Advances in Animal and Veterinary Sciences 2 (6): 359 – 364
http://dx.doi.org/10.14737/journal.aavs/2014/2.6.359.364

Research Article

Effect of Weaning Age and Sex on Meat Quality Traits of Pigs Raised under Intensive System and Slaughtered at 70 Kg Body Weight

Batlhalefi Ganelang*, John Cassius Moreki, Shalaulani James Nsoso, Christopher Mareledi Tsopito

Department of Animal Science and Production, Botswana College of Agriculture, Private Bag 0027, Gaborone, Botswana.
*Corresponding author: bganelang@live.com

ARTICLE HISTORY

Received: 2013–06–10
Revised: 2014–07–03
Accepted: 2014–07–04

Key Words: Colour, drip loss, Meat quality, pH, sex, tenderness, weaning age

ABSTRACT

The aim of the study was to determine the effects of weaning age and sex on carcass quality of pigs slaughtered at 70 kg body weight. A total of 24 piglets were purchased at birth from a commercial farmer and were assigned to three weaning ages: 21 days (treatment 1), 28 days (treatment 2) and 35 days (treatment 3). Feed and water were given *ad libitum* up to 70 kg slaughter weight. Pigs were slaughtered humanely using electrical stunning and the carcasses were dissected into two halves, right and left. From the left carcass, four 2.5 cm thick chops were removed from *longissimus* muscle. The chops were cut at the 9th, 12th, 13th and 14th ribs to measure tenderness, pH, drip loss and meat colour, respectively. Meat pH was measured using pH meter with glass probe while drip loss was measured using gravimetric method. Meat colour was measured on chops taken at 13th rib using Konica Minolta Chroma Meter CR-410 (Konica Minolta Sensing, INC., Japan) while tenderness was measured on boiled meat using TMS light weight blade (1.2 mm thick) attached to a 2.5 KN TMS PRO texture analyser (Food Technology Corporation, West Sussex, UK). Data were analysed as completely randomised design (CRD) using the General Linear Model (GLM) of statistical analysis system, version 9.3. Weaning age did not have significant ($P > 0.05$) effect on meat quality. Sex had significant ($P = 0.03$) effect on yellowness of meat of pigs weaned at 35 days of age. Males had significantly more yellow meat (9.50 ± 0.45) than females (7.63 ± 0.45). However, sex had no significant effect on drip loss, lightness, redness, pH and tenderness. Piglets can be weaned at 21, 28 or 35 days of age without negatively affecting meat quality. A 21 day weaning age is recommended as pigs weaned at 21 days reach market weight early.

RTICLE CITATION: Ganelang B, Moreki JC, Nsoso SJ, Tsopito CM (2014). Effect of weaning age and sex on meat quality traits of pigs raised under intensive system and slaughtered at 70 kg body weight. Adv. Anim. Vet. Sci. 2 (6): 359 – 364.

INTRODUCTION

Weaning age is an extremely important management decision in commercial pig production, which is based upon many factors including sow performance, herd health, pig performance, costs and revenues associated with these factors such as lactation space utilization, weaned pig value (Smith et al., 2006). Weaning is usually undertaken in one of the following four categories: conventional weaning (3–5 weeks of age); early weaning (10 days of age to 3 weeks); segregated early weaning (less than 18 days) and medicated early weaning (5 days) (Roese and Taylor, 2006). The age at which piglets are separated from the sow has been identified as an animal welfare risk in current pig production systems (Whiting and Pasma, 2008). Weaning results in several environmental and social stresses on the piglet as it adapts to a new environment and feed source (Collins et al., 2010). Johnson et al. (2012) stated that farm economics and productivity, sow and piglet welfare, and available facilities will dictate the best weaning age on a given farm.

Meat colour, pH, tenderness and drip loss are some of the major meat quality traits in pork. The amount of water lost when pork is cut is called "drip loss". Drip loss often increases when pork is pale or pH is low. Lower drip loss values indicate lower loss of water which is preferable to consumers (Lammers et al., 2012). Drip loss affects appearance, nutritional value and palatability of the meat to the consumer (Down, 2013). Meat colour is a major determinant of appearance. Appearance is practically the only criterion the consumer can use to judge the acceptability of most meats at purchase (Lammers et al., 2012). The difference in the pH of meat is due to the amount of glycogen present in the muscle at slaughter (Lonergan, 2012), which is directly proportional to the potential amount of lactic acid. A higher pH indicates a lower drip loss and better eating pork (Lammers et al., 2012). The main factors affecting meat tenderness are connective tissue, intramuscular fat content, and myofibrillar structure. Tenderness is associated with size of the muscle fibres. The smaller the fibres the more tender

ISSN: 2307-8316 (Online) ISSN: 2309–3331 (Print)

the meat. Tenderness decreases with age (Cunningham et al., 2005).

There is still much debate about what age piglets should be weaned (Shipka, 2011; King, 2013). Therefore, it is important to identify age at weaning suitable for Botswana conditions that would improve meat quality of pigs. This study was carried out to determine the effects of weaning age and sex on meat quality of pigs raised under intensive system and slaughtered at 70 kg body weight.

MATERIALS AND METHODS

The experiment was carried out at Chemae Farm, near Matebeleng village in Kgatleng District from May to November 2013. The site is situated on 24° 32′ 54.12′′S 26° 1′ 3.55′′E, at an altitude of 980 m above sea level. The area has average daily temperature of 15 °C in winter (May to July) and 29 °C in summer (August to November).

Animal management

Forty eight piglets [(Landrace x Large white) x Topigs (Tempo x Topigs 40) x Topigs cross] were randomly assigned to three treatments. Treatment 1 was for piglets weaned at 21 days, treatment 2 (28 days) and treatment 3 (35 days). A 28 day weaning period served as a control. There were 4 replicates in each treatment and each replicate had 4 pigs (2 males and 2 females). Teeth and tail cutting were performed when piglets were one day old while iron injection and castration were performed at three days of age. Pigs were not vaccinated against any disease but were treated for internal parasites using piperazine (active ingredient: piperazine adipate 100%) at 1.2 g/10 kg body weight. Triatix pour on dip (active ingredient: amitraz 2% m/v) was used to treat external parasites. Cosumix Plus (active ingredients: sulphachlorpyridazine sodium and trimethoprim) and sulfazine 33 1/3 % (active ingredient: sulphadimidine) were used to treat pigs for diarrhoea. Piglets were raised in 12 pens each measuring 2.2 m x 2.2 m in a naturally ventilated house with concrete floor and corrugated iron roofing. Wheat straw was used as bedding material and was replaced every fortnight. During cold days heating was provided to the piglets using coal.

Diets

The pigs in all treatments were fed commercial pig diets that complied with Botswana Bureau of Standards pig feeds specification (BOS 190:2006). From 10 to 35 days of age, piglets were offered creep diet, weaner diet from 35 to 70 days of age and thereafter grower diet up to 70 kg slaughter weight. Feed and water were provided *ad libitum* throughout the study period. The analysed nutritive composition of the diets expressed in g/kg is shown in Table 1

Table 1 : Nutrient composition of diets offered to pigs of pigs raised under intensive system

Nutrient (g/kg)	Creep diet	Weaner diet	Grower diet
Crude protein	185.1 ± 0.34	156.7 ± 7.15	148.5 ± 0.84
Moisture	85.2 ± 0.53	72.9 ± 0.58	76.8 ± 0.18
Crude fibre	14.9 ± 0.006	22.4 ± 1.33	64.0 ± 9.66
Crude fat	10.9 ± 0.27	17.4 ± 0.37	19.1 ± 0.35
Calcium	7.3 ± 0.07	5.5 ± 0.04	4.5 ± 0.03
Phosphorus	3.3 ± 0.06	7.3 ± 0.08	4.5 ± 0.05

Ante mortem treatment

At 70 kg body weight, pigs were transported early in the morning (*i.e.*, 0700 hours) in an open vehicle with rails to local abattoir in Gaborone for slaughter. Upon arrival at the abattoir, pigs were held in lairage for 12 hours with free access to water until slaughter the following morning. The animals were slaughtered humanely by electrical stunning (240 V, 0.5 A, 5s), exsanguinated, scalded, dehaired and eviscerated (Serrano et al., 2009). After slaughter, the carcasses were hanged to allow blood to drain away. *Ante mortem* and *post-mortem* inspections were carried out by a meat inspector as per Botswana Livestock and Meat Industries Act of 2007. After inspection, the carcasses were chilled at 7 °C for 24 hours.

Data Collection

The carcasses were dissected into two halves, right and left. From the left carcass, four 2.5 cm thick chops were removed from *longissimus* muscle (Corino et al., 2008). The chops were cut at the 9th, 12th, 13th and 14th ribs to measure tenderness, pH, drip loss and meat colour, respectively. Meat pH was measured using pH meter with glass probe (CRISON pH meter, model GLP 21). The probe was inserted into a cut made at the centre of the loin to take a reading. Before taking the reading, the probe was rinsed in distilled water.

Pork chops of 2.5 cm thickness weighing 30 g (Honikel, 1998) from *longissimus* muscle were cut and trimmed of fat and connective tissues (Milligan et al., 1998) to measure drip loss. Each sample was placed in a plastic net and suspended in a box wrapped with aluminium foil to prevent entry of air. The samples were suspended such that they did not touch the surface of the box. The samples were stored at 4 °C for 24 hours and thereafter removed from the net, blotted with tissue paper to remove water on their surfaces and individually reweighed. The samples were evaluated in duplicate and the average of the two was calculated and used as measure of the sample drip loss. The difference between initial weight and final weight was considered as drip loss. The formula (Honikel, 1998) used for calculating percentage drip loss was;

% drip loss = (initial weight – final weight)/initial weight x 100

Meat colour was measured on chops taken at 13th rib using Konica Minolta Chroma Meter CR-410 (Konica Minolta Sensing, INC., Japan), D65 illuminant calibrated against a white calibration tile (Milligan et al., 1998). The colour difference method was employed using the white calibration tile as the colour difference target to give colour change with the meat colour readings. The L*a*b system was used to measure colour. The parameters *L** (lightness),

ISSN: 2307-8316 (Online) ISSN: 2309-3331 (Print)

*a** (redness) and *b** (yellowness), were measured on each pork chop surface.

Peak shear force (which was used as measure of meat tenderness) was measured on cooked meat samples. A fresh 2.5 cm-thick *longissimus* muscle slice was boiled in a pressure cooker for 5 minutes and left to cool for 10 minutes and blotted dry. After cooking, three 1.0 cm thick and 3.0 cm long slices were cut once perpendicular to the fibre orientation, with TMS light weight blade (1.2 mm thick) attached to a 2.5 KN TMS PRO texture analyser (Food Technology Corporation, West Sussex, UK).

Statistical Analysis

Data were analysed as completely randomised design (CRD) with treatments arranged factorially using the General Linear Model (GLM) procedure of Statistical Analysis System, version 9.3 (SAS Institute, 2010). Means were separated using least significant difference (t test). The significance level considered for all the statistical tests was $P < 0.05$. The following statistical model was used for analysis;

$$Y_{ijk} = \mu + W_i + S_j + (WS)_{ij} + \beta(AGE_{ijk} - AGE) + \varepsilon_{ijk}$$

where Y_{ijk} is the response variable (carcass quality: meat pH, drip loss, meat colour, meat tenderness)
μ is the general mean,
W_i is the effect of weaning age at level i (21 days, 28 days, 35 days),
S_j is the effect of sex at level j (male, female),
$(WS)_{ij}$ is the effect of interaction WS at level ij,
β is linear regression coefficient of AGE_{ijk} on age at slaughter,
AGE is the mean age of animals at slaughter,
AGE_{ijk} is the age of individual animals at slaughter,
E_{ijk} is the random error.

RESULTS AND DISCUSSION

Weaning age did not have significant ($P = 0.15$) effect on meat pH of pigs slaughtered at 70 kg body weight (Table 2). However, pigs weaned at 35 days of age tended to have higher pH (5.85) than those weaned at 21 days (5.77) and 28 days (5.78). The current results are in agreement with Jiang et al. (2012) and Bérard et al. (2008) who reported pH values of 5.63 - 5.92 and 5.6 - 5.7, respectively for pigs weaned at 35 days of age. In agreement with the current results, Beaulieu et al. (2010) and Gentry et al. (2004) also reported pH values of 5.69 and 5.60, respectively for pigs weaned at 21 days of age. However, the current results are lower than the pH value of 5.92 reported by Morcuende (2007) for pigs weaned at 21 days of age. Kuhn et al. (2004) and Millet et al. (2004) reported pH of 5.46 and 5.45, respectively, for piglets weaned at 28 days which is lower than the value of 5.78 found in the current study. A slightly higher pH of 5.71 for pigs weaned at 28 days was reported by Oksbjerg et al. (2002).

Table 2 Means and standard errors of drip loss, pH, shear force and colour of meat of pigs raised under intensive system, weaned at different ages and slaughtered at 70 kg body weight

Variable	21 days	28 days	35 days	SEM	LSD	P – value
Drip loss (%)	4.81[a]	5.35[a]	5.50[a]	0.26	0.79	0.18
pH_{24}	5.77[a]	5.78[a]	5.85[a]	0.03	0.09	0.15
Tenderness (N)	112.21[a]	111.43[a]	109.85[a]	2.33	7.15	0.77
Colour						
L	48.60[a]	47.32[a]	46.23[a]	1.37	4.18	0.49
A	15.83[a]	14.22[a]	13.65[a]	0.84	2.43	0.19
B	9.02[a]	9.03[a]	8.56[a]	0.52	1.56	0.77
Slaughter age (days)	130.8[a]	134.6[ab]	137.0[b]	1.59	4.72	0.04

SEM = Standard error of means. LSD = Least Significant Difference. [a,b] Means within the same row having different letters differ significantly; $P < 0.05$

Weaning age did not have a significant ($P = 0.18$) effect on drip loss of chops from pigs slaughtered at 70 kg body weight (Table 2). However, pigs weaned at 35 days of age tended to have higher drip loss (5.50%) than those weaned at 21 days (4.81%) and 28 days (5.35%). The current results are in agreement with Bérard et al. (2008) who reported a drip loss of 5.2 to 6.1% for pigs weaned at 35 days of age. Jiang et al. (2012) reported lower drip loss of 2.16 - 2.83% for pigs weaned at the same age. Drip loss for pigs weaned at 28 days of age was higher (5.35%) in the current study compared to a drip loss of 3.66% reported by Alexander et al. (2008). Compared to the current result (5.35 %), Oksbjerg et al. (2002) reported 9.1% drip loss for pigs weaned at 28 days of age. The differences in drip loss values of the current study and previous studies could be due to differences in *ante mortem* conditions.

Weaning age did not have a significant ($P = 0.77$) effect on meat tenderness of pigs slaughtered at 70 kg body weight (Table 2). Weaning pigs at 21 days of age resulted in tougher meat (112.21 N) than 28 days (111.43 N) and 35 days (109.85 N) weaning ages. Pigs weaned at 35 days tended to produce the softest meat. These values are higher than the shear force values of 44 to 45 N reported by Bérard et al. (2008) for pigs weaned at 35 days. The difference in shear force values in the present study compared to Bérard et al. (2008) study could be due to differences in the cooking methods and blades used. In the current study, TMS light weight blade (1.2 mm thick) was used on boiled meat while in the study by Bérard et al. (2008), Warner-Bratzler shear blade (2.5-mm-thick) was used on grilled meat.

Weaning age did not have significant ($P > 0.05$) effect on L (measure of lightness), a (measure of redness) and b (measure of yellowness) values of colour. Pigs weaned at 21 days of age tended to have lighter meat (48.60) than those weaned at 28 days (47.32) and 35 days (46.23). Furthermore, pigs weaned at 21 days of age tended to have redder meat (15.83) than those weaned at 28 days (14.22) and 35 days (13.65). Pigs weaned at 28 days produced meat that was more yellow (9.03) than those weaned at 35 days (8.56). The L values found in the current study falls within the reddish-pink, firm and non-exudative (RFN) range of

ISSN: 2307-8316 (Online) ISSN: 2309-3331 (Print)

43-49 (American Meat Science Association, 2001). The current results are in agreement with Morcuende et al. (2007) and Gentry et al. (2004) who reported Minolta L values of 47.84 and 47.9, respectively for pigs weaned at 21 days of age. Beaulieu et al. (2010) reported slightly higher Minolta L value of 50.45 for pigs weaned at 21 days. The L value of 47.32 for pigs weaned at 28 days reported in the current study is consistent with 48.28 reported by Kuhn et al. (2004) but lower than 55.9 reported by Millet et al. (2005) for pigs weaned at the same age.

The 'a' value of 15.83 for pigs weaned at 21 days reported in the current study is higher than the values of 9.56 and 3.00 reported by Morcuende et al. (2007) and Gentry et al. (2004), respectively for pigs weaned at the same age (21 days). In the current study, pigs weaned at 28 days had "a" value of 14.22 which is higher than the 8.84 and 7.14 reported by Kuhn et al. (2004) and Millet et al. (2005), respectively for pigs weaned at 28 days.

The 'b' value of 9.02 for pigs weaned at 21 days reported in the current study is higher than the value of 4.88 reported by Morcuende et al. (2007) but lower than 12.00 reported by Gentry et al. (2004) for pigs weaned at 21 days. Furthermore, the 'b' value of 9.03 for pigs weaned at 28 days in the current study is lower than 16.66 reported by Millet et al. (2005) but higher than -0.23 reported by Kuhn et al. (2004) for pigs weaned at the same age.

Slaughter age for pigs weaned at 21 and 35 days was significantly (P = 0.04) different (Table 2). Pigs weaned at 35 days of age took a longer time (137 days) to reach market weight (70 kg) compared to those weaned at 21 days (130.8 days) and 28 days (134.6 days). However, there was no significant difference in slaughter age between 28 day weaning age and other weaning ages. These results disagree with Dritz et al. (1996) who found no significant difference in slaughter age between 9 days and 19 days weaning ages for pigs slaughtered at 109 kg.

Table 3 Means and standard errors of drip loss, pH, shear force and colour of meat of pigs raised under intensive system and weaned at 21 days of age

Variable	Male	Female	SEM	LSD	P - value
Drip loss (%)	5.17[a]	4.46[a]	0.44	1.61	0.31
pH_{24}	5.81[a]	5.74[a]	0.05	0.18	0.37
Tenderness (N)	111.20[a]	113.23[a]	3.44	11.91	0.69
Colour					
L	48.71[a]	48.49[a]	2.02	6.99	0.94
a	16.68[a]	14.98[a]	1.12	3.86	0.32
b	8.69[a]	9.35[a]	0.86	2.97	0.60
Slaughter age (days)	130.75[a]	130.75[a]	1.49	3.67	1.00

SEM = Standard error of means. LSD = Least Significant Difference. [a,b] Means within the same row having different letters differ significantly; P < 0.05

Sex had no significant (P = 0.75) effect on pH of meat of pigs weaned at 21, 28 and 35 days (Tables 3 to 5). However, males tended to have higher pH values than females in all the weaning ages. The current results agree with Piao et al. (2004), Correa et al. (2006), and Đurkin et al. (2012) who observed no significant difference between gilts and barrows for the pH of *longissimus* muscle. However, the current results disagree with D'Souza and Mullan (2002) who found significantly lower ultimate pH in gilts (5.46) than in barrows (5.73).

Table 4 Means and standard errors of drip loss, pH, shear force and colour of meat of pigs raised under intensive system and weaned at 28 days of age

Variable	Male	Female	SEM	LSD	P – value
Drip loss (%)	5.33[a]	5.38[a]	0.32	1.13	0.99
pH_{24}	5.79[a]	5.76[a]	0.04	0.14	0.75
Tenderness (N)	110.53[a]	112.33[a]	2.84	9.81	0.67
Colour					
L	46.71[a]	47.93[a]	1.79	6.18	0.65
a	14.93[a]	13.51[a]	1.50	5.20	0.53
b	9.23[a]	8.83[a]	0.81	2.81	0.74
Slaughter age (days)	133.75[a]	135.50[a]	1.82	3.83	0.52

SEM = Standard error of means. LSD = Least Significant Difference. [a,b] Means within the same row having different letters differ significantly; P < 0.05

Sex had no significant (P) effect on drip loss of meat from pigs weaned at 21, 28 and 35 days (Tables 3 to 5). However drip loss tended to be higher in females than male pigs weaned at 28 and 35 days of age. Male pigs weaned at 21 days tended to have higher drip loss (5.17%) than females (4.46%). Drip loss reported in the current study is lower compared to the values of 8.6% for barrows and 9.5% for gilts reported by Jaturasitha et al. (2006). The differences in drip loss could be due to the extent to which glycogen was degraded in the muscle which affect lactic acid concentration. High concentration of lactic acid leads to high drip loss. Similarly, Đurkin et al. (2012) and Correa et al. (2006) observed no significant difference between gilts and barrows for drip loss. On the other hand, Piao et al. (2004) observed higher drip loss in barrows than in gilts.

Sex had no significant (P = 0.67) effect on meat tenderness of pigs weaned at 21, 28 and 35 days (Tables 3 to 5). However, meat from male pigs tended to be more tender than that of females. The current results agree with Latorre

ISSN: 2307-8316 (Online) ISSN: 2309-3331 (Print)

et al. (2004) and Đurkin et al. (2012) who found no significant differences between barrows and gilts in meat tenderness. However, Jaturasitha et al. (2006) found significant difference in shear force between barrows (26.5 N) and gilts (33.9 N). This difference in results could be due to more intramuscular fat found in barrows than in gilts (Latorre et al., 2003).

Table 5 Means and standard errors of drip loss, pH, shear force and colour of meat of pigs raised under intensive system and weaned at 35 days of age

Variable	Male	Female	SEM	LSD	P - value
Drip loss (%)	4.92[a]	6.09[a]	0.44	1.40	0.44
pH_{24}	5.88[a]	5.82[a]	0.04	0.13	0.79
Tenderness (N)	109.28[a]	110.43[a]	3.56	12.31	0.83
Colour					
L	45.43[a]	47.03[a]	2.00	6.91	0.59
A	14.05[a]	13.24[a]	0.84	2.89	0.52
B	9.50[a]	7.63[b]	0.45	1.56	0.03
Slaughter age (days)	133.0[a]	141.0[a]	3.10	2.87	0.18

SEM = Standard error of means. LSD = Least Significant Difference. [a,b] Means within the same row having different letters differ significantly; $P < 0.05$

Sex had significant (P = 0.03) effect on yellowness of meat from pigs weaned at 35 days of age but not in other weaning ages (Tables 3 to 5). Males had significantly more yellow meat (9.50) than females (7.63). However, sex had no significant difference in brightness and redness of meat produced by pigs irrespective of age at weaning. For pigs weaned at 21 days, males tended to produce brighter meat (48.71) than females (48.49). Males tended to produce redder meat than females in all the weaning ages. The current results agree with Cisneros et al. (1996) who found that meat from barrows have a higher myoglobin content than meat from gilts. In this study, males tended to produce meat that was more yellow than females in pigs weaned at 28 and 35 days of age. Previous studies by Latorre et al. (2004), Đurkin et al. (2012) and (Correa et al., 2006) found that sex had no effect on meat colour. On the contrary, Alonso et al. (2009) reported more intense meat colour in males than females.

Sex did not significantly ($P > 0.05$) influence slaughter age (Tables 3 to 5). However, females tended to take longer to reach 70 kg slaughter weight compared to males. Latorre et al. (2003), Morales et al. (2011) and Piao et al. (2004) argued that males eat more feed and hence grow faster than their female counterparts. The current findings are in disagreement with Serrano et al. (2009) who found females to be superior in growth performance to their castrated male counterparts.

CONCLUSION

Drip loss, pH, tenderness, colour (lightness and redness) and tenderness of meat from pigs raised under intensive system were not affected by weaning age and sex. Weaning at 35 days of age promoted production of yellow meat. These piglets can be weaned at 21, 28 or 35 days of age under intensive system without negatively affecting meat quality. A 21 day weaning age is recommended as piglets weaned at 21 days of age reach slaughter weight earlier than other weaning ages.

ACKNOWLEDGEMENT

The authors would like to thank the sponsors of the research, Botswana government for the financial assistance needed to carry out the study. Management of Chemae farm are thanked for providing the facilities for carrying out the trials. The following institutions are thanked for helping in analyzing the samples and data; University of Botswana, Ministry of Agriculture (Botswana) and Botswana National Food Research and Technology Centre.

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ISSN: 2307-8316 (Online) ISSN: 2309-3331 (Print)

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ISSN: 2307-8316 (Online) ISSN: 2309-3331 (Print)