean meat index will give significant improvements in progeny growth rate and reduced carcass fat levels. The factors influencing foetal growth and birth weight in pigs reported that calf birth weight differed substantially among the nine breeds of pigs. Weights of piglets from sows on the very high feed level had the highest birth weight, followed by medium and lowest feed levels gave the lowest birth weights. The nutritional effects were much less than the breed effects and were in general larger in magnitude in breeds having larger piglets. It was suggested that low levels of maternal nutrition may result in reduced birth weight, but nutritional levels above adequate result in no further increase.

Crossbred litters showed higher live weight at birth than those of pure bred litters (Abdel-Azeem et al., 2007). It is widely believed that crossing local and imported genotypes improves fertility through exploiting heterosis (Lekule et al 1990; Pathiraja 1986). Ncube et al., (2003) observed that the chances of survival to weaning age were higher in the crossbred piglets than in pure indigenous pig breed. The reproductive capacity of the indigenous sows was improved by using Large White pigs as sire lines. Effect of birth weight on weaning weight of crossbred and purebred pigs was consistently positive whereas litter size influenced weaning weight negatively. Survival of the pigs was not dependent on parental crossing and did not change over the years when crossbreeding intensified (Hale and Bondari, 1986).These results were in agreement with those reported by Seleem (2005). Superiority of crossbred litters weight may be due to hybrid vigour which appeared in different ages of kits and to superiority in litter size traits. The effect of breed are highly significant although not quite as important as litter size in pigs. It was evident that the primary contributor of differences in foetal growth is foetal genotypes which consisted of contributions from both the sire and dam (Ferrell, 1993). Pig birth weight is largely the expression of genetic differences between dams and then some of the other environmental common to litter mates is really genetic in origin but depends on the genotype of the dam rather than on the genotype of the offspring. This is mainly expressed in crossbreeding systems. Non-genetic factors in pig production are those effects that are not part of the genetic make-up of an animal. These factors are not transmitted from parent to offspring (). When the genetic effect on a trait is weak, it is lowly heritable and the environment has the greatest influence on that trait. Environmental factors tend to obscure the animal's true genetic ability. (Missanjo et al. 2011) observed that selection within the best environment allowed better gene expression and selection response were therefore improved. Environmental variance, which by definition embraces all variation of non-genetic origin, is a source of error that reduces precision in genetic studies. Crossbred sows generally outperformed pure-bred sows for litter size because they exhibit maternal heterosis (Mungate et al., 1999). While it is well understood that the sow and boar of a calf play a role in the genetically predicted growth traits weight of their progeny, other factors do come into play. It is important to keep the other factors in mind that impact the growth of the piglets to help ensure a successful and prosperous furrowing. Meanwhile, the search continues for useful indirect criteria for selection, from testis size to molecular markers, and scientists are working with highly prolific breeds of Chinese pigs to better understand the physiologic and genetic basis of large litter size (McLaren and Bovey, 1992).

3. Genotype and meat quality

Amongst the production characteristics, carcass and meat quality properties that commercial pig breeds share, they also possess breed-specific characteristics. In an attempt to evaluate the effect of genotype and housing system on physiological traits and meat quality of pigs, Lebret et al., (2010) observed that Duroc pigs had more tender meat than synthetic lines. However, bedding with outdoor area system resulted in higher feed intake, faster growth rate, increased intramuscular fat, and improved eating quality in both genotypes. Outdoor rearing during summer and winter improved meat juiciness, whereas odor, flavor, and tenderness were unaffected (Lebert et al., 2006). This alludes to the fact that management system is one of the many factors which could affect productive traits and meat quality since in a farm situation young ones will be subjected to the same non genetic factors. The available information on the eating quality of pork from the perspective of production systems considered at farm level which among the specifications differentiating systems having a claim on eating quality are breed/ genotype, feeding strategy, rearing conditions and slaughter age/weight of the pigs (Bonneau and Lebret, 2010). Touraille et al (1989) showed that the meat of Large White x Meishan crosses had a more intense flavour, was more juicy and tender than the meat of pure Large White. Gandemer et al (1990), who compared animals in an intensive system to those reared in covered pens with access to a yard and receiving beet root and concentrates, the conditions of accommodation have no noticeable influence on the technological and organoleptic qualities of the meat. On the contrary, it is well known that composition of the feed affects the organoleptic qualities of the meat (Girard et al 1986). The effect of breed and diet on growth performance, carcass, physical and chemical composition were determined for two South African indigenous pig breeds, Kolbroek and Windsnyer. The moisture, fat and protein content were only influenced by the African pigs with a higher fat, but lower protein and moisture content for the African pigs with an ad lib diet compared to that of the African pigs receiving a restricted diet. Breeds and diets had a substantial influence on the fatty acid composition of the meat (Hoffman et al., 2005). Specific genetic by environment interactions such as the use of slow growing-fat local breeds reared in extensive conditions, as encountered in local Mediterranean systems, lead to high eating quality of pork and pork products. The Large White and local "Creole" pigs, intensively reared in a tropical environment, in terms of growth performance and meat quality, local "Creole" pigs was superior to that of Large White, as the former exhibited a higher ultimate pH value, lower drip loss and better sensory qualities. A taste panel judged the meat of local pigs of better sensory quality than that of Large White, the meat was found to be more tasty, more juicy and more tender (Depres et al., 1994). However, local pigs were considered to be of little importance for commercial pig production due to their fatness. The same genotype (Large White) registred a different pH in a temperate country (Gandemer et al., 1990; Castaing, 1991) which may imply that the tropical climate influences the evolution of the pH after slaughter. The higher pH values have been associated with better capacity of water retention of the muscle for the local pig genotype. However, the results of Okubanjo (1998) showed no effect of breed types including the Nigerian indigenous, Duroc, Large White and Landrace pig breeds on the ultimate pH of the meat. Townsend et al. (1978) also found no difference in ultimate pH between different breed types including Yorkshire, wild and crossbred pork carcasses. It can be deduced that different genotpes may produce bacon and ham with different meat quality. Duroc pigs are known for their high intramuscular fat content in comparison to other commercial pig breeds (Warris et al., 1996) and for their higher concentrations of saturated and mono-unsaturated fatty acids (and lower concentrations of poly-unsaturated fatty acids) (Cameron and Enser, 1991), characteristics that play key roles in meat quality.

4. Piglet performance as influenced by litter size at birth and weaning

Litter size in pigs has been defined in a number of ways, depending on the goals of the specific production system. However, the number of piglets born alive have all been used as endpoints of litter size in genral pig production. The size of the litter in which a piglet is reared has a large effect on growth rate (Hermesch et al., 2001; Wolf et al., 2008) but effects on carcass traits have been related to size of birth. There was a relationships between birth-weight-associated modifications in histological or chemical muscle characteristics and meat quality traits in pigs. Estimated lean meat content, relative proportions of loin and ham in the carcass, and weights of longissum muscle and semitendinosus muscle were decreased in low birth weight pigs compared with heavy birth weight pigs (Gondret et al., 2006). Conversely, the large birth pigs exhibited a fatter carcass, greater activity levels of fatty acid synthase and malic enzyme in backfat , and enlarged subcutaneous adipocytes compared with the high birth pigs. Their study demonstrated a lower tenderness of meat from pigs that had a low birth weight , partly as a result of their enlarged myofibers at market weight.

Possible effective and better fertilization capacity may result in higher litter size at birth, which may be ascertained by mating the same genotype of the dam with the same boars therefore any variation observed will attributed to the effect of the breed of the boar. The higher weights of pigs born of landrace sires at birth indicate the superiority of the imported blood on litter weight, as also reported by Pathiraja (1986). Litter size had a significant influence on birth weight in pigs and higher litter size was connected with lower birth weights average (Wolf et al., 2008). An increase in litter size will decrease the average piglet birth weight, leading to an increase in pre-weaning mortality (Hermesch et al., 2001; Knol et al., 2002). This could suggest that the higher litter size in sows might be due to reduced embryonic death or foetal mortality in crossbred piglets due to increased prenatal weight gain.

The number of piglet born alive and average piglet weight at birth are antagonistic traits, the weighting of both traits in the total merit index should be done cautiously in order not to overemphasize birth weight traits and unintentionally decrease litter size by selecting heavier piglets from smaller litter (Suarez et al., 2004). Litter size has low heritability (Rico et al 2000) and crossbreeding has been found to improve it (Adebambo 1986). In pigs this was attributed to the fact that the maternal uterine space has finite capacity to gestate foetus and as litter size increases individual birth weight decline due to a maternal constraint of foetal development in pigs. The low birth weight and subsequent growth rate of larger litter size in pigs can be attributed to competition for nutrients in utero. As litter size increases, there is decrease in birth weight of individual piglet . The differences in foetal weight because of differences in litter size appears early as the first month of pregnancy (Hulet et al., 1969; Dingwal et al., 1981). In certain cases low birth weight is the leading negative cause of piglet viability. Therefore, particular nutritional attention should be given to sows giving large litters. Nutritional stress limits the litter mates from expressing their full genetic potential for birth weight. Therefore, in pigs a single focus on litter size can obviously result in lower birth weights and decrease uniformity because litter size and piglet quality traits appear to be negatively correlated. This is because heavier pigs are farrowed in the smaller litter although the relationship seemed not quite rectilinear. Selection for sow's ability to give birth to higher number of piglets has led to an increased within-litter variation in piglet birth weight (Tribout et al., 2003). Optimise selection for litter size, studies showed that larger litters with more than 13 piglets are not always desirable given the high mortality rates of these litters. Mortality rates were increased for litters with larger variation hence reduction within litter variation in piglet weight at birth reduced mortality.

Litter size might affect birth weight either by changing the intensity of competition among the developing foetus for the available nutrient supply oxygen and space or by affecting the length of gestation period so that larger litters might be born at an earlier stage of development than smaller litters (Wright, 1921). Apparently the conditions which lead to the conception of exceedingly small litters are not the optimum for developing large pigs among those which are conceived. Litter size can influence piglet survival after birth as piglet losses tend to be greater in larger litters which may be attributed to within-litter variation in piglet birth weight. (Marchant et al., 2000; Lay et al., 2002). A difference of one more or one less in each litter has much less effect on the average birth weight in some sow units. Wright (1921) reported that size of litter had much more effect on birth weight by reducing the rate of growth of the foetus than by causing early parturition. Placental weight is a primary factor determining size of birth in many animal species (Heasman et al., 1999). Kelly (1992) and many workers working with sheep concluded that numerous factors influence placental growth and development and having investigated the role of maternal nutrition as a regulator of placental and foetal size. The major restriction in foetal growth in rapidly growing sows may occur irrespective of high concentration of essential nutrients in the maternal circulation and suggests that the small size or altered metabolic and transport capacity of placenta is the primary constraint to foetal growth hence the low birth weight. The large birth weights of the crossbreds could also mean that crossbreeding should be exercised on fairly bigger sows, if problems of dystocia are to be minimised (Gordon 1997). The problem of young sows produce piglets of low birth weights because they are still physiologically immature and hence have to partition nutrients between their own nutrient requirements and those of the foetuses.

Restricting maternal nutrition to decrease birth weights is not a sound management practice. Extreme reductions in feed, such as feeding less than 70% of the sow's nutrient requirements will result in decreased birth weights. However, it often times results in an increase in furrowing difficulties because the sows are weak and undernourished. Slightly restricting the nutrient requirements of the sows will result in decreases in energy reserves (body fat) before limiting the nutrient flow to the foetus. In partitioning of nutrients, the sow puts her pregnancy at the top of the list, right below keeping herself alive, therefore her body will work overtime to metabolize stored nutrients to allow the foetus to grow. This is why restricting feed, unless in an extreme case, has little impact on birth weight inpigs. In pigs, placental weight peaks at approximately mid gestation, with structural remodelling occurring over the second half of pregnancy to meet the increasing nutritional demands of the growing foetus.

Competition between foetus is indicated as the major way in which litter size affects birth weight. Litter mates are more apt to have the same genes than are pigs less closely related than full brothers and sisters. Yet litter mates are unlikely in many genetic factors. Litter mates also tend to be alike because they develop in the same uterus and were thus exposed to an environment remarkably uniform for members of the same litter but perhaps differing distinctly from litter to litter. Litter size at birth, number born alive and the number of piglets that were weaned were higher in crossbred than in local pigs (Ncube et al., 2003).

The higher weaning weights for the crossbreds indicate the phenomenon of heterosis (Van Vleck et al 1987). More importantly, differences in the weaning weights were detected when no creep feeding was used. It is also possible that the high weaning weights of crossbred pigs could also have been a reflection of their higher birth weights (Whittemore 1993). The higher weaning weight in the crossbred piglets was also attributed to the higher birth weight of the piglets. Heavier piglets at birth had significantly higher weaning weights, which was expected because piglet birth weight is genetically highly correlated to other subsequent weight traits. Piglets of higher birth weights consume more milk per suckle than their lighter littermates and this could be the major reason why heavier piglets outgain lighter ones (Dzama et al 1999). The low weaning weights could also have been due to poor milk production qualities of the Mukota pigs that were used as dam lines. Higher birth weights and weaning weights imply that the chances of survival of the piglets to maturity are enhanced.

5. Parity and maternal nutrition

Sows in the later parities can produce enough milk to support fast growing piglets. However, difference in milk supply to piglets should be not confused with characteristic growth rates of certain genotypes. The inability to grow fast in indigenous pis reflects the inherent poor genetic potential of this group. It has been previously demonstrated that inappropriate maternal nutrition at key stages of pregnancy is one of the measureable factors leading to decreased live weight in pig production . The relative competition for nutrients between the still growing sow and developing foetus may be the reason for depression in birth weight in pigs born to younger sows. This is related to higher capacity of milking in association with older sows in comparison to younger sows. The effect of nutrition was relatively small, yet statistically quite significant in pig production. There is significant effect of year on birth weight due to improvements in management and feeding of sows during pregnancy Maternal nutrition during pregnancy plays an important role in the regulation of foetal and placental development, therefore has the potential to influence foetal growth as indicated by heavier birth weight. With multiple fetuses, the nutritional requirements of sow are magnified, resulting in a greater nutrient drain on maternal resources and an accelerated depletion of body's energy reserves The increased demand for nutrieth at this point are worsened during the second half of pregnancy, with more rapid lessening of body's energy stores. Such a scenario, a sudden increase in nutritional demands occurs as a result of a rapid development of the fetus and placenta in young sows, the capacity of digestive system is reduced because of the larger mass of multiple fetuses Physical limitation of the digestive system in late gestation may lead to insufficient feed consumption to meet the sow's nutritional requirements which in turn may cause toxemia and reduction of litter birthweight. In other species, this has been associated with a decrease in placental weight (Greenwood et al. 2000) and total placental vascularity (Vonnahme et al. 2008), or even a series of developmental adaptations that permanently change the structure, physiology and metabolism of the offspring (Gootwine et al.2007; Reynolds et al. 2010). In pigs litter mates are subjected to similar environmental conditions during their intra-uterine life, which might well make the dam more important than the sire in affecting birth weights even though both sire and dam contribute equally to the unborn piglets. With the sire hold constant within year was but slightly more than the eliminated by year alone and it appeared certain that the boar had some effect on the birth weight of the offspring. Maternal under nutrition in pregnancy resulted in low birth weights and impaired postnatal survival in pigs (). It was indicated that the nutrition of dam and the size of placenta are well known to determine the foetal growth rate (Mellor, 1980). Knight et al. (1988), Konyali et al. (2007), Jawasreh et al., (2009), Alkass et al. (1999) and Oramari et al. (2011) showed that birth weight was strongly associated with placental traits such as placental weight. Over nourishing the adolescent dam to promote rapid maternal growth through out pregnancy resulted in a major restriction in the placental weight, and leads to a significant decrease in birth weight relative to moderately fed normally growing adolescents of equivalent gynaecological age (Wallace et al., 1999). Inappropriate maternal nutrient intake at key developmental points during ovine pregnancy had a profound influence on the outcome of pregnancy and aspects of post natal productivity.

Pig birth weight may be reduced in low intake sows compared with high intake sows, but the incidence of malpresentation at delivery may be greater in low intake sows. Piglets with low birth weight has a negative influence on neonatal development progress. Piglets with low birth weights are slower than heavier litter mates to stand and suckled less frequently hence increased mortality in this group. This could have been associated with the reason to say that lower birth weight than optimum are associated with reduced energy reserves and increased calf deaths or near birth. It may suggest that less frequent suckling by under weight young ones may result into death due to starvation and also affect neonatal piglet behaviour. The level of nutrition of dam and calf birth weight are positively correlated, especially in the last trimester when 70% of the calf's absolute growth takes place. There is need to reduce feed to minimize difficult birth cases, or use boars known to produce smaller piglets, especially in young sows. This process makes birth weight of piglets to be influenced by the nutrition of the dam received during the pregnancy term. In a case where the regression of birth weight of piglets is positive on dam weight at furrowing and each of cotyledon number and cotyledon density is negatively correlated on dam weight at furrowing , respectively. The weight of sow at furrowing is significantly correlated with birth weight of their piglets. There is a positive correlation between birth weight and the weight of cotyledons (Osgerby et al., 2003; Madibela, 2004; Oramari et al., 2011), however the number of cotyledons per foetus varies between and within breed, litter size, sex and environmental conditions (Alexander, 1964). Therefore, the survival of a newborn is affected by sufficiency of placenta (Mellor and Stafford, 2004).

6. The effects of feeding levels and diet composition on meat quality

The issue of meat quality is becoming important because consumers are increasingly quality oriented. This calls for understanding of factors that influence product quality as a prerequisite to development of programs to produce quality pork to meet different market requirements (Ellis et al., 1998). A number of nutritional approaches to improve meat quality in pig production have been studied. These include evaluation of the role of specific dietary ingredients, feeding levels, dietary protein: energy ratio and dietary fat source on their effects on meat quality. Lebret (2008) studied the effects of feeding level and protein:energy ratio on meat quality and concluded that these can be used to manipulate growth rate or composition of weight gain in pigs. Decreasing the protein : energy ratio of the diet actually increases intramuscular fat and improves eating quality, but gives fatter carcasses. A restriction/realimentation feeding strategy was applied to pigs to increase the age at market weight and final average daily gain, modify protein and lipid deposition rates at carcass and muscle levels, and thereby improve eating quality of the pork (Heyer and Lebret, 2007). This suggest that elevated intramuscular fat content and improved pork quality might be achieved by modifying the onset or duration of the restriction and realimentation periods. Kuhn and Burgstaller (1995) revealed no significant difference in carcass traits in pigs fed with low protein diet. Several workers on the other hand, had obtained increased lean growth (Cunningham et al., 1973; Baird et al., 1975 and lrwin et al. 1975) and decreased back fat thickness (Irwin et al., 1975) on higher dietary protein levels. Diet influenced growth rate and fatness, the low protein diet slowing growth and producing fatter meat, more so in the two modern breeds, and particularly in intramuscular rather than subcutaneous fat (Woods et al., 2004). . This diet produced more tender and juicy meat, although pork flavour and flavour liking were reduced. The red psoas major muscle had higher tenderness, juiciness, pork flavour, flavour liking and overall liking scores than white longissimus dorsi The concentration of phospholipid fatty acids was higher in the _red_ psoas major than white longissimus dorsi but neutral lipid fatty acid content and marbling fat were higher in white longissimus dorsi. In a comparative carcass traits of the three breeds of pigs fed with different rations (Ramakrishnan, 2013) observed that dressing percentage, carcass weight, carcass length, back fat thickness and loin eye area did not show any significant difference between the treatment groups. This was due to the small differences in protein levels used in the experimental rations. Elsewhere, similar results were reported by Aunan et al., (1961) in their studies with pigs using rations with protein levels of 18, 16 and 14 per cent. These results are also supported by Clawson et al., (1962) and Ramachandran (1977) who could not detect any significant difference in carcass characteristics of pigs maintained on different dietary protein levels. Shields and Mahan (1980) found that temporary moderate protein restrictions in diets did not affect carcass traits. Apple et al., (2009) showed that t fat source had little to no impact on live pig performance, but feeding a polyunsaturated fat source altered the fatty acid profile of the longissimus muscle, and including 5% soyabean meal in swine diets could lead to economical ramifications associated with soft pork or fat. Feeding 10 mg/kg of ractopamine will improve rate and efficiency of gain, carcass composition, and longissimus muscle quality. And, even though fatty acid composition of backfat samples was altered by dietary fat source, performance and carcass composition, as well as quality during 5 d of retail display, were similar when pigs were fed diets formulated with beef tallow and soyabean oil.

7. Pre slaughter handling and meat quality

Pre-slaughter handling can affect both specific behavioural and physiological responses resulting different meat quality products. Appropriate handling of swine, as contrasted with improper or inappropriate handling, can result in improved productivity of live animals; in higher quality of slaughter livestock, carcasses and cuts; and in greater profitability in the production and packing sectors (Smith and Grandin, 1999). During the time between leaving the farm and slaughter, animals are subjected to removal from their home environment, loading and unloading from vehicles, transport, and holding in unfamiliar surroundings (Warriss, et al., 1994). They may be exposed to stressors such as noise, strange odors, deprivation of food and water, vibration and changes of velocity, extremes of temperature, breakdown of social groupings, close confinement and often overcrowding. These stressors often elicit behavioral and physiological responses, some of which can, if extreme, contribute to a reduction in carcass and meat quality. There is undisputable link between pig handling and meat quality. The gilts transported for a period of up to 30 h experience acute stress and changes in homeostasis probably due to dehydration, food deprivation, and transport. Physiological measures of dehydration and muscle breakdown were observed in gilts after transport, regardless of transport duration (Bryer et al., 2011). Handling practices prior to slaughter have significant influence in the stress level and animal welfare of pigs, and consequently, in the final meat quality (Alvarez et al., 2009). Slaughterhouses are located some distance from pig farms, hence, pigs are inevitably exposed to pre-slaughter handling procedures that may affect the quality of pork (Muchenje and Ndou, 2011). Pre-slaughter welfare procedures that stress the pigs may not only influence the conversion of muscle to pork, but may also compromise pig health and well-being. Accompanying improvements in meat quality,carcasses and cuts in pig slaughtering is the appropriate handling of animals in the form of fewer bruises, improved tenderness and lessened occurrence of pale, soft and exudative as well as dark, firm and dry pork. Quiet, calm handling of slaughter hogs can reduce the incidence of carcasses with pale, soft and exudative muscle by 10% to 12% based on field studies conducted at two packing plants (Grandin, 1998). The same author observed that psychological stressors, such as excitement and fighting, will often have a more detrimental effect on meat quality than physical stressors, such as fasting or cold weather. Fighting caused by mixing strange animals together is a major cause of dark cutters in and deaths in stress susceptible pigs. It has been suggested that animals could be prepared to accept irregularity in management (Reid and Mills, 1962) or could be preconditioned to handling stresses (Kilgour, 1976). (Luyerink and Van Baal, 1969) observed that pigs trained to certain handling procedures had better meat quality than untrained pigs.

Loading pigs onto the truck is considered the most critical stage of the transport period as showed by the 110- 130 increase in the heart rate and by the increase of stress indicators (lactate) levels in blood compared to the values observed for a pig at rest, with these effects lasting until slaughter and eventually affecting meat quality. The stress associated with the loading procedure results from a combination of different factors, such as the design of the loading facility (either ramp or quay), group size and handling system. A short journey duration may have a negative influence on welfare, meat quality and in extreme cases on the mortality rate of market pigs. it has been observed that pigs hauled very short distances are less easy-to-handle at the plant and may produce pale and exudative pork than pigs transported for longer distances. However, it appears that transport longer than six hours, especially in winter, may result in muscle energy depletion and an increased incidence of meat quality defects related to the production of dark pork (Faucitano, 2013). Hans Selye (1973) defined stress as a nonspecific response of the body to a demand made on it. Therefore it is reasonable to suggest that meat quality variables are also indicators of stress, but when assessing muscle pH, color, or meat tenderness, it is important to remember that these parameters vary according to the part of the carcass from which the sample is obtained (Shorthouse, 1978). Superficially, the simplest method of measuring acute stress is comparing baseline levels for heart and breathing rate and body temperature with those obtained under stress conditions, but these parameters are complicated by physical activity.

Pre-slaughter handling subject pigs to various stressors which elicit specific behavioural and physiological responses resulting different meat quality products. Pre-slaughter stress influences pork attributes such as acidity, pale, soft exudative, dark firm dry, aroma, bruising, toughness, sogginess, cooking loss, meat dryness, colour, water holding capacity, texture and rancidity in stored products. When pigs are stressed and have no shortage of glycogen the muscles acidify at a rapid rate while the carcass is still warm. Stress is the inevitable consequence of the process of transferring animals from farm to slaughter. The effects of chronic stress on muscle glycogen depletion and the consequent dark cutting condition have been well documented This combination can lead to the formation of PSE (pale, soft and exudative) meat, especially in specific strains of pigs. Typical stress responses such as elevation of heart rate and body temperature and increased circulating corticosteroid levels are seen. Serum cortisol and blood lactate levels, widely used indicators of stress, were positively correlated with blood glucose and electrolytes, such as calcium, potassium and sodium. Moreover, these parameters were significantly correlated with a rapid rate of early postmortem glycolysis and reduced water-holding capacity. The pre-slaughter welfare of a pig refers to the influence of the various internal challenges or conditions on the physiological or biochemical state of the pig at the time of observation, during the growth phase and handling before slaughter. Topel (1979) reports that differences in the way the animals are handled can affect meat color. However, suggested that the effects of sex, breed, weight, weather conditions, length of transport time, resting time prior to slaughter, number of animals in each pen, shape of pen, stunning method, access to feed and water and mixing of strange animals shoud be investigated. This is because contradiction might be explained by the problems of comparing studies with conflicting variables such as transport time, amount of fighting and the stockyard design. In a study (Weschenfelder et al., 2013) describes the breed-specific coping characteristics of pigs in response to transport stress. The use of a pot-belly trailer for short distance transportation of pigs to slaughter negatively affected stress responses and meat quality. The dynamic changes of behavior, the activities of creatine kinase and lactate dehydrogenase , as well as the plasma concentrations of stress and metabolic hormones in Erhualian and Pietrain pigs during transport were investigated by Li et al., (2008). Erhualian and Pietrain pigs exhibit distinct behavioral, endocrine and biochemical responses during transport due to differentiated rate of coping starties in breeds studied.

The major influence of pre-slaughter handling on lean meat quality is through the potential effect on muscle glycogen stores. Pigs which had been on a long trip in a truck will have lower glycogen levels than rested pigs (Lewis et al., 1963), while Barton (1971) reported that pigs hauled for a short distance had more PSE meat than pigs hauled for a long distance. Excitement, long driving races, and excessive use of the electric goad increase the pigs' energy consumption and this may affect the degree of glycogen depletion. Long-term preslaughter stress, such as fighting, cold weather, fasting and transit, which occurs 12 to 48 hours prior to slaughter depletes muscle glycogen, resulting in meat which has a higher pH, darker color, and is drier (Grandin, 1980). Lactic acid produced from glycogen breakdown is important in determining the final pH of the meat. The pH rises when the glycogen stores become depleted from a more prolonged stress and lactic acid can no longer be produced. The rate at which lactic acid is removed from the muscle appears to be reduced in pigs with inherited stress susceptibility (Ball et al., 1973). Serum cortisol, blood lactate and glucose have potential as indicators of the rate and extent of postmortem metabolism and ultimate pork quality under the standard procedure and handling conditions of pre-slaughter (Choe et al., 2014). Blood catecholamines and glucocorticoids have been used to determine how stressed an animal is since these hormones are involved in the body's reaction and adaptation to stress. The use of catecholamines and glucocorticoids as measures of stress is accurate only when viewed in relation to the entire animal and its environment. Kilgour (1978) considers that epinephrine levels are the most sensitive indicators of an animal's response to acute stressors such as fear or excitement caused by handling methods in the slaughter yards or stunning pen. Stott (1978) has stated that a series of measurements must be conducted if blood levels of either epinephrine or the glucocorticoids are to be used as meaningful indicators of an animal's reaction to stress. Ante mortem factors which include fasting period, farm handling, mixing, loading, unloading, transport, lairage conditions, and driving to the stunner have been studied on how they influence pork quality with special emphasis on technological quality attributes (Alvarez et al., 2009). Pork that is dark in colour represents a major problem to the pork industry due to its poor processing characteristics and unacceptable appearance to both processors and consumers. Losses in carcass yield are caused by both mobilisation of tissues to provide energy for maintaining the vital functions of the body and the dehydration which often accompanies the inevitable period of food and water deprivation together with the stress of transport. The PSE pork is characterised by pale colour, soft texture and low water-holding capacity. The PSE is a meat quality defect, which is caused by a combination of factors, such as stress-susceptible genes, rough handling shortly after slaughter and poor carcass chilling. Pork which has high fluid loss can reduce profitability due to reductions in weight. There is a need to ascertain or quantify actual optimum resting time for optimisation of desired pork quality.

Ethological principles should be applied to the handling of animals and the design of slaughterhouse facilities. Pre-slaughter handling methods that result in high carcass temperatures during slaughter may lead to inferior pork quality. Keeping pigs cool is very important because a hot pig will have more PSE (pale, soft, exudative, stressed pork).Pigs become over heated easily because they have a layer of fat and they do not sweat. (Moss and Robb, 1978; Skjerheim, 1978) observed that pigs which are slaughtered either upon arrival or shortly afterwards had a lower muscle pH and more PSE meat than pigs held in the stockyard overnight. Efforts should be made to improve handling facilities and slaughter methods which ensure appropriate meat quality while reducing costs. Pigs that are easily agitated by nature, are difficult to drive and handle for short periods and are at a greater risk of producing inferior pork which appears pale, lacking firmness and with fluid dripping from its cut surfaces (Muchenje and Ndou, 2011). This pork quality is commonly referred to as pale, soft, exudative and is difficult to use when preparing pork by-products such as ham, polony and sausages.

8. Implications

Most non genetic factors are significant source of variation for growth and carcass traits, and play an important role in expression of genetic potential of individual animal. Therefore, the effects of various non genetic factors on pig perforamnce should be determined because they are considered major causal factors which may limit animal performance in terms of productive traits, carcass and meat quality properties. Genotype, nutrition, litter size at birth and weaning, will affect pig productivity. It is thus necessary to pre adjust data for these non genetic factors when carrying out genetic evaluations of production traits in pigs. Genotype is a dominant factor which may increase both productive and reproductive efficiency, and reduction in pre-natal mortality, which is, largely, a maternal trait. The superiority of productive traits and reproductive traits which are associated with total litter weight at birth and weaning have been linked to specific genotypes, and if this is taken into account could result in economic viability of pig enterprise.

The general principles for slaughter, as related to moving and animal handling following their arrival at the slaughterhouse, lairage design and construction, care of animals in lairages, and animal welfare issues associated with acceptable handling, restraining, stunning and slaughter methods applicable to pigs should be adhered to in order to obtain good quality meat. The development in slaughter technologies and their practical applications in pig slaughterhouses will enhance final meat quality. Slaughter techniques, poor pre-slaughter operations lead frequently to an increase of physiological and physical stress in pigs resulting poor meat quality. The natural patterns of behaviour of pigs, particularly their following and instincts, can be exploited to facilitate proper handling and improve meat quality. Ante mortem factors, such as lairage time or moving pigs into the slaughter rooms, and inadequate design of slaughterhouse facilities have an important effect on pig stress, affecting meat quality after slaughter hence this highlights the importance of good design of handling facilities. Pre-slaughter mortality is not only an extremely serious quality problem leading to meat being condemned, it is also an indication of a serious animal welfare problem. Further quantification of the biological costs of pre-slaughter stress and the consequences to meat quality need to be revisited and ascertained..

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