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## The Effects of Noise and Vibration Generated by Mechanized Equipment in Laying Hen Houses on Productivity

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This study was carried out to investigate the effects of noise (N) and vibration (V) generated by mechanized equipment in laying hen houses on productivity of laying hens. N/V were measured at designated location in cages and facilities, and analyzed, with and without operation of feed supplier system, belt conveyor of layer feces, automatic egg collecting system, and feed distribution system at 13 mechanically-ventilated layer farms. Based on the characteristics of the N/V, levels of N/V were established for layer rearing experiments, and productivity was analyzed. Maximum and mean levels for noise were 90 and 69 dB, and they were 2.856 and 0.956 cm s<sup>-1</sup> for vibration, respectively. Results showed that most noise and vibration were produced by feed supplier and feed distribution systems. Noise seemed not to affect productivity of laying hen, while vibration at levels greater than 1.0 cm s<sup>-1</sup> did.

### INTRODUCTION

Recently, due to the development of the Korean economy, food consumption pattern has changed and egg consumption per capita has increased. Higher egg consumption necessitates increased number of laying hens. Due to the development of the industry and livestock technology, traditional small-scale facilities have changed to large-scale mechanized units (National Agricultural Products Quality Management Service in Republic of Korea, 2005). Typical mechanical equipment within a laying hen house are ventilation system, feed supplier system, belt conveyor of layer feces, automatic egg collection system and feed distribution system. The studies on noise and vibration (N/V), affecting livestock productivity directly or indirectly, have conducted by Baek *et al.* (2002), Campo *et al.* (2005), Graul *et al.* (1976), Kim *et al.* (2001), Lee *et al.* (2003), Lee *et al.* (2004), Stephen *et al.* (1998), Warris *et al.* (1997), Yun (1998) and etc. All the results referenced above, were related to the effects of intermittent noise and vibration generated outside the layer hen houses on the productivity of layers in the houses. Otherwise, studies on the effects of noise and vibration generated and repeated by the facilities and machinery within the layer hen houses on the productivity of layers are limited.

The objective of this study was to measure and analyze N/V in laying hen houses equipped with multi-tier vertical cages when mechanical systems were or were

not in operation. Specific objectives of the study were to: (1) characterize N/V data measured in laying hen houses and (2) investigate the effects of N/V on productivity of laying hens through rearing experiments.

### MATERIALS AND METHODS

#### Test farms and measurement conditions

N/V measurements were taken on a nation-wide scale at 13 laying hen farms, located all over the country, and were measured for a week each barns. The farms are equipped with multi-tier vertical cages so as to investigate the characteristics of housing equipment at various levels of N/V (ASTM D 3580–95, 1995; ASTM E 756–05, 2005; KS B 0714, 2001; KS B 0712, 2003; Dong *et al.*, 2005). Table 1 shows the list of surveyed laying hen farms for the N/V measurements.

The laying hen breed used in the test farms was the

**Table 1.** List of the surveyed laying hen farms for noise and vibration measurement

Name of farm	No. of layer (thousand head)	Years of mechanization (yr)	Type of feed supplier
SY	50	7.0	Hopper
SS	70	10.0	Hopper
KP	50	3.0	Hopper
TH	35	10.0	Hopper
HA	18	13.0	Hopper
HJ	40	1.0	Hopper
SJCS	27	8.0	Hopper
MJG	65	8.0	Hopper
KPA	12	3.0	Chain
YS	70	1.0	Chain
YACS	20	10.0	Chain
YCS	39	0.4	Hopper
DS	40	1.0	Hopper

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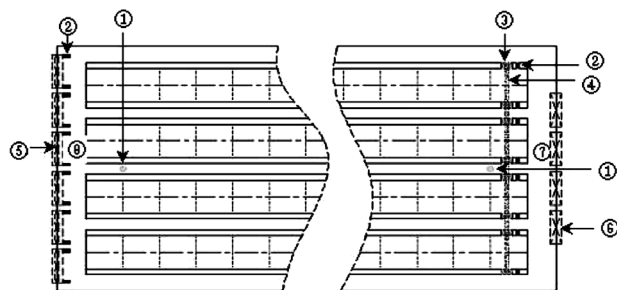
Hi-Line Brown. Operating schedule of the mechanical facilities of the laying hen houses were: (1) mechanical ventilation system operated continuously for 24 hours, (2) feed conveyor operated for 30 minutes 6–8 times during the lighting period, (3) feed distributor operated for 10–15 minutes after every operation of the feed supplier system and (4) feces belt and egg collection systems operated for two hours every morning. Normal light period lasted from 05:00 to 21:00 h, resulting in total lighting of 16 hours per day. After turning off the light no mechanical systems operated apart from the ventilation system.

Feces belt and egg collection system were same type at all 13 farms while type of feed supplier (feed supplier and feed distribution system) were different as Table 1.

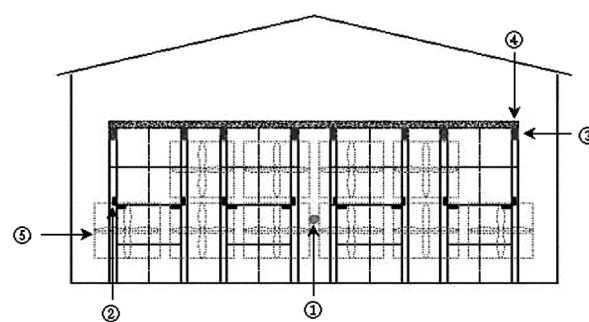
### Measurement and analysis of N/V data

N/V data were measured for a week at each 13 mechanically-ventilated laying hen farm with and without operation (normal condition) of the systems. And the operating schedules of mechanical systems for them were investigated.

Noise measurement regarding the ventilation system was taken at 2 m from the back side of the laying hen house. And for normal operation and for all the other mechanical systems, the measurement locations were at 2 m from the front side of the laying hen house as shown in Fig. 1 and Fig. 2. For the noise measurement and analysis, AC output values by sound level meter (NL-20) were saved with an oscilloscope (TDS5052B) and Vrms data were transformed to dB data by the calibration equation of NL-20 (spectrum technique). Noise recording with Panasonic PV400 was taken at same location as noise measurement location for reproducing noise of productivity experiment. Data on N/V of ventilation system were not taken, because its N/V might not directly or indirectly affect production and egg quality of laying hens. For vibration measurement and analysis, Vrms signals from the B&K noise/vibration meter (logger : 5935L; accelerometer : 752A12) were saved with an oscilloscope (TDS5052B) through amplification circuit of the vibration meter, then measured signals were transformed to data of  $\text{cm s}^{-1}$ . Data were characterized by FFT (Fast



**Fig. 1.** Layout of noise/vibration measurement locations in laying hen houses (top view).  
Conditions: ①Noise measurement system ②Vibration measurement system ③Feed conveying system ④Feed distribution system ⑤Ventilation system ⑥Air inlet ⑦Front side ⑧Back side.



**Fig. 2.** Layout of noise/vibration measurement locations in laying hen house (front view).  
Conditions: ①Noise measurement system ②Vibration measurement system ③Feed conveying system ④Feed distribution system ⑤Ventilation system.

Fourier Transform) analysis technique.

Equipments for the N/V measurement and analysis are as follows:

- Sound level meter: RION NL-20 (RION Co. Ltd., Japan)
- Sound and video recording: Panasonic PV400 (Matsushita Inc., Japan)
- B&K noise/vibration meter
  - Logger: Dual Microphone Supply with LEMO Socket 5935L (B&K Inc., Denmark, 2 channel)
  - Accelerometer: General Purpose-Type 752A12 (B&K Inc., Denmark)
- Oscilloscope: Tektronix TDS5052B (Tektronix Inc., U.S.A., 2 channel)
- Sound level meter (NL-20) and noise/vibration meter were calibrated by NC-73 (RION Co. Ltd., Japan)
- Portable Calibrators – Type 4294 (accelerometer calibrator, B&K Inc., Denmark) and TDS5052B (probe calibrator included itself) before the test, respectively.

Sound and vibration levels were calibrated by NL-20, B&K noise/vibration meter during productivity experiment with laying hens.

### Treatments for the rearing experiments

The operating test schedule (Table 2) was established based on the general mechanical facilities operating schedule of 13 laying hen farms.

Nine treatments (3 levels of noise  $\times$  3 levels of vibration) were designed and randomly allocated. Each treatment had six layers of Hi-Line Brown. Experiments were conducted in three replications and each replication took 30 days. Relocation of laying hens was carried out 10 days prior to beginning of each test and for the laying hens tested 10 days of stabilization period was used in order to reduce the effects of the relocation and previous test. The soundproofing walls were established in each cage for preventing to spread the noise.

It was assumed that the noise and vibration of the feed distribution system hardly affected in laying hens productivity of all cages, because it was located at front

**Table 2.** Operating schedule of mechanical equipment for rearing tests

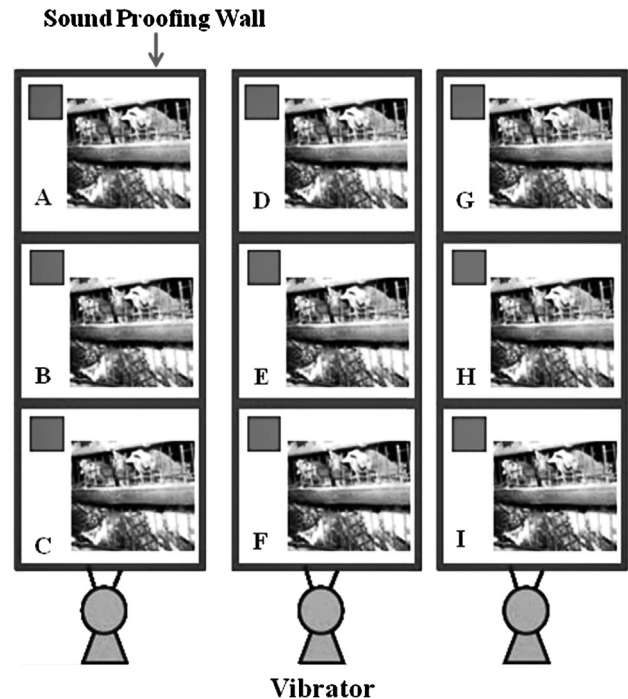
Hour	Mechanical equipment			
05:00				
05:30	Feeding			
06:00				Feces belt
06:30				
07:00				
07:30	Feeding			
08:00				
08:30				
09:00				
09:30	Feeding	Egg collecting belt		
10:00				
10:30				
11:00				
11:30	Feeding		Egg collecting elevator	
12:00				
12:30				
13:00				
13:30	Feeding		Egg collecting conveyor	
14:00				
14:30				
15:00				
15:30	Feeding			
16:00				
16:30				
17:00				
17:30	Feeding			

side in most 13 farms and length of cage was very long (about 100 m) in laying hen house as above Fig. 1. Therefore, it was excluded during this experiment.

- The noise reproducing equipment and the vibration generator were operated for 10 minutes each on 05:30, 07:30, 09:30, 11:30, 13:30, 15:30 and 17:30, according to the operating schedule of the feed supplier system (Table 2). The selected three levels for noise were 70, 80 and 90 dB and for vibration were 0.3 (31.1), 1.0 (8.8) and 2.5  $\text{cm s}^{-1}$  (1.7 Hz) based on the result of this investigation. Noise was recorded by a camcorder in the laying hen house and was reproduced using a PC, three amplifiers and nine speakers. In order to control the noise-reproducing equipment and the vibration generator, a program was developed using LabWindow/CVI 6.5 Package (National Instrument, USA). Levels of N/V were tested and adjusted with Sound level meter (RION NL-20, RION Co. Ltd., Japan) and B&K noise/vibration meter (General Purpose-Type 752A12, B&K Inc., Denmark). Fig. 3 shows a layout of the rearing experiment.

#### Analysis of N/V effects on productivity of layinghens

Lee *et al.* (2003) reported that the artificial noise affects productivity and stress of laying hens. So it was assumed that N/V affect to productivity and egg quality of laying hens in this study. Productivity of laying hens was analyzed in order to investigate the effects of N/V

**Fig. 3.** Layout of the rearing experiment (A–I : experimental treatment).

Conditions: A–70 dB & 0.3  $\text{cm s}^{-1}$ , B–80 dB & 0.3  $\text{cm s}^{-1}$ , C–90 dB & 0.3  $\text{cm s}^{-1}$ , D–70 dB & 1.0  $\text{cm s}^{-1}$ , E–80 dB & 1.0  $\text{cm s}^{-1}$ , F–90 dB & 1.0  $\text{cm s}^{-1}$ , G–70 dB & 2.5  $\text{cm s}^{-1}$ , H–80 dB & 2.5  $\text{cm s}^{-1}$ , I–90 dB & 2.5  $\text{cm s}^{-1}$ .

generated by the mechanical facilities within the laying hen houses. During the experimental period, at 10:00 AM every 10 days, quantity of feed intake, rate of eggs laying and quality of eggs (e.g. shell thickness, shell stiffness, weight of egg, HU (Haugh Unit) and xanthophylls) were measured. Shell thickness was measured by a shell thickness meter (Dial pipe gauge, Ozaki MFG Co. Ltd., Japan) and shell stiffness was measured by a shell stiffness meter (Egg shell force gauge model II, Robotmation Co. Ltd., Japan). Weight, HU, and xanthophylls were measured by Egg QCM+ (Technical Services and Supplies, York Co. Ltd., England).

Measured data were analyzed using the SAS GLM procedure (SAS Inc., U.S.A., 1999) and significant differences were determined using the Duncan's multiple range test.

## RESULTS AND DISCUSSION

Maximum levels of noise and vibration for each of the equipments within the laying hen houses were 82 (mean : 60) dB and 0.2027 (mean : 0.0985)  $\text{cm s}^{-1}$  under normal condition, 90 (mean : 68) dB and 2.8560 (mean : 0.9563)  $\text{cm s}^{-1}$  for hopper type feed supplier system, 92 (mean : 69) dB and 1.0296 (mean : 0.2107)  $\text{cm s}^{-1}$  for chain type feed supplier system, 88 (mean : 67) dB and 0.2387 (mean : 0.1523)  $\text{cm s}^{-1}$  for belt conveyer for layer feces, 87 (mean : 67) dB and 0.1865 (mean : 0.0928)  $\text{cm s}^{-1}$  for automatic egg collection system and 90 (mean : 69) dB and 2.0222 (mean : 0.9214)  $\text{cm s}^{-1}$  for feed distribution system, respectively. The levels of noise and

**Table 3.** Results at 1st day of experiment

Treatment		Quantity of feed intake (g hen <sup>-1</sup> day <sup>-1</sup> )	Rates of laying eggs (%)	Weight of egg (g)	Shell thickness ( $\mu$ m)	Shell stiffness (kg cm <sup>-2</sup> s <sup>-1</sup> )	HU	Xanthophylls
Vibration (cm s <sup>-1</sup> )	Noise (dB)							
0.3	70	165.8	94.4	58.3	541.2	4.7	91.0	12.1
0.3	80	166.7	94.4	57.5	539.1	4.5	92.7	12.4
0.3	90	172.2	94.4	58.5	539.0	4.8	93.5	12.1
1.0	70	163.8	94.4	55.9	540.3	4.3	92.9	12.4
1.0	80	164.5	94.4	57.8	540.0	4.7	94.8	12.2
1.0	90	160.0	94.4	58.3	539.3	4.7	92.1	12.2
2.5	70	167.5	94.4	58.0	540.2	4.3	92.4	12.5
2.5	80	167.2	89.9	57.3	539.0	4.9	92.1	12.3
2.5	90	166.7	88.9	57.8	539.1	4.5	92.8	12.0
SEM		3.07	1.61	0.28	0.00	0.07	0.45	0.05
Items		Degree of freedom		Significance probability				
Treatment	8	0.9991	0.9882	0.5321	0.5057	0.3878	0.7596	0.4941
Vibration	2	0.8084	0.6480	0.5168	0.7406	0.7591	0.6445	0.7049
Noise	2	0.9976	0.8954	0.4532	0.1683	0.2146	0.6220	0.1877
Vibration & noise	4	0.9888	0.9770	0.3902	0.5411	0.3037	0.5383	0.5035
Main effect								
Vibration (cm s <sup>-1</sup> )	0.3	168.2	94.4	58.1	539.6	4.7	92.3	12.2
	1.0	162.7	94.4	57.3	539.5	4.6	93.3	12.3
	2.5	167.1	90.7	57.7	539.2	4.6	92.4	12.3
Noise (dB)	70	165.7	94.4	57.4	539.9	4.5	92.1	12.3
	80	166.1	92.6	57.5	539.2	4.7	93.1	12.3
	90	166.3	92.6	58.2	539.2	4.7	92.8	12.1

\* SEM : Standard Error of Means

**Table 4.** Results at 10th day of experiment

Treatment		Quantity of feed intake (g hen <sup>-1</sup> day <sup>-1</sup> )	Rates of laying eggs (%)	Weight of egg (g)	Shell thickness ( $\mu$ m)	Shell stiffness (kg cm <sup>-2</sup> s <sup>-1</sup> )	HU	Xanthophylls
Vibration (cm s <sup>-1</sup> )	Noise (dB)							
0.3	70	167.2	94.4 <sup>a</sup>	57.6	538.2	4.2	96.8 <sup>c</sup>	11.9
0.3	80	168.0	94.4 <sup>a</sup>	57.6	538.4	3.9	96.7 <sup>c</sup>	12.3
0.3	90	171.4	94.4 <sup>a</sup>	58.7	539.3	3.9	103.5 <sup>A</sup>	11.9
1.0	70	161.9	83.3 <sup>ab</sup>	57.5	537.6	4.0	97.9 <sup>BC</sup>	12.3
1.0	80	163.9	77.8 <sup>ab</sup>	56.8	537.5	4.2	96.5 <sup>c</sup>	12.1
1.0	90	160.5	78.8 <sup>ab</sup>	56.8	538.2	4.1	103.5 <sup>A</sup>	12.1
2.5	70	163.3	72.2 <sup>b</sup>	58.3	537.4	3.7	98.6 <sup>BC</sup>	12.4
2.5	80	165.3	77.8 <sup>ab</sup>	58.7	537.3	4.0	101.4 <sup>AB</sup>	12.2
2.5	90	166.4	77.8 <sup>ab</sup>	58.4	538.1	4.4	101.6 <sup>AB</sup>	12.2
SEM		1.21	2.18	0.53	0.00	0.08	0.48	0.06
Items		Degree of freedom		Significance probability				
Treatment	8	0.6165	0.2633	0.8795	0.4418	0.6653	0.0001	0.3185
Vibration	2	0.1150	0.0177	0.2827	0.1487	0.8918	0.2526	0.1789
Noise	2	0.7953	0.9199	0.9528	0.3482	0.7830	0.0001	0.5333
Vibration & noise	4	0.9086	0.9306	0.8997	0.7399	0.2817	0.0774	0.3298
Main effect								
Vibration (cm s <sup>-1</sup> )	0.3	168.9	92.6 <sup>A</sup>	57.9	538.2	4.0	98.9	12.0
	1.0	162.1	83.3 <sup>AB</sup>	57.0	537.2	4.1	99.3	12.2
	2.5	165.0	75.9 <sup>B</sup>	58.5	537.5	4.0	100.6	12.3
Noise (dB)	70	164.1	83.3	57.8	537.3	4.0	97.7 <sup>B</sup>	12.2
	80	165.7	85.2	57.7	537.5	4.1	98.1 <sup>B</sup>	12.2
	90	166.1	83.3	57.9	538.1	4.1	102.9 <sup>A</sup>	12.1

<sup>a, b, c</sup> : Means with the different superscripts in the same column differ significantly (p<0.05).<sup>A, B, C</sup> : Means with the different superscripts in the same column differ significantly (p<0.01).

\* SEM : Standard Error of Means

**Table 5.** Results at 20th day of experiment

Treatment		Quantity of feed intake (g hen <sup>-1</sup> day <sup>-1</sup> )	Rates of laying eggs (%)	Weight of egg (g)	Shell thickness ( $\mu\text{m}$ )	Shell stiffness (kg cm <sup>-2</sup> )	HU	Xanthophylls
Vibration (cm s <sup>-1</sup> )	Noise (dB)							
0.3	70	172.7	100.0 <sup>A</sup>	59.5	537.6	4.1	96.1	12.4
0.3	80	175.7	94.4 <sup>AB</sup>	58.7	536.7	4.2	96.8	12.5
0.3	90	168.0	94.4 <sup>AB</sup>	62.7	535.9	4.3	99.5	12.5
1.0	70	161.7	77.8 <sup>C</sup>	59.8	535.5	4.0	96.8	12.6
1.0	80	161.0	88.9 <sup>ABC</sup>	59.9	536.4	4.2	95.0	12.4
1.0	90	165.7	88.9 <sup>ABC</sup>	59.5	537.3	4.3	96.6	12.6
2.5	70	158.3	83.3 <sup>BC</sup>	61.2	536.5	4.0	96.8	12.4
2.5	80	170.0	77.8 <sup>C</sup>	61.3	535.9	4.1	98.5	12.6
2.5	90	159.3	77.8 <sup>C</sup>	60.3	535.5	4.0	97.6	12.4
SEM		2.31	2.05	0.38	0.00	0.06	0.38	0.05
Items		Degree of freedom		Significance probability				
Treatment	8	0.6673	0.0290	0.2366	0.1307	0.8505	0.2006	0.9296
Vibration	2	0.2105	0.0019	0.3433	0.1346	0.4975	0.2070	0.7200
Noise	2	0.6725	1.0000	0.4305	0.6929	0.5045	0.2466	0.9455
Vibration & noise	4	0.8068	0.3129	0.1569	0.0985	0.8662	0.2722	0.6867
Main effect								
Vibration (cm s <sup>-1</sup> )	0.3	172.1	96.3 <sup>A</sup>	60.3	536.4	4.2	97.4	12.4
	1.0	162.8	85.2 <sup>B</sup>	59.7	536.2	4.2	96.1	12.5
	2.5	162.6	79.6 <sup>B</sup>	61.1	535.2	4.0	97.6	12.5
Noise (dB)	70	164.2	87.0	60.1	536.3	4.0	96.5	12.5
	80	168.9	87.0	59.9	535.7	4.2	96.7	12.5
	90	164.3	87.0	61.0	535.9	4.2	98.0	12.5

\* SEM and <sup>A, B, C</sup>: See Table 4.**Table 6.** Results at 30th day of experiment

Treatment		Quantity of feed intake (g hen <sup>-1</sup> day <sup>-1</sup> )	Rates of laying eggs (%)	Weight of egg (g)	Shell thickness ( $\mu\text{m}$ )	Shell stiffness (kg cm <sup>-2</sup> )	HU	Xanthophylls
Vibration (cm s <sup>-1</sup> )	Noise (dB)							
0.3	70	166.7	94.4 <sup>A</sup>	61.9	534.3	3.9	91.9	12.6
0.3	80	168.0	94.4 <sup>A</sup>	62.0	533.9	3.9	91.8	12.6
0.3	90	164.3	94.4 <sup>A</sup>	62.4	434.3	4.0	93.1	12.5
1.0	70	174.3	83.0 <sup>AB</sup>	62.1	533.7	4.2	91.5	12.9
1.0	80	170.3	83.3 <sup>AB</sup>	63.8	534.5	3.9	92.3	12.7
1.0	90	165.0	88.9 <sup>AB</sup>	64.0	533.6	3.7	91.6	12.6
2.5	70	167.8	72.2 <sup>B</sup>	62.5	534.2	3.9	91.4	12.6
2.5	80	171.7	72.2 <sup>B</sup>	61.3	535.0	4.1	93.5	12.5
2.5	90	170.3	77.8 <sup>AB</sup>	62.7	535.1	4.2	92.2	12.6
SEM		1.54	2.34	0.34	0.00	0.06	0.29	0.06
Items		Degree of freedom		Significance probability				
Treatment	8	0.9139	0.0566	0.6917	0.8494	0.6262	0.7359	0.9283
Vibration	2	0.6299	0.0019	0.2951	0.1906	0.4289	0.6920	0.4848
Noise	2	0.6789	0.6771	0.5505	0.9580	0.9169	0.5027	0.6215
Vibration & noise	4	0.8489	0.9812	0.7485	0.9616	0.3699	0.5493	0.9571
Main effect								
Vibration (cm s <sup>-1</sup> )	0.3	166.3	94.4 <sup>A</sup>	62.1	533.6	3.9	92.3	12.6
	1.0	169.8	85.2 <sup>B</sup>	63.3	533.4	3.9	91.8	12.7
	2.5	169.9	74.1 <sup>C</sup>	62.2	534.7	4.1	92.4	12.6
Noise (dB)	70	169.4	83.3	62.1	533.8	4.0	91.6	12.7
	80	170.0	83.3	63.3	533.8	3.9	92.4	12.6
	90	166.6	87.0	62.2	534.0	4.0	92.3	12.6

\* SEM and <sup>A, B, C</sup>: See Table 4.



vibration of feed supplier system and the feed distribution system were higher than 50 dB and  $0.3 \text{ cm s}^{-1}$  of intermittent construction N/V which may induce decrease of productivity in laying hens by KME (Korean Ministry of Environment, 2002). Repeated noise does not affect production (rates of laying eggs and weight of egg) and egg quality (shell thickness, shell stiffness, HU and Xanthophylls) in laying hens (Graul *et al.*, 1976; Lee *et al.*, 2004), but vibration may affect egg production of laying hens by the result of this study. Therefore, chain type feed supplier system with lower vibration levels is suitable than hopper type with higher in laying hen house.

Results of rearing experiments are summarized in Table 3, Table 4, Table 5 and Table 6. During the experimental period, the noise and vibration levels seem not affect quantity of feed intake, weight of egg, shell thickness, shell stiffness, and xanthophylls ( $p > 0.05$ ). Furthermore, HU was affected by N/V on the 10th day ( $p < 0.01$ ), but not on the 20th day and the 30th day of experiment ( $p > 0.05$ ). Finally, rates of laying eggs were not affected by noise ( $p > 0.05$ ), but they were affected by vibration ( $p < 0.01$ ). In other words, rates of laying eggs (92.6 to 96.3%) at vibration velocity of  $0.3 \text{ cm s}^{-1}$  was significantly ( $p < 0.01$ ) greater than those (74.1 to 85.2%) at vibration velocities of 1.0 and  $2.5 \text{ cm s}^{-1}$ . Based on the level of vibration affecting productivity of laying hens, a design guideline for vibration protection could be proposed and it would be applied for the optimum design condition of vibration for the mechanical systems within laying hen houses.

When livestock are exported to intermittent loud noise, heart rate, breathing rate and secretion of stress hormone was increased while rate of laying eggs and growth rate were decreased. And mortality, abortion and stillbirth may happen (Baek *et al.*, 2002; Kim *et al.*, 2001; Yun, 1998). However, because laying hens exposed to repeated artificial construction noise stress back to initial status over seven days by Graul *et al.* (1976) and Lee *et al.* (2004), noise did not affect production and egg quality in laying hens. Noise from indoor laying hen house is repeated noise. These previous results accord with the findings of this study. Vibration from construction affects production of laying hens by KME (Korean Ministry of Environment, 2002). There are no findings of vibration effect on egg quality in laying hens until these days.

Considering these previous results and our results, repeated vibration affects production of laying hens while repeated noise does not affect it.

## CONCLUSIONS

This study was carried out to investigate the effects of N/V generated by the mechanical systems (ventilation fans, feed supplier system, belt conveyor of layer feces, automatic egg collection system and feed distribution system) in laying hen houses on productivity of laying hens. N/V were measured and analyzed at designated points of cages and facilities. Maximum levels of noise for each of the equipment were 82 dB (normal condition) to 92 dB (chain type feed supplier system) and vibration were

$0.2027 \text{ cm s}^{-1}$  (normal condition) to  $2.8560 \text{ cm s}^{-1}$  (hopper type feed supplier system). Based on the characteristics of N/V various levels, N/V levels were established for rearing experiments (noise : 70, 80 and 90 dB; vibration : 0.3, 1.0, and  $2.5 \text{ cm s}^{-1}$ ). Nine treatments (3 levels of noise  $\times$  3 levels of vibration) were selected and randomly allocated. Then tests were conducted, and productivity (feed intake and egg production) and egg quality (shell thickness, shell stiffness, weight of egg, Haugh Unit and xanthophylls) were analyzed. Major findings were: (1) Noise seemed not to affecting productivity of laying hens while significantly impacted HU on Day 10, (2) Vibration only affected egg production at levels greater than  $1.0 \text{ cm s}^{-1}$ , and others were not affected by vibration. Based on the level of vibration affecting egg production, a design guideline for vibration protection could be proposed and it would be applied for the optimum design condition of vibration for the mechanical systems in laying hen houses.

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