The Effect of Automatic Environmental Control by Image Analysis System on the Performance of Pigs in Different Seasons[a]

D. I. Chang, C. S. Park[1], H. S. Lee[1], B. D. Lee[1,*] and H. H. Chang[2]
Department of Agricultural Machinery Engineering, Chungnam National University, Daejeon 305-764, Korea

ABSTRACT : A computer software was developed in our laboratory to automatically control the pigs environment by the image analysis system (IAS), which monitors and analyzes the pig's behavior and feeds the results back to the computer hardware. Three feeding trials were conducted with growing pigs (L×Y) to test the effectiveness of the IAS under various seasons. In all three trials, the open-sided conventional pens with half-slatted floor were used as controls; for the IAS treatment, fully-slatted floors were used in the windowless pens. Experiment 1 was conducted in the winter for 30 d with 24 growing pigs. There were two treatments (Conventional vs. IAS), and three pens (replicates) per treatment. During the growing period, the feed efficiency was significantly ($p<0.05$) improved by the IAS. In addition, the pigs reared under the IAS during the growing period displayed better growth rate during the finishing period than did the pigs reared under the conventional conditions. Experiment 2 was conducted in the summer for 30 d with 24 growing pigs. The experimental design was the same as Experiment 1. During the finishing period, all the pigs were kept in conventional open-sided pens until their market weights to evaluate their carcass characteristics. During the growing period, the growth rate and feed efficiency of the pigs in the IAS was better than those of the control pigs. In addition, various carcass characteristics were significantly improved by the IAS rearing during the growing period. Experiment 3 was conducted with 30 growing pigs for 30 d in the spring. The experimental design was the same as Experiment 1. No difference was found in growing performance between the control and IAS pigs. It could be concluded that the IAS is effective in providing optimum conditions for the growing pigs in summer and winter seasons. In addition, providing an optimum environment during the growing period results in improved growth rate, feed efficiency, and carcass qualities for the finishing pigs. *(Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 5 : 681-685)*

Key Words : Image Analysis System, Seasonal Growth, Pig, Controlled Environment

INTRODUCTION

Among the many factors in the pig's environment, the air temperature is most important (Boon, 1981; Geers et al., 1986; MWPS, 1990). However, a pig's performance is also influenced by other environmental factors such as velocity and moisture of the air, type and temperature of the floor, and harmful gases. Therefore, the environment control systems developed for the existing windowless pig houses could be unsatisfactory at times, because they do not take all these environmental factors into consideration.

For automatic environment control in piglet houses, the image analysis system (IAS) was introduced to acquire raw images of pigs by Wounters et al. (1990). Then it was developed to the level of FFT (Fast Fourier Transform) analysis for the binary image of pigs by Shao et al. (1996). However, the technology for classifying the thermoregulatory behavior of pigs using IAS was not yet developed.

In our laboratory, computer software was developed to automatically control the pig's environment by the IAS, which monitors and analyzes the pigs' behavior and feeds the results back to the computer hardware (Chang, 1998). Three feeding trials were conducted to test the effectiveness of the IAS under various seasonal conditions. The hypothesis of this study is that if thermal environment control were accomplished based on the thermoregulatory behavior classified by an IAS, the same effect as environment control based on thermal environmental factors such as air temperature, air velocity, humidity, floor type, and harmful gases, would be shown.

MATERIALS AND METHODS

Experiment 1

A 30-d feeding trial was conducted with 18 gilts and six barrows (L×Y), weighing about 30 kg each, during the winter. They were randomly allotted to three conventional open-sided pens (Conventional treatment) and three windowless pens whose environments were controlled by the IAS (IAS treatment, figure 1). Thus, there were two treatments (Conventional

* Address reprint request to B. D. Lee. Tel: +82-42-821-5778, Fax: +82-42-825-9754, E-mail: leebd@hanbat.chungnam.ac.kr.

[1] Department of Animal Science, Chungnam National University, Daejeon 305-764, Korea.

[2] Present address: Faculty of Animal Science, Gyeongsang National University, Jinju 660-701, Korea.

[a] This study was funded by the Agricultural R & D Promotion Center, Ministry of Agriculture and Forestry, Republic of Korea.

Received May 20, 1999; Accepted September 1, 1999

vs. IAS) and three pens (replicates) per treatment in this experiment. The floors of the Conventional treatments were half-slatted, but the floors of the IAS pens were fully slatted. Each pen housed three gilts and one barrow, providing 0.77 m^2/pig. A commercial grower diet (CP 17.5%, DE 3,350 kcal/kg) was provided *ad libitum*, and water was provided through nipples. After the feeding trial, all the pigs in the IAS were transferred to three conventional open-sided pens, and fed the same diet until their market weights to compare their growth rates during the finishing period. A paired t-test (Snedecor and Cochran, 1967) was used to detect the statistical significance at the level of 5%.

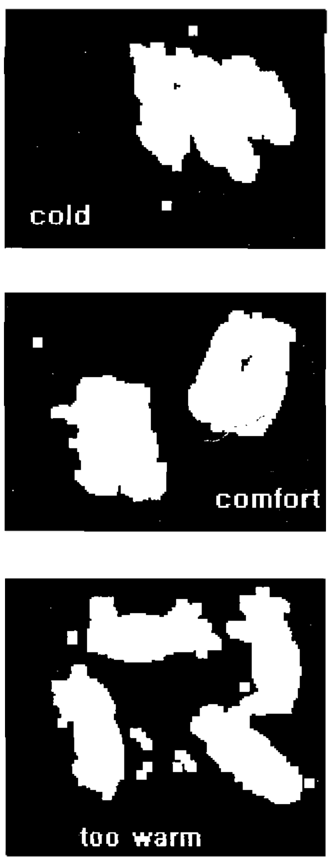

Figure 1. Processed binary images under the various environmental conditions

Experiment 2

A 30-d feeding trial was conducted with 12 gilts and 12 barrows (L×Y), weighing about 30 kg each, during the summer. They were randomly allotted to three conventional open-sided pens (Conventional treatment) and three windowless pens whose environments were controlled by the IAS (IAS treatment, figure 1), making the design exactly like that of Experiment 1. Each pen housed two gilts and two barrows, providing 0.77 m^2/pig. The same diet as in Experiment 1 was provided *ad libitum*, and water was provided through nipples. After the feeding trial, all the pigs in the IAS were transferred to three conventional open-sided pens, and reared until their market weights to measure the growth rate during the finishing period. In addition, various carcass characteristics were measured according to the method of Park (1996), and compared between the two treatments. Statistical significance was tested as in Experiment 1.

Experiment 3

A 30-d feeding trial was conducted with 18 gilts and 12 barrows (L×Y), weighing about 15 kg each, during the spring. They were randomly allotted to three conventional open-sided pens (Conventional treatment) and three windowless pens whose environments were controlled by the IAS (IAS treatment, figure 1). Therefore, there were two treatments, and three replicates per treatment as in the previous experiments. Each pen housed three gilts and two barrows, providing 0.6 m^2/pig. A commercial piglet diet (CP 17.5%, DE 3,350 kcal/kg) was provided *ad libitum*, and water was provided through nipples. Statistical significance was tested as in Experiment 1.

Image analysis system

An operating software was programmed using the LabWindows/CVI system (Chang, 1998). The orders of algorithm of the environmental control system were the classification of pig behavior by image processing, the measurement of ammonia concentrations, the relative humidity, the indoor and outdoor temperatures of pig housing, the determination of ventilation control stage, the controlling of the exhaust fan and air inlet, and the operation of heater or air cooler depending on the thermal comfortable behavior of pig.

During the three 30-d feeding trials, the temperature and ammonia gas concentration were recorded as shown in table 1. During the winter, the pigs in IAS pens were kept in a proper temperature range as compared to those in Conventional pens. During the summer, the IAS seemed to be effective in alleviating the heat stress manifested by the pigs housed in the Conventional pens. During the spring, however, the temperatures in Conventional pens were moderate, indicating that the IAS might not be useful in mild temperature conditions. Regardless of the season, the ammonia gas concentrations in the IAS pens were markedly lower than those in the Conventional pens.

RESULTS AND DISCUSSION

Table 1. The temperature and ammonia gas concentration during the three 30-d feeding experiments

Experiments		Temperature (℃)			NH_3 (ppm)	
		Out door	Conventional[1]	IAS[2]	Conventional	IAS
Experiment 1 (winter)	Min.	-2.4	3.7	14.8	2.0	0.4
	Max.	16.1	17.6	23.4	9.4	3.1
	Mean	6.5	11.2	17.9	5.8	1.9
	SD	3.2	2.9	2.1	2.1	0.7
Experiment 2 (summer)	Min.	16.2	14.9	22.0	4.2	0.3
	Max.	32.5	32.0	27.2	9.6	2.6
	Mean	24.2	26.0	24.6	6.2	0.8
	SD	3.8	3.2	0.7	1.3	0.2
Experiment 3 (spring)	Min.	9.0	12.5	17.4	4.2	0.3
	Max.	29.8	30.4	26.6	8.8	3.2
	Mean	19.5	21.6	22.7	5.9	0.7
	SD	4.2	3.5	1.9	1.3	0.2

[1] Open-sided conventional pens. Half-slatted floor was used.
[2] Fully slatted floor was used in the windowless pens of which environments were controlled by image analysis system (IAS).

Experiment 1

Although no significant difference was found in the BW gain and feed intake, the feed/gain ratio was significantly ($p<0.05$) improved in the IAS (table 2). According to the standard of Mayrose et al. (1992), daily gain of 1.5 lb or more and feed/gain ratio of 3.0 or less are classified as "Excellent". The BW gains of both treatments (table 2) were excellent, however, the feed/gain ratio of the Conventional treatment was relatively poor, indicating that the pigs in the Conventional treatment needed more dietary energy in maintaining the body temperature than did the pigs in the IAS. The results in table 2 indicate the IAS was successful in maintaining the room temperature optimum for the pig growth.

Table 2. Effects of image analysis system (IAS) on the performance of pigs during 30-d growing period in winter (Experiment 1)

Items	Treatments	
	Conventional[1]	IAS[2]
Initial BW, kg/head	31.64 ±1.37[3]	28.68 ±0.99
Final BW, kg/head	53.66 ±1.88	51.08 ±0.77
BW gain, kg/head	22.02 ±1.18	22.41 ±0.79
Feed intake, kg/head	74.12 ±6.30	64.15 ±3.66
Feed/gain	3.366±0.09[a]	2.864±0.10[b]

[1,2] See table 1; [3] Mean±SE; [a,b] $p<0.05$.

After the 30-d winter feeding trial, the pigs in the IAS were moved to the Conventional pens, and all of the experimental pigs were kept until marketing. As shown in table 3, the daily BW gain was significantly better for the pigs that had been kept in the IAS during the growing period. This implies that providing an optimum environmental condition during the growing period is essential in obtaining the best growth performance during the later finishing period, as reported by Chung (1998). In commercial practice, the pigs could be reared in IAS pens, and transferred to cheap, Conventional pens during the finishing period, to lower the production cost.

Table 3. Effect of the facilities during the growing period on the growth rate of growing-finishing pigs (Experiment 1)

Items	Facilities (growing/finishing)	
	Conventional/ conventional[1]	IAS/ conventional[2]
Initial BW, kg/head	31.34±1.37[3]	28.68±0.99
Final BW, kg/head	98.38±1.41	99.42±1.16
BW gain, kg/head	67.04±1.21[b]	70.74±1.03[a]

[1] Pigs were reared under the conventional conditions throughout the growing (30-50 kg) and finishing (50-100 kg) periods (See table 1).
[2] Pigs were reared under the IAS treatment during the growing (30-50 kg) period. During the finishing period (50-100 kg), the pigs were moved to the conventional conditions.
[3] Mean±SE; [a,b] $p<0.05$.

Experiment 2

The pigs in the IAS showed significantly higher BW gain during the 30-d growing period than did those in the Conventional treatment (table 4). In addition, the former resulted in significantly better feed efficiency than did the latter. However, there was no significant difference in feed intake between the two treatments.

As shown in table 1, the IAS was quite successful in reducing the maximum high temperature from 32.0 to 27.2℃. The growth rate and feed/gain ratio of the IAS in table 4 were better than those of Park et al. (1996), who also employed ordinary windowless pig housing units to control the environmental temperature during the summer. This indirectly indicates that not only the temperature but also proper ventilation are important for the best performance of pigs. The IAS was quite successful in providing the optimum condition as shown in table 1.

Table 4. Effects of image analysis system (IAS) on the performance of pigs during 30-d growing period in summer (Experiment 2)

Items	Treatments	
	Conventional[1]	IAS[2]
Initial BW, kg/head	25.43±1.33[3]	25.96±0.82
Final BW, kg/head	49.39±0.30[b]	51.25±0.31[a]
BW gain, kg/head	23.94±0.23[b]	25.29±0.31[a]
Feed intake, kg/head	58.42±3.05	54.17±1.11
Feed/gain	2.438±0.08[a]	2.142±0.12[b]

[1,2] See table 1; [3] Mean±SE; [a,b] $p<0.05$.

After the 30-d summer feeding trial, the pigs in the IAS were transferred to the conventional pens, and all of the experimental pigs were kept until marketing. The growing performance and carcass characteristics were shown in table 5. Although no significant differences in BW gain and feed intake were detected, the feed efficiency was significantly improved by the IAS rearing during the growing period; in addition, various carcass characteristics were also improved by the IAS rearing system. These results indicate that the optimum environment during the growing period improves the feed efficiency and carcass characteristics of the growing-finishing pigs. Chung (1998) also reported that providing optimum environment during the growing period improved not only daily gain but also carcass qualities in finishing pigs.

Experiment 3

No significant differences were found in growth rate, feed intake, and feed/gain ratio between the Conventional and IAS treatments (table 6). According to the standard of Mayrose et al. (1992), the growth performances shown in table 6 belong to "Excellent.' These results indicate that the environment of the Conventional treatment was optimum for the growing pigs during the spring season in Korea. Accordingly, the mild weathers of the spring and fall in Korea do not justify the use of the IAS for the growing pigs, which could lead to a higher production cost.

Major environmental factors which have direct influence on pig productivity are temperature, relative humidity, air velocity, and noxious gases. These factors could be automatically controlled by the system developed in this study and this would have positive effects on productivities of piglets and growing pigs which are very sensitive to these environmental factors. Needless to say, the environment control pig house is very expensive to build and to operate compared to the conventional pig house, thus raising the production cost.

Table 5. Effects of the rearing facilities during the growing period on the various economic traits of growing-finishing pigs in summer (Experiment 2)

Items	Treatments	
	Conventional[1]	IAS[2]
Initial BW, kg/head	25.43±1.33[3]	25.96±0.82
Final BW, kg/head	106.34±2.28	107.88±0.52
BW gain, kg/head	80.91±1.93	81.92±0.26
Feed intake, kg/head	272.7±14.3	262.8±4.54
Feed/gain	3.370±0.01[a]	3.208±0.01[b]
Carcass weight, kg/head	67.08±0.44[b]	70.00±0.29[a]
Mean backfat thickness, mm	17.25±0.14[b]	18.40±0.08[a]
APGS quality score[4]	3.833±0.11[b]	4.417±0.19[a]

[1,2] See table 1; [3] Mean±SE.
[4] Based on Animal Products Grading (APGS) of Korea National Livestock Cooperatives Federation (Park, 1996).
[a,b] $p<0.05$.

Table 6. Effects of the rearing facilities during the growing period on the various economic traits of growing-finishing pigs in spring (Experiment 3)

Items	Treatments	
	Conventional[1]	IAS[2]
Initial BW, kg/head	14.70±0.86[3]	16.10±0.79
Final BW, kg/head	38.85±1.50	39.26±0.64
BW gain, kg/head	24.15±0.73	23.16±0.30
Feed intake	49.51±2.22	46.18±1.31
Feed/gain	2.05±0.03	1.99±0.06

[1,2] See table 1; [3] Mean±SE.

According to the results of the present study, however, using the environment control pig house and IAS, better productivity of piglets and growing pigs could be attained than in the conventional one during the summer and winter season when outside weather conditions are not favorable. Under favorable weather conditions such as spring, however, there was not much difference in pig productivity between the environment control house and the conventional ones. It appears that, during the summer and winter, the environment control system is essential for the maximum growth performance of growing pigs.

REFERENCES

Boon, C. R. 1981. The effect of departures from lower critical temperature on the group postural behavior of pigs. Anim. Prod. 33:71-79.

Chang, H. H. 1998. Studies on the automation of environmental control systems for windowless pig-housing. Ph.D. thesis, Chungnam National University, Daejeon, Korea.

Chung, H. K. 1998. Effective disease control systems for the improvement of pork quality. Swine Research. Oct. pp. 112-123, Seoul, Korea.

Geers, R. V., G. G. Parduyns and G. Vercruysse. 1986. The group postural behavior of growing pigs in relation to velocity, air and floor temperature. Appl. Anim. Behav. Sci. 16:353-362.

Mayrose, V. B., K. Foster, G. W. Libal and K. L. Esbenshade. 1992. Pork Industry Handbook, Purdue University Cooperative Extension Service. IN. pp. 5-6.

MWPS. 1990. Mechanical ventilating systems for livestock housing MWPS-32. Midwest Plan Service, Iowa State University, Ames, IA.

Park, B. H., H. W. Bang, I. K. Whang, S. K. Paik, D. W. Lee, D. K. Kim and C. Y. Whang. 1996. Improving the rearing technology in modern windowless pig house. Rural Development Administration, Ministry of Agriculture and Forestry, Korea.

Park, T. J. 1996. Manual of Animal Products Grading Service, Korea National Livestock Cooperatives Federation, Seoul, Korea.

Shao, J., H. Xin and J. D. Harmon. 1996. Evaluating thermal comfort behavior of young pigs by neural network. ASAE Paper No. 96-4-58.

Snedecor, G. W. and W. G. Cochran. 1967. Statistical Analysis, 6th Ed. The Iowa State University Press, Ames, IA.

Wounters, P., R. Geers, G. Parduyns, K. Goossens, B. Truyen, V. Goedseels and E. Van der Studyft. 1990. Image analysis parameters as inputs for automatic environmental temperature control in the piglets houses. Computer and Electronics in Agriculture. 5:233-246.