



Research Journal of Animal Sciences



The Effects of Group Sizes on Behaviors, Meat Characteristics and Growth Performance of Growing and Finishing Pigs in the Tropics

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Key words: Group size, growing and finishing pigs, temperature-humidity, index, feeding behaviors, feeding frequency

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Page No.: 33-37

Volume: 14, Issue 3, 2020

ISSN: 1993-5269

Research Journal of Animal Sciences

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Abstract: The group sizes were 4, 8 and 12 pigs/pen, providing a floor allowance of 1.50, 0.75 and 0.51 m²/pig, respectively. The pigs that were reared in a group size of 12 pigs/pen ate, drank, walked, mouth piped, rooted the floor, rooted the pipe and pawed more significantly often ($p < 0.05$) than did the pigs that were reared in group sizes of 4 and 8 pigs/pen. These feeding behaviors and the high temperature of Thailand caused high rectal and skin temperatures which were the highest in the group size of 12 pigs/pen. Moreover, the high temperature and the increased group size may cause heat stress which would decrease the Average Daily Gain (ADG). The largest group size of 12 pigs/pen presented the lowest ADG in both growing and finishing phases which significantly differed ($p < 0.05$) compared to the group sizes of 4 and 8 pigs/pen. In addition, the high temperature and the feeding frequency in the group sizes of 8 and 12 pigs/pen provided a better back fat thickness that was significantly less than that of the group size of 4 pigs/pen ($p < 0.05$).

INTRODUCTION

Pig products from Thailand are accepted by ASEAN countries regarding farming and processing standards. Thailand has a better potential for the production and export of pork products compared to other ASEAN countries^[1]. The climate in Southeast Asia is 27-31°C from April-October and the highest temperature can be >42°C for several weeks of the year^[2] which may be a significant problem that decreases pig performance and meat quality. The Thai climate can be both hot and dry or hot and wet and can decrease pig performance and meat quality due to heat stress^[3]. Heat stress causes behavioral disturbances and negatively affects feed intake,

weight gain and feed conversion^[4]. According to LeBellego *et al.*^[5] the reduction in feed intake that was observed in pigs that were submitted to high ambient temperatures is probably a defense mechanism of the organism to reduce heat production resulting from digestive and metabolic processes.

Moreover, the high temperature more significantly affected the carcass weight during autumn than during winter and spring^[6]. Farmers understand this problem very well and have tried many ways to resolve it. Air conditioning or evaporative cooling systems are used in boar (AI) housing. Dripping and fogging systems are used in sow houses. Both systems help to improve performance. However, these systems require much

investment and redesign which some older farms cannot implement^[2]. The choice of appropriate group size is a way to solve this problem; Small group sizes may become a new approach to decrease cost and should be studied^[7]. Schmolke *et al.*^[8] reported that in growing and finishing pigs during the first 2 weeks, the ADG was lower for pigs in groups of 40 (554 g/day) than for pigs in groups of 10 (632 g/day; $p < 0.05$)^[9] found that the ADFI and ADG decreased with an increasing group size (i.e., 3, 5, 6, 7, 10 and 15 pigs/pen) during both the growing and finishing phases (25-97 kg body weight).

Quiniou and Noblet^[10] found that the feed intake decreased to avoid an excessive increase in body temperature and^[11] found that finishing pigs changed feeding behavior and had decreased ADFI and ADG with increasing group size. Therefore, the objectives of our study were to determine the effect of group size on productivity over a range that is typical of experimental and small commercial pens reared during hot season in Thailand.

MATERIALS AND METHODS

About 48 (24 males and 24 females) of three-way crossbred pigs (Large white×Landrace×dorc jersey) were blocked by sex and randomly assigned to each pen within a block. Three group size treatment as 4, 8 and 12 pigs/pen provided the floor area allowance as 1.50, 0.75 and 0.51 m², respectively. Pigs were watered and fed with ad libitum access to complete pellet diets based on corn, soybean meal, wheat bran and broken rice in the growing and finishing stages. The mean initial weight of pigs in the growing stage was 25±0.08 kg and in the finishing stage was 70±0.24 kg. The pigs were fed with complete pelleted concentrate diets according to National Research Council^[12], formulated to provide 3,159 and 3,301 kcal kg⁻¹ of energy and 16 and 14% CP during the growing and finishing stages, respectively (Table 1). A commercial concentrate (Table 1) The samples of concentrate were taken from the feed storages at weekly intervals and the kept at -20°C for chemical analysis by proximal analysis^[13]. Internal and external parasites were controlled by injecting Ivomec® in all of the piglets.

The data was collected at 14.00 pm and consisted of ambient temperatures, wet-dry bulb temperatures and Relative Humidity (RH). From this data, Temperature-Humidity Index (THI) was derived using the following equation^[14]:

$$THI = Tdb + 0.36(Tdp) + 41.2$$

Where:

Tdb = The dry bulb temperature (°C)

Tdp = The dew point temperature (°C)

Table 1: Composition of the experimental diets

Ingredients	Amount	
	Growing	Finishing
Corn	54.90	52.90
Soybean meal (44% cp)	16.90	18.40
Wheat bran	16.70	16.70
Broken rice	6.70	7.70
Limestone	2.00	1.90
Mono dicalciumdiphosphate	1.10	0.70
Molasses	1.00	1.00
Salt	0.40	0.30
Vitamin-mineral premix ^a	0.20	0.20
Lysine	0.20	0.20
DL-methionine	0.10	0.01
Total	100	100
Proximate Analysis ^b		
Dry matter	89.30	89.78
CP (%)	16.00	14.00
Gross energy (kcal/kg)	3.159	3.301
Calcium (Ca)	0.78	0.67
Total Phosphorus (P)	0.66	1.04
Crude Fiber (CF)	5.04	5.63

^aVitamin-mineral premix contained 11% Fe, 11% Zn, 2.6% Mn, 1.1% Cu, 0.02% Se, 909,091 IU of vitamin A, 136,364 IU of vitamin D, 3,636 IU of vitamin E, 0.6 mg of D-pantothenic acid and 4,546 mg of niacin per kilogram. ^bBased on ingredient values measured and analysis in our laboratory

The feeding behavior, drink walk, mouth pipe, root floor, root pipe and paw behaviors were recorded continuously on video tape. Skin Temperature (ST) and Rectal Temperature (RT) were measured three times per day at 3 and 7 h (daily heat stress period) and 2 h after lowering the thermostat for the warm period; The rectal temperature was measured by inserting a clinical thermometer into the rectum to a depth of 7 cm while the animal was placed in a racing stall with head support near the paddock and the skin temperature was measured using punctual samples^[15]. After feeding for 22 weeks in the growing stage (18-22 wk) and for 26 weeks in the finishing stage (22-26 weeks), the pigs were individually weighed and the data were calculated for the ADG, ADFI and feed efficiency (gain/intake). At the end of the experimental period, the animals were put on a fast from solid feed for 18 h, after which they were weighed and slaughtered for carcass characteristics and meat quality evaluation. Immediately after stunning by electronarcosis, the animals were bled via jugular incision and scalded, eviscerated and divided into two half-carcasses. Then, 45 min after slaughter, the pH and temperature of the carcasses were recorded using a pH meter that was coupled to a penetration probe and inserted into the center of the Longissimus dorsi muscle in the left half-carcass between the 12 and 13th thoracic vertebrae. The procedure was repeated 24 h after slaughter. The carcasses were weighed in order to obtain the Hot Carcass Weight (HCW). The length of the carcasses was recorded using the Brazilian Method for Carcass Classification

(BMCC). The back fat thickness between the 7 and 8th thoracic vertebrae, between the 3rd and 4th lumbar vertebrae and at the point P2 was measured using calipers. The Loin Eye Area (LEA) was recorded according to the methodology that was proposed by Boggs and Merkel^[16] which consisted of the section between the 10 and 11th ribs of the left half carcass, where a cross section of the Longissimus dorsi was exposed. The Fat Area (FA) and Longissimus muscle Area (LA) were measured to calculate Longissimus muscle Area/Fat Area (LA/FA) according to standard methods described previously by Sripomma^[17]. The fat-lean ratio was expressed according to the LSQ (Lenden-Speck-Quotient) system of Pfeiffer and Falkenberg^[18]. Briefly, the LSQ is calculated as $(B1+B2)/(2 \times B3)$ where B1 = the back fat thickness at the front base of the gluteus muscle, B2 = the back fat thickness on top of the gluteus muscle (at the thinnest part of the back fat) and B3 = the shortest distance from the front base of the gluteus muscle to the dorsal border of the spinal cord.

The qualitative measurements of the Longissimus dorsi muscle were performed using the methodologies described as follows: Meat color: Aiming for muscle oxygenation, each sample remained exposed to the air for 15 min. After this period, the meat was slightly dried with paper towels and the color was measured using a portable color meter (Minolta CR 410). The components L*(lightness), a*(red-green) and b*(yellow-blue) were shown in the CIELAB color system and assessed at three different points of the muscle surface using the D65 illuminant and an observational angle of 10°^[19].

Exudate Loss (EL): Samples in steak form with a 2.5 cm width were prepared with the external fat removed and were weighed on a semi-analytic scale. The samples were kept as in a simulated retail sale on a shelf with a 45° angle of inclination in trays that were covered with a plastic film at 4±1°C for 48 h. After this period, the exudate was discharged and the samples were weighted again. The EL was expressed as a percentage of the initial weight (Caldara *et al.*, 2013).

Weight Loss by Cooking (WLC): Samples in steak form with a 2.5 cm width were prepared with the external fat removed and were weighed on a semi-analytic scale and roasted without the addition of condiments. The oven was pre-heated to a temperature of 170°C. The internal temperature of the samples was monitored during cooking using sensors that were tied to a digital thermometer. When the sample's internal temperature reached 80°C, they were removed from the oven and cooled at room temperature, after which they were

weighed. The WLC was expressed as a percentage of water lost in relation to the original sample weight^[19].

Shear Force (SF): Three cylindrical sub-samples were removed from each WLC sample, parallel to the muscle fiber orientation. These sub-samples were placed with the fiber oriented perpendicular to the Warner-Bratzler lamina as described by Froning *et al.*^[20]. The average of three repetitions and the value of shear force for each sub-sample were used to assess the tenderness of the meat^[19].

The data were analyzed by ANOVA^[7] and the means compared by Least Significant Different (LSD) using the General Linear Model (GLM) procedure of SAS (SAS Inst 1999) as a randomized complete block design. Orthogonal single degree-of-freedom contrasts were used to determine the main effects of group size (4, 8 and 12 pigs/pen). These effects were considered significant at $p < 0.05$. Probability values of $p > 0.05$ and $p < 0.10$ were considered trends and probability values of $p > 0.10$ were considered not significant.

RESULTS AND DISCUSSION

The temperature during this experiment from February to July 2014 of Thailand, averaged across rooms were 30.8±1.1°C and the highest temperature was 34°C. Bull *et al.*^[15] reported that heat stress occurs at a temperature of 34.2±2.8°C, resulting in increased respiration rates and rectal temperatures, slowed growth, and poor reproduction. For this experiment found that the larger group sizes of 4-12 pigs/pen affect to increase of temperature in rectal and skin of pigs which was the highest in the largest group size with 12 pigs/pen after rearing for 42 days by 38.9°C and 36.8°C, respectively (Table 2). In addition, Trezona *et al.*^[6] found that pigs that were slaughtered from July-October were heavier and fatter than pigs that were slaughtered from January to March (hot season).

The larger group sizes of 4-12 pigs/pen changed their feeding behavior to increase frequency in eating, drinking, urinating, defecating, turning, walking, mouth watering, mouth piping, rooting the floor, rooting the pipe and pawing in both the growing and finishing stages. Which these behavior in a group size of 12 pigs/pen more often (time/day) than did the group sizes with 4 and 8 pigs/pen by significant difference ($p < 0.05$) in both the growing and finishing stages (Table 3).

The similar report by Hyun and Ellis^[11] found that finishing pigs changed feeding behavior with increasing group size of 2 and 12 pigs during either the growing or finishing periods, particularly showing an increase in the rate of feed consumption.

Table 2: Rectal and skin temperature during the hot season of Thailand

Date after rearing	Rectal				Skin			
	4	8	12	SEM	4	8	12	SEM
7	37.5 ^b	37.7 ^b	38.3 ^a	0.33	34.2 ^b	34.6 ^b	35.5 ^a	0.11
14	37.4 ^b	38.1 ^a	38.4 ^a	0.40	34.1 ^b	35.1 ^a	35.8 ^a	0.43
21	37.5 ^b	38.2 ^a	38.7 ^a	0.34	34.1 ^b	34.8 ^b	35.7 ^a	0.40
28	37.3 ^b	38.1 ^a	38.4 ^a	0.53	34.2 ^b	34.5 ^b	35.1 ^a	0.16
35	37.2 ^b	38.1 ^a	38.5 ^a	0.62	35.4 ^b	35.2 ^b	36.6 ^a	0.40
42	37.5 ^b	38.2 ^a	38.9 ^a	0.58	35.4 ^b	36.4 ^a	36.8 ^a	0.53

^{ab}Means within rows showing different superscripts are significantly different (p<0.05)

Table 3: Feeding behavior of pigs during the growing and finishing stages

	Group size (pigs/pen)				
Behaviors (time day ⁻¹)	4	8	12	SEM	p-values
Growing stage					
Eat	74.2 ^b	75.2 ^b	84.2 ^a	4.1	0.03
Drink	26.1 ^b	25.3 ^b	37.2 ^a	2.3	0.02
Urinate	3.0	3.9	3.5	0.1	0.12
Defecate	3.8	3	3.6	0.9	0.22
Turn	2.5	2.7	2.6	0.7	0.31
Walk	3.3 ^b	3.6 ^b	13 ^a	0.3	0.01
Mouth water	1.5	1.2	1.8	0.6	0.12
Mouth pipe	4.2 ^b	4.5 ^b	14.6 ^a	0.9	0.03
Root floor	8.3 ^b	11.7 ^b	31.1 ^a	0.5	0.04
Root pipe	0.3 ^b	0.8 ^b	38.7 ^a	0.9	0.03
Paw	0.2 ^b	0.3 ^b	24.8 ^a	4.1	0.02
Fishing stage					
Eat	3.2 ^b	3.4 ^b	6.6 ^a	0.9	0.03
Drink	1.2 ^b	1.2 ^b	2.5 ^a	0.4	0.03
Urinate	0.3	0.2	0.3	0.3	0.11
Defecate	0.2	0.3	0.3	0.6	0.08
Turn	2.4	2.6	2.8	1.54	0.09
Walk	1.4 ^b	1.5 ^b	7.1 ^a	0.4	0.04
Mouth water	0.2	0.2	0.3	0.5	0.06
Mouth pipe	2.21 ^b	2.11 ^b	6.2 ^a	2.1	0.03
Root floor	3.2 ^b	3.5 ^b	9.3 ^a	1.6	0.03
Root pipe	0.5 ^b	0.6 ^b	2.5 ^a	4.4	0.02
Paw	2.2 ^b	2.3 ^b	6.1 ^a	2.7	0.03

^{ab}Means within rows showing different superscripts are significantly different (p<0.05)

Table 4: Effects of group size on performance in growing and finishing phases

Items	Group size (pigs/pen)			SEM	p-values
	4	8	12		
Growing Pigs (18-22 wk)					
ADG (g d ⁻¹)	780 ^a	778 ^a	772 ^b	0.15	0.04
ADFI (kg d ⁻¹)	2.25	2.22	2.20	0.35	0.08
Efficiency (ADG/ADFI)	0.34	0.34	0.34	0.47	0.54
Finishing Pigs (23-26 wk)					
ADG (g d ⁻¹)	850 ^a	849 ^a	825 ^b	0.11	0.03
ADFI (kg d ⁻¹)	2.95	2.93	2.90	0.24	0.09
Efficiency (ADG/ADFI)	0.28	0.27	0.28	0.10	0.10

^{ab}Means within rows showing different superscripts are significantly different (p<0.05)

Although, the feeding behavior in a group size of 12 pigs/pen more often (time/day) than the group sizes with 4 and 8 pigs/pen but it had no effect on the feed intake, similar to the report by Hyun and Ellis^[11]. In

Table 5: Effects of group size on carcass traits and meat qualities

Items	Group size, pigs/pen				p-values
	4	8	12	SEM	
Carcass length (cm)	106.31	106.25	105.93	0.49	0.11
Back fat thickness (cm)	3.54 ^a	3.35 ^b	3.31 ^b	0.31	0.03
LSQ	0.36	0.34	0.35	0.34	0.10
Hot carcass (kg)	103.13	101.26	100.31	0.42	0.09
Lion eye area (cm ²)	53.50	53.40	53.67	0.15	0.12
Fat area (cm ²)	19.9	18.52	18.72	0.44	0.08
Lion eye area/Fat area	2.55	2.82	2.86	0.24	0.09
pH 45 min	6.64	6.68	6.70	0.15	0.08
Temperature 45 min (°C)	39.02	39.2	38.98	0.31	0.11
L* (lightness)	53.51	52.79	52.70	0.31	0.10
a* (redness)	5.04	5.64	5.70	0.32	0.12
b* (yellowness)	2.44	2.53	2.43	0.45	0.13
Cooking loss (%)	30.01	30.2	30.23	0.44	0.10
Drip loss (%)	2.18	1.19	1.86	0.67	0.11
Shear force (kg/cm ³)	3.62	3.36	4.15	0.15	0.08

^{ab}Means within rows showing different superscripts are significantly different (p<0.05)

addition, Gonyou and Striklin^[9] reported that ADG decreased with increasing group size (3, 5, 6, 7, 10 and 15 pigs/pen) during both the growing and finishing stages.

For this report showed that the group size of 12 pigs/pen had a lower ADG than that of group sizes with 4 and 8 pigs/pen during the growing and finishing stages (Table 4 and 5) which was significantly different at (p<0.05). This result affect form the highest body temperature in the group size of 12 pigs/pen which Harapin *et al.*^[3] reported that the high temperature was caused heat stress related to decrease of growth performance.

On carcass traits and meat qualities, the group size did not affect the carcass length, Lenden-speck-quotient, hot carcass weight, lion eye area, fat area, Longissimus muscle Area/Fat Area (LA/FA) and all of the studied meat qualities (p<0.05). Similar report by Wolter *et al.*^[21] presented that the group size did not affect the hot carcass weight, loin-eye depth or carcass dressing percentage. However, this report shows that a larger group size of 8 and 12 pigs/pen reared under the high temperature of Thailand had the less back fat thickness than that in a group size of 4 pigs/pen (Table 5) which was significantly different (p<0.05).

CONCLUSION

This study indicates that group size affects feeding behaviors and that these feeding behaviors do not affect the Average Daily Feed Intake (ADFI). However, the Average Daily Gain (ADG) of the larger group size (12 pigs/pen) was lower than that of the smaller group size (4 and 8 pigs/pen). This result may have resulted from changed feeding behaviors and from heat stress during the experiment. Moreover, the high temperature decreased the

back fat thickness as the larger group size had a significantly lower back fat thickness than that of the smaller group ($p < 0.05$).

ACKNOWLEDGEMENT

This research received financial support from the National Research Council of Thailand and Nakhon Sawan Rajabhat University.

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