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Full Length Research Paper

Effect of Weight Asymmetry on Growth Performance, Carcass Characteristics and Economic Analysis in Pigs

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Weight deviation groupings were investigated for growth performance, digestibility and carcass characteristics in pigs. One hundred twenty crossbred pigs (Landrace × Yorkshire) of similar age were assigned to 3 treatments groups based on body weight with 4 replications having 10 pigs per replication for 10 weeks. The treatment groups were- 1) MW= Mixed weight group of heterogeneous high and low weight pigs, 2) HW = High weight group of homogeneous high weight pigs and 3) LW = Low weight group of homogeneous low weight pigs. Results revealed that body weight gain was higher ($p<0.05$) in the homogeneous group (HW and LW) compared to heterogeneous group (MW), however, feed intake and feed efficiency was statistically not different. Higher aggressive behavior was found among the individuals of heterogeneous group compared to homogeneous group. In addition, digestibility of DM of homogeneous group showed higher value ($p<0.05$) compared to heterogeneous group (MW) while digestibility of nitrogen was not significantly differed. Furthermore, warm carcass weight, dressing percentage and back fat thickness was significantly higher ($p<0.05$)in homogeneous group (HW and LW) compared to heterogeneous group (HW).Better carcass quality and yield grade was found in case of homogeneous group but there were no significant differences among weight groups. Economic analysis indicated that per unit of body weight gain of homogeneous group was better than the heterogeneous group ($p<0.05$). In conclusion, weight grouping might be applicable for better management for obtaining uniform slaughter weight group, better growth and carcass characteristics, and ensure animal welfare.

Keywords: Body weight, Carcass quality, Digestibility, Economy, Growth performance, Pig.

INTRODUCTION

Pig behavior is the aggregate of pig actions and reactions in response to internal and external stimuli. Understanding and selecting for beneficial behaviors is very important for successful management, performance, economical return, and overall pig welfare. Due to dominance hierarchy sub-grouping behavior among the mixed group is found mostly in pig and in poultry (Turner et al., 2003). Once the hierarchy is established, a large weight asymmetry in the group can lead to long-term problems of food access for the smaller pigs (Marchant-Forde and Marchant-Forde,

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2005). Usually pigs are reared in mixed condition which increase aggression, affect productive as well as reproductive performance (Nakanishi et al., 1993; Arey and Edward, 1998), induce physiological stress (Mench et al., 1990), increase the development of pathologies by decreasing the immunity (Moberg, 1987), and deteriorate the carcass composition and quality (Warriss and Brown, 1985). Much research has been devoted to investigate practical techniques that might help to reduce fighting, such as the use of sedatives and other drugs, or masking of odors (Tan and Shackleton, 1990). However, none of the methods have been proved to be particularly successful, and usually aggression occurs at the full magnitude once the acute effects of the agents have vanished. These studies have shown that fighting between pigs consist of a series of exchanged bites, mounting, pushes and head-knocks. Some of these studies indicate that factors such as familiarity and weight differences between the contestants may be important in determining the amount of aggression shown between pigs. Partly the ambiguities regarding pig management might be explained by different methods of recording details of aggressive behavior, and a lack of a common theoretical framework for experiments, predictions and interpretations. Domestic pigs as reared in mixing where fighting behavior constitutes a major welfare and production problem in pig husbandry (Warriss and Brown, 1985; Tan and Shackleton, 1990).

Animal welfare are major issues in most developed countries and are based on the fact that animals can suffer, eventually leading to aberrant meat quality, especially when the five familiar freedoms that define the animal's fundamental needs and freedoms are not met. In order to minimize production losses and to ensure animal welfare, researchers are searching effective method for pig production to reduce aggressive behavior (Francis et al., 1996) which ultimately affects the carcass characteristics and composition. In the last decade, a growing demand of consumers for improvements in meat quality and an increased interest in animal welfare have led to the development of alternative production systems. The use of drugs for reducing aggression is problem based on consumer's perspective while the aggression affects the carcass quality. Such considerations required the research on how to minimize the aggression effects and avoid the use of any types of sedatives. There are some researches had been done on pig aggression but there are limited researches on how much production losses occurred due to mixing and what is the actual impact of the weight grouping regarding body physiology, production and carcass characteristics. It was hypothesized that, if pigs could be reared on the weight group basis, there might be ensured animal welfare, better management, reduced the degree of aggression and improve the growth performance, digestibility and carcass characteristics by reducing behavioral stress. The ultimate goal was to obtain the maximum benefits, better management, uniform slaughter weight group, better carcass characteristics and ensure animal welfare. Therefore, the objective of this study was to investigate the effect of grouping based on body weight on growth performance, digestibility and carcass characteristics of pigs.

MATERIALS AND METHODS

Experimental design and pig husbandry

The experiment was carried out for ten weeks at the pig farm of the Sunchon National University, approved by the institutional Animal Care and Use Committee of Sunchon National University, Republic of Korea. The pig farm has separate rooms and subdivided into pens. The pig house is well insulated and has a plastic-slatted floor. The temperature and ventilation of the house are automatically controlled according to the adjustment chart provided by the technical advisor. A total of 120 crossbred (Landrace × Yorkshire) piglets were housed, feed and water were provided ad-libitum and lighting and other management practices were carried out in accordance with general practices.

A completely randomized design was used with three treatments and four replications (pens of 10 piglets with an equal sex ratio of five male and five female) per treatments, where piglets were allotted according to body weight. Three weight groups were formed; each consisted of 40 piglets (four replicates with ten pigs per pen). The weight groups included: 1) MW = Mixed weight group composed of heterogeneous group of high and low weight pigs, 2) HW = High weight group composed of homogeneous group of high weight pigs and 3) LW = Low weight group composed of homogeneous group of low weight pigs. A commercial corn-soybean based diet in pellet form was used as a basal diet, formulated to meet the nutrient requirements of piglets as recommended by the National Research Council (NRC, 1998). Molasses was added at 4.3% level to help in the manufacture of pellets. All pigs were housed in an environmentally controlled isolation trailer with a slatted plastic floor in adjacent pens. Each pen was equipped with a one-sided self-feeder and a nipple drinker to allow *ad libitum* access to feed and water throughout the experimental period. The room temperature and relative humidity were 25^0C and 60%, respectively.

Feeds were analyzed for moisture by oven drying method (934.01), crude ash by muffle furnace (942.05), crude protein by the Kjeldahl method (988.05) (AOAC, 2000). Minerals were determined using Atomic Absorption Spectrophotometer (AA-6200, Dong-il Shimadzu Corp. Korea). The apparent digestible energy (DE) was calculated from the gross energy of the feed and feces by the following equation: DE, % = $(GE_{feed} - GE_{feces})/GE$

Table 1. Ingredients and chemical composition of the experimental diets (%)

Ingredients (%, DM basis)	**Finisher (55-110 kg)**
Yellow corn	45.15
Wheat	25.00
Wheat bran	4.00
Soybean meal	16.00
Limestone	0.78
Calcium phosphate	1.10
Salt	0.25
Vit-min. premix[1]	0.55
Animal fat	2.50
Molasses	4.50
L-lysine-HCL (78%)	0.17
Chemical composition[2]	
ME (kcal/kg)	3,265.00
Crude Protein (%)	16.00
Ca (%)	0.50
Available. P (%)	0.45
Lysine (%)	0.80
Methionine	0.27

[1]Vit-min. mix provided following nutrients per kg of premix: vitamin A, 6,000 IU; vitamin D3, 800IU; vitamin E, 20IU; vitamin K3, 2mg; thiamin, 2mg; riboflavin, 4mg; vitamin B6, 2mg; vitamin B12, 1 mg; pantothenic acid, 11mg; niacin, 10mg; biotin, 0.02mg; Cu (copper sulfate), 21mg; Fe (ferrous sulfate), 100mg; Zn (zinc sulfate), 60mg; Mn (manganese sulfate), 90mg; I (calcium iodate), 1.0mg; Co (cobalt nitrate), 0.3mg; Se (sodium selenite), 0.3mg.
[2] calculated value.

$_{feed}$ × 100. Metabolizable energy was calculated from DE × 0.82 (Johnson, 1972).Amino acid concentrations were determined by ion exchange chromatography following acid hydrolysis. Methionine was determined following oxidation with performic acid (Moore, 1963). Ingredients and chemical composition of the diets are shown in Table 1.

Measurement of growth performance and observation of behavior

Individual pig body weights were measured from the beginning up to the finishing (0 to 10 weeks) of the experiment. Feed consumption per pen was recorded during the experimental period and the body weight gain (BWG), feed intake (FI) and feed efficiency (FE) (Gain : Feed) was calculated. The feed efficiency for each pen was calculated by dividing the BWG by FI. Each group of pigs was observed three times per day (at 20-min intervals) over the experimental period. During each observation, the frequency of occurrence of behaviors listed in Table 3 was recorded for a 1-min period. The identity of individual pigs involved in different aggressive behaviors was not recorded.

Measurement of digestibility

A digestibility trial was conducted using chromium oxide (0.20%) as an indigestible marker (Fenton and Fenton, 1979). All pigs were fed diets mixed with chromium oxide (Cr_2O_3), and fecal grab samples were collected from all pigs and stored immediately in sealed plastic bags at -20°C until analysis. For chemical analysis, the fecal grab samples were dried in a force-air drying oven at 70°C for 72 h and then finely ground to pass through a 1 mm screen. Analyses of feed and fecal samples were done in accordance with the methods established by the AOAC (2000). The chromium concentration was measured with an atomic absorption spectrophotometer (Model AA-6200; Shimadzu Corp., Kyoto, Japan) in a cuvette blanked with distilled water at 440 nm. Standard curves were prepared by using a stock solution of pure Cr_2O_3 (100 mg/100 ml), diluted to several working standards of 5, 10, or 20 mg/100 ml and carrying them through each method. The optical

Table 2. Effects of weight deviation on the growth performance of pigs

Measurements	Weight groups			SEM	P-value
	MW	HW	LW		
ILW (kg)	49.87^{b}	56.96^{a}	45.81^{c}	1.71	0.03
FLW (kg)	97.59^{c}	108.70^{a}	101.22^{b}	3.96	0.04
BWG(kg)	47.95^{c}	51.81^{ab}	55.75^{a}	2.15	0.009
FI (kg)	145.80	151.50	150.97	5.01	0.07
Gain: Feed	0.33	0.35	0.37	0.03	0.16

$^{a, b, c}$ Means with different superscripts within the same row are significantly different ($p<0.05$).
Treatment groups:
1) MW = Mixed weight group of heterogeneous high and low weight pigs
2) HW = High weight group of homogeneous high weight pigs
3) LW = Low weight group of homogeneous low weight pigs

density was plotted against milligrams of Cr_2O_3. The digestibility was then calculated using the following formula:

$$\text{Digestibility (\%)} = [1-\{(N_f \times C_d) /(N_d \times C_f)\}] \times 100$$

where
N_f = Nutrient concentration in feces (%DM)
N_d = Nutrient concentration in diet (%DM)
C_f = Chromium concentration in feces (%DM)
C_d = Chromium concentration in diet (%DM)

Measurement of carcass characteristics

Pigs from each of the replicates were killed at the Sunchon National University experimental slaughterhouse at the end of the experimental period. Measurements were made to determine the effect of weight asymmetry on carcass characteristics. The day before slaughter, pigs were maintained without feed for 7 h and transported to the abattoir where they had a 10 h rest period with full access to water but not feed. On the morning of slaughter day, pigs were removed from their pens and weighed. Pigs were handled gently without the use of electric prods. Pigs were re-weighed just before slaughter. All pigs were slaughtered, shackled, exsanguinated, scalded, eviscerated and the carcass split into left and right sides according to standard commercial procedures and split down the midline. Head, heart, liver, reproductive tract and bladder, lungs and trachea, blood, spleen, full gut (esophagus, stomach, small and large intestines and fat depots) weights were recorded at slaughter. Carcass weight (head, feet, kidneys, kidney fat included) and back fat thickness were recorded at 45 min postmortem. Weights of hot carcass and of gastro-intestinal content were recorded to determine dressing percentage (hot carcass weight/empty live weight). Warm carcass weight included the head, kidney fat and kidneys, feet and tail. The carcasses were chilled for 24h at 1^{0}C (Aalhus et al., 1990). After overnight chilling a 60 cm loin section was removed from both sides of each carcass, and transported to the Sunchon National University Meat Science Laboratory. Loin sections were deboned and, alternating between right and left sides within each carcass for laboratory analyses. In preparation for meat quality analysis, the longissimus muscle from the anterior half of the loin section was dissected and minced twice through a 6.0 mm plate (Kenwood MG 450 Mincer, Hagemeyer, Australia) with subcutaneous fat added back to provide a 20% fat mixture. Back fat thickness was determined by measuring, perpendicular to the outside surface, at a point two-thirds of the length of the ribeye ribbed between the last rib and the first lumbar vertebrae. The area of the ribeye was determined at the surface of the cut using a standard grid (Moon et al., 2006). Carcasses were processed according to the simplified European Community-reference method (Branscheid et al., 1990).The carcass quality and yield grade was measured based on Korean system explained by Park et al. (2002) and Moon et al. (2003). Korean meat grading system based on the USDA (1970) grading procedures was used to determine carcass traits and carcass composition.

Economic analysis

For economic analysis, the total feed intake, weight gain and feed cost was measured. Finally, feed cost for per unit of weight gain was measured for calculating the economy of weight grouping management.

Statistical analysis

All data were subjected to analysis of variance (ANOVA) appropriate for a completely randomized design by using the general linear model procedures (GLM) of the SAS Institute Inc. (SAS, 2003). Statistically significant effects were further analyzed, and means were compared using Duncan's multiple range tests. Probability values of p<0.05 were considered as statistically significant, whereas p<0.01 was considered a tendency.

RESULTS

Effect of weight asymmetry on growth performance

Grouping based on weight deviation had significant effect on body weight gain, feed intake and feed efficiency in the present study (Table 2). The mean starting weight in each weight groups of the treatments was different. It was found that, the final live weight of the homogeneous groups (HW and LW) were significantly differed (p<0.05) with the heterogeneous group (MW). Among the weight groups, the highest body weight gain (BWG) was found in homogeneous group, LW and lowest was found in heterogeneous group, MW while another homogeneous group, HW found medium but significantly differed with both LW and MW (p<0.05). The feed intake (FI) was higher in the homogeneous group (HW and LW) compared to heterogeneous (MW) group, where there was no significant difference between the homogeneous groups (HW and LW). In addition to that, the feed efficiency (FE= Gain: Feed or G: F) was increased in the LW in comparison to HW and MW and but there was no significant difference.

Effect of weight asymmetry on behavior

It was observed that, there was higher dominant fighting, biting, head thrusting, lesion, bruises and skin damage in the heterogeneous group (MW) compared to the homogeneous group (HW and LW) (Table 3). More aggressive behavior was observed in heterogeneous group (MW) compared to homogeneous group (HW and LW). Competition over feed and biting was found dominant in the heterogeneous group compared to homogeneous group. Moreover, some of the pigs found weak due to dominant subordinate behavioral aggression in the heterogeneous group. Play/game was similar in both the uniform and heterogeneous group.

Effect of weight asymmetry on digestibility

The nutrient digestibility of homogeneous and heterogeneous groups was presented in the Figure 1. The present study revealed that, digestibility of dry matter (DM) was significantly higher (p<0.05) both in the homogeneous groups (HW and LW) compared to the heterogeneous group (MW). However, digestibility of nitrogen (N) was higher but not significant both in the homogeneous groups (HW and LW) compared to the heterogeneous group (MW).

Effect of weight asymmetry on carcass characteristics

Mean values for slaughter and carcass characteristics for different weight groups were presented in Table 4. There was weight deviation effect on live weight at slaughter, warm carcass weights and dressing percentage. The hot carcass weight and cold carcass weight was significantly higher (p<0.05) in both the homogeneous groups (HW and LW) when compared with the heterogeneous group (MW). In addition to that, the dressing percentage was significantly higher in HW and LW compared to MW (p<0.05). Furthermore, it was observed that, the back fat thickness was significantly higher (p<0.05) in the LW group, where the HW and MW groups statistically found similar although there was little numerical difference. Moreover, the carcass quality grade and the carcass yield grade of both the uniform group (HW and LW) was found higher compared to MW, where HW group possesses the highest value but there was no significant difference.

Economic analysis of weight asymmetry

It was found from the economic analysis of present study that, weight grouping affected the feed cost for the per kg body weight gain (Figure 2), which was lower in case of homogeneous group compared to the heterogeneous group. In addition to that, significant lower value was found in homogeneous group, LW followed by the HW and MW (p<0.05).

DISCUSSION

Growth performance

In the present experiment, grouping was formed based on the weight of the similar aged group of pigs. According to Gondret et al. (2005); Rehfeldt et al. (2008) ranking could be applicable based on birth weight and post weaning weight of individuals. The performance data of the present experiment indicated there were differences in body weight gain, feed intake and feed efficiency between homogeneous (HW and LW) and heterogeneous (MW) groups (Table 2). Increasing trend of growth performance of the present study was also observed by Francis et al. (1996) in different trial of different weight groups but it was observed for very short duration. Where they found that, uniform group showed a trend to higher gain than heterogeneous weight pigs. But the opposite conclusion was drawn from another trial in which heterogeneously grouped pigs gained weight more rapidly than uniformly grouped pigs. In the present study, uniform groups gained

Table 2. Effects of weight deviation on the growth performance of pigs

Measurements	Weight groups			SEM	P-value
	MW	HW	LW		
ILW (kg)	49.87[b]	56.96[a]	45.81[c]	1.71	0.03
FLW (kg)	97.59[c]	108.70[a]	101.22[b]	3.96	0.04
BWG(kg)	47.95[c]	51.81[ab]	55.75[a]	2.15	0.009
FI (kg)	145.80	151.50	150.97	5.01	0.07
Gain: Feed	0.33	0.35	0.37	0.03	0.16

[a, b, c] Means with different superscripts within the same row are significantly different (p<0.05).

Treatment groups:

1) MW = Mixed weight group of heterogeneous high and low weight pigs
2) HW = High weight group of homogeneous high weight pigs
3) LW = Low weight group of homogeneous low weight pigs

Table 3. Effect of weight deviation on observed behaviors recorded during experimental period

Behavior	Observed activities	Weight groups		
		MW	HW	LW
Fighting	Mutual pushing and ramming or pushing of the opponent with the head in rapid succession, with or without biting. Lifting an opponent by pushing the snout under its body.	**	*	*
Biting	Biting any part of another pig in an event that is not recorded as part of a fight or a head thrust.	**	*	*
Head thrusting	Pushing another pig with the head, with or without biting, in an event that is not recorded as part of a fight.	**	*	*

** Indicate higher

* Indicate lower

Treatment groups:

1) MW = Mixed weight group of heterogeneous high and low weight pigs
2) HW = High weight group of homogeneous high weight pigs
3) LW = Low weight group of homogeneous low weight pigs

Table 4. Effect of weight deviation on the carcass characteristics of pigs

Parameters	Weight groups			SEM	P-value
	MW	HW	LW		
Slaughter weight (kg)	97.59^{c}	108.70^{a}	101.22^{b}	3.96	0.04
Warm carcass weight (kg)	77.51^{c}	87.35^{a}	81.90^{b}	1.53	0.01
Dressing percentage (%)	79.43^{b}	80.36^{a}	80.91^{a}	1.03	0.006
Backfat thickness (mm)	17.34^{b}	18.08^{a}	18.25^{a}	0.14	0.01
Carcass quality grade ^{p}	1.24	1.44	1.41	0.06	0.09
Carcass yield grade ^{q}	3.99	4.46	4.36	0.17	0.21

$^{a, b}$ Means with different superscripts within the same row are significantly different (p<0.05).
DP, % = Dressing percentage
Carcass quality grade ^{p} ,QG1+=0, QG1 =1, QG2=2, QG3=3;
Carcass yield grade $^{q:}$ A-5, B-4, C-3, D-2
Treatment groups:
1) MW = Mixed weight group of heterogeneous high and low weight pigs
2) HW = High weight group of homogeneous high weight pigs
3) LW = Low weight group of homogeneous low weight pigs

significantly better than the heterogeneous groups (p<0.05) while heterogeneous group showed lower value. Body weight loss of 10-15% was observed in the subordinate animals when stressed by the dominants in case of weight variation groupings. Consistent to the present experiment, feed intake was found higher in homogeneous groups in a trial but found lower in another trial (Francis et al., 1996). Francis et al. (1996) observed higher feed efficiency in uniform group compared to the heterogeneous group in different trial with different weight groups. All pigs gain during the overall experimental period but social as well as behavioral stress suppressed the intake, weight gain and feed efficiency in heterogeneous group in the present study. Which support the previous findings of McGlone et al., (1987). But Friend et al. (1983) observed no difference in the growth performance between pigs of mixed and unmixed of different weight groups. The beneficial effect of maintaining pigs in the same rearing unit has been suggested by Karlsson and Lundstrom (1992). The reason for the differences between experiments appear to be that not all mixed groups do less well but because of subordinate individuals the value comes to lower, indicating that there is a benefit to uniform weight groups. However, pigs are mixed at several stages of the production cycle in order to obtain groups of uniform weight.

Behavioral pattern

The behavioral pattern found in homogeneous weight group and heterogeneous weight group in the present study (Table 3) was in agreement with the previous study (Friend et al., 1983; Francis et al., 1996). The incidence of biting, lying and lesion was higher in heterogeneous weight group than uniform weight group and play/flight behavior was common for the uniform weight group than heterogeneous weight group (Francis et al., 1996). Similar types of results also reported by and Rushen (1987), suggested that a reduction in play/fight behavior in groups of a wide weight range occurs because dissimilar individuals may more quickly perceive the fighting ability. The fighting behavior is generally mouth-to-neck attacks with strong thrusts sideways and upwards (McBride et al., 1964). Dominance hierarchy is the social organization established in groups of weaned pigs. When a number of pigs are mixed together they fight to establish a dominance hierarchy, usually of a simple linear type. The larger pigs show dominance over the smaller and subordinate pigs. The establishment of the dominance hierarchy occurs within 24hours of mixing (Symoens and Van DenBrande, 1969) but it is important as the social rank appears to influence productivity in the long run.

It has been shown by some workers that behavioral stress influences growth, feed intake and feed efficiency (Bielharz and Cox,1967), while others foundno correlation with dominance hierarchy (Meese and Ewbank, 1973).Mixing of pigs in different weight groups after weaning is common practice in pig production which results vigorous fighting and severe injury (McGlone and Curtis, 1987 and Moore et al., 1994), and causes health problems and growth retardation (Tan and Shackleton, 1990). Dramatic reduction in productivity occurred if different pigs are mixed randomly compared to individually penned pigs. It was also reported that, mixing of individuals at the beginning of the finishing period induced stress due to decreased cohesion within groups (Mounier et al., 2005). Animals respond to a stressor with a series of endocrine responses that increases the immediate availability of energy, in part by inhibiting physiological processes that are not required for immediate survival (Sapolsky, 1992). One of the primary responses to stress is an increase in the activity of the hypothalamic–pituitary–adrenocortical axis, causing an increase in the concentration of circulating adrenal glucocorticoids which consequently causes reduction of feed intake, weight gain and feed efficiency, and alter the other mechanism of body physiology (Sapolsky, 1992). These might be the clue of lower growth performance found in the heterogeneous weight groups of the present study compared to the homogeneous group. Inhibition of food intake and weight loss in rats exposed to stress is well established, although the specific feeding effect may be modulated by the severity of stress, the duration and the frequency of exposure. Exposing to stress is well documented for changes in food intake and body weight gain in case of rats (Marti et al, 1994). Usually, fighting prolonged with unevenly matched opponents. It was postulated that, due to mixing of high and low weight pigs in the heterogeneous group (MW) in the present study results fighting and stress, which affects the weight gain, feed intake and feed efficiency and showed lower value compared to other uniform weight groups (HW and LW).

Digestibility

Systematic management and breeding has certainly altered not only the growth potential but also significantly changed the structure and morphology of their digestive tract (Uni et al. 1995). In the present study it was found lower value of both the DM and N digestibility in the heterogeneous group (MW) compared to the homogeneous group (HW and LW) (Figure 1).Zuprizal et al (1993) found that true digestibility of protein and amino acids decreased due to stress. Hai et al (2000) reported that the activities of several enzymes (trypsin, chymotrypsin and amylase) decreased significantly due to different types of stress. Liver and pancreas are the important part in the digestive system and function. Mixing of pigs results in agonistic behaviour eliciting social stress that may produce gastro-intestinal disturbances and adversely affect the pig performance (D'Souza et al., 1995). Effect on liver and pancreas is detrimental specially when liver glycogen is depleted to provide energy in the form of glucose due to stressed condition (Tarrant, 1989). In addition, different types of stress impair absorption of different vitamins and causes reduction in plasma and tissue concentrations of minerals which are related to the digestive and immune system (MacPherson, A., 1994). Furthermore, loss of mineral impairs the protection of liver and pancreatic tissue which alters the proper secretion of bile salts and pancreatic juices (MacPherson, A., 1994), reduce digestibility of nutrients along with a reduced intake, eventually decreased performance of livestock. The concept can explain how different stress can impact on the physiological and biochemical process in general in the present study. The higher value of digestibility in the homogeneous group (HW and LW) compared to the heterogeneous group (MW) might be the impact of social as well as behavioral stress. Because of the dominant aggressive interaction in the heterogeneous group, the mean value might be reduced compared to homogeneous group, which also reflected on the productivity of pigs.

Carcass characteristics

Among the weight groups the uniform weight group (HW and LW) showed better slaughter weight and warm carcass weight than heterogeneous weight group (MW) (Table 4). It was observed more fighting among the individuals of mixed weight group compared to homogeneous group which might affect the carcass weight of the heterogeneous group. The loss of live weight and warm carcass weight due to fighting in mixed group was reported by previous research (Warris, 1986; Murray and Jones, 1994) which was consistent to the present study. At the fixed age at marketing the higher carcass weight was reported in heavy weight pigs than light weight pigs (Rehfeldt et al., 2008). In the present experiment when compared within homogeneous groups (HW and LW), it was observed that, carcass weight was higher in HW than LW groups. Consistent observation of the previous researches (Albar et al., 1990; Latorre et al., 2003), there were significant increase in carcass weight and dressing percentage as live weight at slaughter was increased in the present study (Table 4).

Similar to the present study, back fat thickness was reported higher in past studies (D'Souza et al., 2004). In the current research, it was found that uniform weight group (HW and LW) grow faster than the heterogeneous weight group (MW) and the back fat thickness of HW and LW was higher compared to MW. Correa et al. (2008) found the faster growth pigs had higher back fat thickness than the slower growth pigs. In the present study it was also found that the faster growth group LW had the higher back fat thickness. Furthermore, Rehfeldt et al. (2008) observed low weight pigs showed higher back fat thickness than medium weight and heavy weight pigs, which was the indication of the present findings, where LW showed higher value of back fat thickness. As birth weight have direct effect on the post-natal growth performance and carcass quality (Rehfeldt et al. 2008), so it could be assumed from the present study that, the carcass traits (carcass weight,

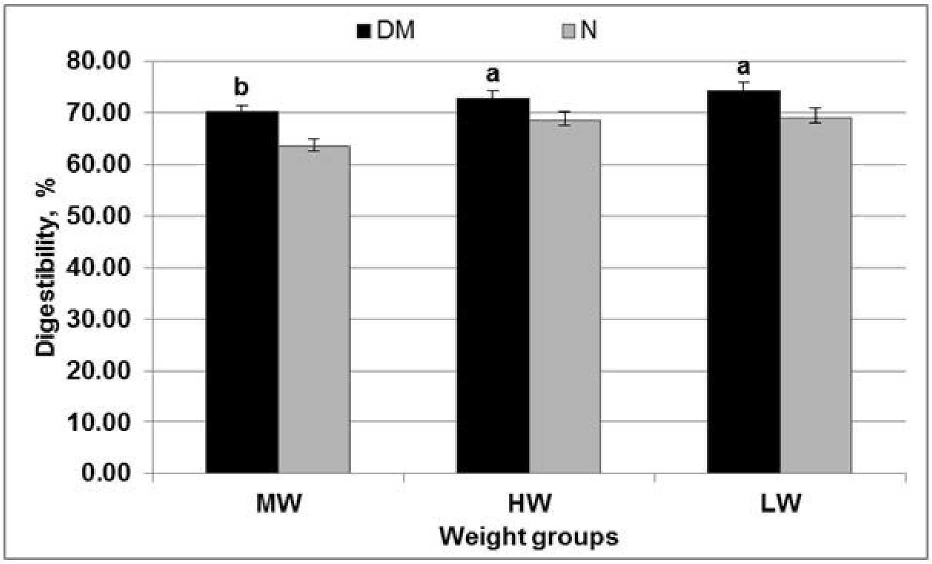

Figure 1. Effect of weight deviation on digestibility of pigs

[a, b] Means within the same bar are significantly different (p<0.05).
Treatment groups:
1) MW = Mixed weight group of heterogeneous high and low weight pigs
2) HW = High weight group of homogeneous high weight pigs
3) LW = Low weight group of homogeneous low weight pigs

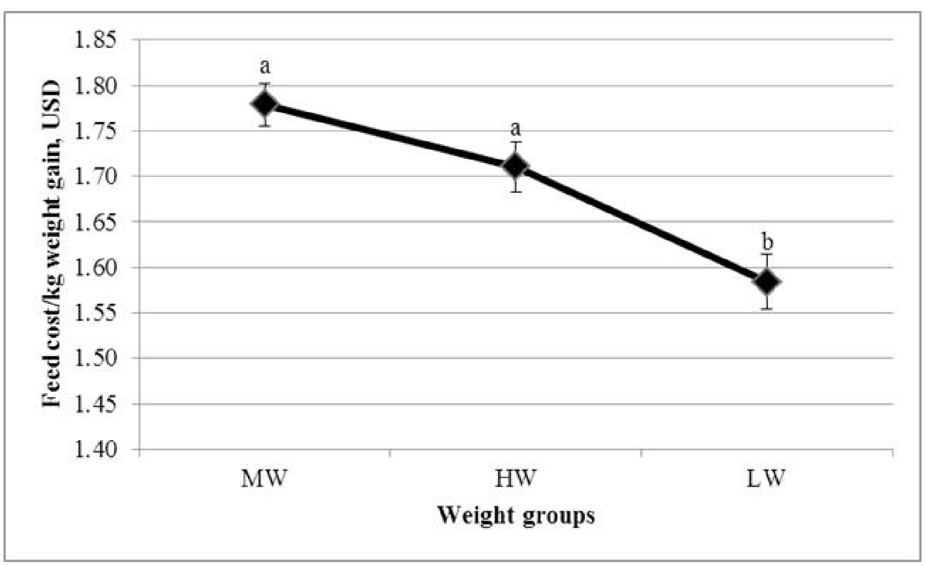

Figure 2. Effect of weight deviation on feed cost per unit of body weight gain of pigs

[a, b] Means within the same line are significantly different (p<0.05).
Treatment groups:
1) MW = Mixed weight group of heterogeneous high and low weight pigs
2) HW = High weight group of homogeneous high weight pigs
3) LW = Low weight group of homogeneous low weight pigs

dressing percentage and the backf at thickness) was affected by the different weight groups (MW, HW and LW) having different growth rates. Effects of birth weight on carcass traits during growing is usually happened on high birth weight pigs, but during finishing and marketing, the most effect is found in low birth weight pigs (Rehfeldt et al., 2008). In the present study, it was also found the differences in back fat thickness in case of homogeneous (LW) group during finishing and marketing.

The carcass quality and yield grade was higher in homogeneous group compared to heterogeneous group in the present study (Table 4).Heavier carcass weight with thicker back fat thickness indicates the better quality grade (Moon et al., 2003). It was reported that there is a positive relationship between carcass weight and quality grade according to Korean grading system (Park et al., 2002) and US grading system (Lorenzen et al., 1993). Higher carcass weight or fatter carcass indicates the higher quality grade (Lorenzen et al., 1993). Carcass with higher back fat thickness related to higher marbling which indicates higher quality grade and higher yield grade according to Korean Grading System (Moon et al., 2006). In the present experiment, it was found the higher carcass weight and back fat thickness in case of homogeneous group, indicated higher carcass quality and yield grade. Although to some extent the quality grade and yield grade is negatively associated (Moon et al., 2003)but regression analysis indicated that back fat thickness is the prime determinant of yield grade (Moon et al., 2003).

It was found better carcass quality and yield grade in homogeneous groups compared to heterogeneous group in the present study. There was numerical differences of quality and yield grade between homogeneous HW and LW group, which indicated that the HW group possess the better value compared to LW in the present study. Birth weight and rate of gain greatly influence subsequent gain at slaughter and back fat is strongly influenced by fighting behavior among the individuals (Hartsock et al., 1977; Rehfeldt and Kuhn, 2006) which might be the reason of variation of carcass quality and yield grade between two homogeneous groups and as well as between homogeneous and heterogeneous groups. Slight to extensive skin and carcass blemishes is occurred in almost 80% cases of mixed pigs (Murray and Jones, 1994) and stress is responsible for the development of aberrant pork quality which affects the quality and yield grade (Grandin, 1980). Similarly carcass quality and yield grade was affected in the present study especially in the heterogeneous group due to more behavioral stress during the experimental period.

Economic analysis

Economic analysis showed significant differences in case of per unit weight gain in homogeneous group, LW compared to heterogeneous group, MW (Figure 2). Based on the feeding and management, the unit cost was measured in the present study. The costs of agonistic interactions may come in many forms, including physical injury, time and energy investment, and physiological costs. Carcass damage caused by fighting can result in an economic loss of pig production (Correa et al., 2006). The lower value of the heterogeneous group in the present study might be the impact of behavioral interaction among the individuals.

The fighting which occurs during heterogeneous mixing results in physiological stress responses which can have detrimental effects on productive, reproductive parameters (Nakanishi et al., 1993; Arey and Edward, 1998). It was also observed in the current observation that, the better performance obtained in the homogeneous grouping when compared with heterogeneous grouping. Large group sizes may result in increased difficulty in animal management, increased aggression, causes potential loss of animal productivity and impaired animal welfare (English et al., 1988).

CONCLUSION

Considering the well-being pigs of pigs of different weight was grouped in the present study, where it was found that homogeneous grouped (HW and LW) performed better compared to heterogeneous group (HW).The results indicated that there were benefits of forming uniform weight groups at the finishing period in terms of reducing within-group variation in slaughter weight. In addition, weight grouping at this stage had no adverse effects on growth performance, digestibility and carcass characteristics. To sum up, weight grouping might be applicable for better management, obtaining uniform slaughter weight group, better carcass characteristics and ensure pig welfare.

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