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Effect of Nipple Angle on Water Disappearance by Pigs

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ABSTRACT : This experiment was conducted to investigate the effect of different nipple angles on water disappearance in growing pigs, which is defined as the water which leaves the watering device but is not consumed by the pig. This water adds to the volume of the total waste slurry. Four crossbred pigs averaging 70.0±1.4 kg were assigned into 1 of 4 treatments using a 4×4 Latin-square design. Treatments were distinguished by the angle between nipple terminal and the perpendicular wall. These angles were: 1) NA-30 (= Nipple Angle 30°), 2) NA-45 (= Nipple Angle 45°), 3) NA-60 (= Nipple Angle 60°) and 4) NA-90 (= Nipple Angle 90°). All of the nipples were fixed at shoulder height of each pig. After a 7-day adaptation period, samples were collected from each pig for 4 days, followed by a day for change-over. Pigs were fed a 0.8 kg diet twice daily at 08:00 and 20:00 and supplied water *ad libitum*. Throughout the experimental period, pigs in the NA-30 treatment group showed greater water disappearance than other treatments. Water disappearance was the lowest for the NA-60 treatment group ($p<0.01$). The percentage of water disappearance to the water supply was significantly reduced in the NA-60 treatment group ($p<0.01$). Water intake was the same for all the treatment groups. The rate of water disappearance per unit of water intake was significantly decreased in pigs in the NA-60 treatment group compared to other groups ($p<0.01$). These results suggested that the nipple angle for growing pigs should be 60° to reduce water disappearance and, subsequently, the amount of waste generated. (**Key Words :** Nipple Angle, Water Disappearance, Livestock Waste)

INTRODUCTION

The livestock industry has made great improvements in productivity and large scale industrialization. However, this progress has been accompanied by environmental pollution in the form of livestock excreta, which is a pressing problem that must be solved to ensure sustainable livestock production (Yang, 2007). In the swine industry, pig manure is a serious source for water pollution, soil contamination such as acidification, and atmospheric pollution by odor. In EU countries, regulations and restrictions on the environmental pollution have been strengthened, with movements toward eco-friendly swine production in many countries of the world. The Korean government is planning to restrict the ocean disposal of piggery waste, such that efforts should be made to reduce the volume of waste production.

The quantity of slurry and wasted drinking water produced daily by animals makes up the total waste stream, and its volume varies considerably depending on animal behavior, animal size, type of feed, and types of feeding and watering systems (Yu et al., 2005). In commercial swine farms, there are many different types of watering devices, but the most common design is that of a nipple drinker installed at an angle of 90° to the wall. Water disappearance, where water leaves the drinker but is not consumed by the pig and instead falls to the floor to join the waste stream, is a greater problem with growers or finishers than weaning pigs. As this water dilutes feeds, feces, and urine discharge, the waste stream assumes a more liquid consistency. Phillips and Fraser (1990) reported water disappearance of greater than 25% in weaning pigs, and more than 60% in grower-finishers when a nipple drinker was used (Brooks, 1994). Grower and finisher production stages account for approximately 66% of total piggery waste, while gestation, weaning and farrowing periods accounted for 15%, 11% and 8% of the waste, respectively (DGH Engineering Ltd., 2001). Therefore, research on effective measures for reducing water disappearance in grower-finisher production is urgently needed to ensure production competitiveness and environmental preservation.

Limited information is available on the effect of nipple drinker design on water disappearance. There are several

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Table 1. Chemical composition of experimental diets (as-fed basis)

Items	%
Corn	74.80
Soybean meal	22.44
Tallow	0.95
Limestone	0.53
DCP	0.78
Vit. mix[a]	0.10
Min. mix[b]	0.10
Salt	0.30
Total	100.00
Chemical compositions[c]	
ME (kcal/kg)	3,300.71
CP (%)	15.56
Lysine (%)	0.79
Ca (%)	0.44
Non-phytate P (%)	0.18

[a] Provided per kg of complete diet: vitamin A, 10,000 IU; vitamin D_3, 1,500 IU; vitamin E, 35 IU; vitamin K_3, 3 mg; pantothenic acid, 10 mg; niacin, 20 mg; biotin, 50 μg; vitamin B_{12}, 15 μg; folic acid, 500 μg; vitamin B_2, 4 mg; vitamin B_6, 3 mg.

[b] Provided per kg of complete diet: Cu, 55 mg; Fe, 75 mg; I, 250 mg; Mn, 20 mg; Se, 100 μg; Zn, 30 mg; Co, 250 mg.

[c] Calculated value.

factors affecting the water disappearance, which are drinker shape, position, height and velocity of water flow, and in particular, the effect of nipple angle. Consequently, this experiment investigates the best nipple angle for reducing water disappearance by growing-finishing pigs to minimize waste slurry treatment costs.

MATERIALS AND METHODS

Experimental animals and design

Pigs averaging 70.0±1.4 kg were used, and 4 crossbred pigs (L×Y×D) were assigned to 1 of 4 treatments generated by a 4×4 Latin-square design. The treatments were 1) NA-30 (= Nipple Angle 30°), 2) NA-45 (= Nipple Angle 45°), 3) NA-60 (= Nipple Angle 60°) and 4) NA-90 (= Nipple Angle 90°), where the nipple angle represents the degree between nipple terminal and wall. During the experimental period, the ambient temperature was maintained at 20-25°C and 60-70% relative humidity.

Experimental diet

Experimental feeds were formulated at 3,300.71 kcal/kg for ME, 15.56% for CP and 0.79% for lysine. Vitamins, minerals and other nutrients met or exceeded NRC requirements (1998) in the finishing period (BW 50-80 kg). The formula and chemical composition of the diet are presented in Table 1.

Equipment and sampling

All pigs were housed in an individual experimental crate where the nipple angle was adjusted according to the treatment group. The floor of crate was made with plastic woven to measure the volume of effluent effectively.

After a 7-day adaptation period, amounts of water supply, water intake, water disappearance and urine were measured for 4 days, after which a one-day transition period was provided. Nipple drinkers were then adjusted at shoulder height for each pig, and set at a flow rate of about 2 L/min, which is above than 0.7L/min from dong and pluske (2007). The pigs were fed 0.8 kg of diet twice daily at 08:00 and 20:00 and provided water *ad libitum*. All sampling was done 30 min prior to the 20:00 feeding. The water supply was monitored with a small water meter in each cage and the amount of water disappearance and urine

Figure 1. Features of pig to consume water forward nipple.

Table 2. Effect of nipple angle on water disappearance in growing pigs

Contents	NA-30	NA-45	NA-60	NA-90	SEM
Water supply (L)	7.87^{a}	5.80^{b}	5.68^{b}	6.60^{b}	0.48
Water disappearance (L)	2.56^{x}	1.35^{yz}	0.71^{z}	1.61^{y}	0.23
Water disappearance/water intake (%)	47.4^{x}	29.6^{y}	13.5^{z}	31.8^{y}	3.54
Water intake (L)	5.31	4.46	4.98	4.99	0.29
Water retention (L)	2.89	2.64	3.10	3.00	0.19

$^{a, b}$ Means with different superscripts in the same row significantly differ ($p<0.05$).

$^{x, y, z}$ Means with different superscripts in the same row significantly differ ($p<0.01$).

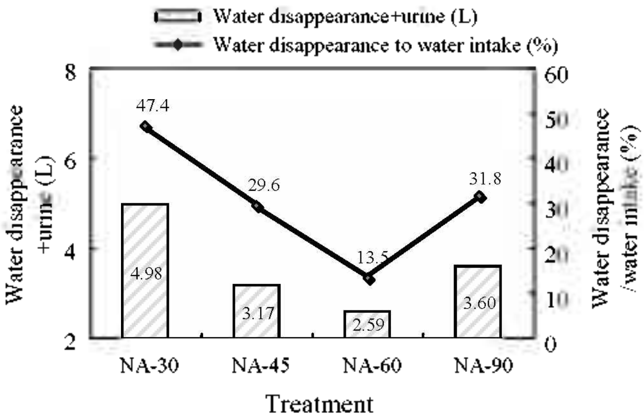

Figure 2. Slurry amount and water disappearance percentage by nipple angle.

were calibrated in a graduated cylinder. Specially designed sampling equipment was installed to collect urine and water spilled around the nipple drinker (Figure 1).

Statistical analysis

Data was analyzed using the General Linear Model procedure in SAS (1985), and treatment means were compared using the LSD multiple range test.

RESULTS AND DISCUSSION

As the feed intake was restricted throughout the experimental period, there were no differences in weight gain between the different groups. The initial weight of pigs averaged 70.0±1.4 kg and the final weight was 80.8±2.2 kg.

Figure 1 shows the different nipple angles and the equipment used to measure water disappearance. In each crate, the nipple drinker was set at the individual pig's shoulder height, following a calculation based on a theory by Gill and Barber (1990), where nipple height must be $15\times(\text{body weight (kg)})^{0.33}$ cm for the 90° nipple angle, and be $18\times(\text{body weight (kg)})^{0.33}$ cm for angles less than 90°.

The effects of nipple angle on water supply and disappearance are shown in Table 2. The water supply in the NA-30 group was greater than in any other treatment ($p<0.05$) and there were no significant differences among the other treatments. The NA-30 treatment group had the greatest water disappearance, while the NA-60 treatment group had the least ($p<0.01$). The NA-30, NA-45 and NA-90 treatment groups showed more water disappearance than NA-60 by 1.85, 0.64, and 0.90 liter/day, respectively. These values represent 72 (NA-30), 47 (NA-45), and 56% (NA-90) of the NA-60 treatment value. No differences were seen between the NA-45 and NA-90 treatment groups, which agreed with results from Pedersen (1987) who reported that quantities of water supply and slurry production showed no differences between nipple angles of 90° and 45°. According to Cumby (1986), the minimum water requirement was 2-2.5 kg per 1 kg of feed in restricted feeding and up to 3.5 kg per 1 kg of feed when administered *ad libitum*. In this experiment, the daily water intake averaged 4.94 L, with no differences among the treatments, which was in agreement with the findings of Cumby (1986). Water retention, defined as the volume of water intake minus the volume loss in urine, showed no differences among treatments.

The total waste produced by water disappearance and urine with the different treatments are presented in Figure 2. The waste slurry is comprised of water disappearance, urine, and feces. The volume was the least in the NA-60 group, and the greatest in the NA-30 group at 2.59 and 4.98 L, respectively ($p<0.01$). Similarly, the percentage of water disappearance relative to the water intake was the lowest in the NA-60 group at 13.5% and highest in the NA-30 group at 47.4% ($p<0.01$), with NA-45 and NA-90 groups being indistinguishable at 29.6 and 31.8%, respectively. From this perspective, the water disappearance needed to compensate for the same water intake was the smallest in NA-60 treatment group. To summarize Figure 2, the NA-60 treatment reduced the total water waste (water disappearance+urine) by 2.39, 0.58, 1.01 L/day compared to NA-30, NA-45, and NA-90 respectively. Based on this data, we believe that the differences in water disappearance are related to appropriate nipple angle for the pig. Certain angles cause less water to drip from the pig's mouth as they drink water than others, which is more attractive piggery waste fermentation and eco-friendly environment (Shim et al., 2007).

Wasteful water disappearance while the pig consumes water is affected by amount of water intake, type and location of drinker, water velocity and environmental temperature. However, as observed above, alteration of the nipple angle had significant effects on water disappearance under non-discriminating conditions. Therefore, reducing water disappearance through a change of the nipple angle could save additional construction and disposal costs for piggery waste by diminishing the slurry quantity. In turn, this would save water and make pig production more eco-friendly and sustainable.

IMPLICATIONS

Water disappearance from a water drinker using a nipple angle of 60° was the most economical compared to NA-30, NA-45 and NA-90 treatments, concomitant with the best reduction in total waste slurry volume. This simple adjustment in the angle of the nipple drinker will go a long way for making the swine farms more eco-friendly, sustainable, and economical industry.

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