Pakistan Veterinary Journal

ISSN: 0253-8318 (PRINT), 2074-7764 (ONLINE)
DOI: 10.29261/pakvetj/2023.080

SHORT COMMUNICATION

Effects of Liquid Feeding on Growth and Antimicrobial Resistance in Weaned Piglets

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ARTICLE HISTORY (23-228)

Received: June 8, 2023
Revised: July 9, 2023
Accepted: July 11, 2023
Published online: September 05, 2023

Key words:
Swine
Liquid feeding
Average daily gain
Escherichia coli
Antimicrobial resistance

ABSTRACT

This study aimed to examine whether the feeding method affected growth performance of weaned piglets, and whether antimicrobial resistance was expressed differently when dry feed or liquid feed was administered. The study was conducted on a farm with 600 sows, using 80 21-day-old weaned piglets. The piglets were divided into two equally-sized groups. Piglets were monitored up to 70 days of age. The average daily gain in the liquid-feed group were significantly higher (394.5 ± 165.99g) compared to the dry-feed group (342.7 ± 158.39g). Additionally, the resistance to ceftiofur was significantly lower in liquid-feed group (55.8%) compared to dry-feed group (70.3%). Based on these results, it can be inferred that liquid-feeding is advantageous for pig farming.

To Cite This Article: Jung CM, Lee SW, Do K-H, Lee -K, Seo K, 2023. Effects of liquid feeding on growth and antimicrobial resistance in weaned piglets. Pak Vet J, 43(4): 835-837. http://dx.doi.org/10.29261/pakvetj/2023.080

INTRODUCTION

In traditional farming systems, piglets are typically weaned abruptly at around 3-4 weeks of age, which is significantly earlier compared to the gradual transition period of 15-22 weeks observed in semi-natural rearing conditions (Byrgesen *et al*., 2021). The early postweaning period characterized by various challenges, including stress, reduced appetite, and suboptimal performance (Byrgesen *et al*., 2021). Moreover, the susceptibility of weaned piglets to diseases is attributed to factors such as decreasing levels of maternal antibodies and rapid alterations in the structure and functionality of the small intestine (Do *et al*., 2020a; Do *et al*., 2020b; Byrgesen *et al*., 2021). Poor growth performance in piglets can result in substantial financial implications for commercial swine operations (Byrgesen *et al*., 2021).

Antimicrobials are added frequently to feed for piglets from birth to weaning with the aim of improving the composition of intestinal microflora in piglets and thus ameliorate the potential consequences of postweaning diarrhea (Brooks 2003; Do *et al*., 2020a). However, antimicrobial-resistant bacteria have emerged due to excessive and inappropriate use of antimicrobials in veterinary medicine (Aarestrup *et al*., 2008; APQA, 2019; Do *et al*., 2022). In 2006, the use of antibiotics as growth promoters was forbidden in the EU (Do *et al*., 2021). With the ban on the use of antimicrobials as growth promoters and the impending extension of the ban to other nations, extensive research efforts have been directed towards the exploration of alternative strategies that can effectively uphold animal health and performance (Do *et al*., 2020b).

Several studies have reported that the feeding method is known to have effect on the growth performance in piglets (Brooks *et al*., 2001; Brooks 2003; Byrgesen *et al*., 2021). Liquid feeding offers several advantages, such as reduction of food loss, improved dry matter intake in problem groups, and improving the overall environment and health of pigs by reducing airborne dust particles (Brooks, 2003). This study aimed to examine whether the feeding method affected growth performance of weaned piglets, and whether antimicrobial resistance was expressed differently when dry feed or liquid feed was administered.

MATERIALS AND METHODS

The experimental procedures conducted in this study were approved by the Institutional Animal Care and Use Committee of Chungbuk National University (CBNUA-2118-23-02). This experiment was conducted on a farm with 600 sows, using 80 21-day-old weaned piglets as subjects. The piglets were divided into two groups (40 piglets per group): dry-feed group, in which dry feed was administered; liquid-feed group, liquid feed was administered. On day 0, neomycin and gamithromycin were administrated for preventing diarrhea. After the experiment, both groups were administrated lincomycin-colistin (day 5), amoxicillin and penicillin G-streptomycin (day 7),

Table 1: Differences on growth performance of weaned piglets according to feeding method.

Item	Dry Feed	Liquid Feed	*p*-value
Age (days)	21-70	21-70	-
No. of initial pigs	40	40	-
No. of final pigs	36	36	-
Growth rates	90.0 %	90.0 %	1.000
Clinical signs per individuals during experimental period*	5.1±5.97[a]	2.3±4.64[b]	< 0.001
Initial body weight (kg)	5.8±0.58	5.5±0.57	0.538
Final body weight (kg)*	25.2±1.02[b]	27.6±1.14[a]	< 0.001
Total weight gain (kg)*	16.8±7.76[b]	19.3±8.13[a]	< 0.001
Average daily gain (g)*	342.7±158.39[b]	394.5±165.99[a]	< 0.001

Data were expressed as mean±S.D.
Different superscript letters (a and b) and star marks (*) means statistically different group by chi-sqaure test and t-test (*p*<0.05).

Table 2: Antimicrobial resistance patterns of *Escherichia coli* isolates.

Antimicrobial subclass	No. of resistant isolates (Antimicrobial resistance %)		*p*-value
Antimicrobial agents (dose/disc)	Dry-feed (n=145)	Liquid-feed (n=95)	
beta-lactams			
Ampicillin (10μg)	126 (86.9%)	81 (85.3%)	0.839
Amoxicillin-clavulanic acid (20/10μg)	18 (12.4%)	21 (22.1%)	0.089
Piperacillin-tazobactam (110μg)	1 (0.7%)	0 (0.0%)	1.000
Meropenem (10μg)	1 (0.7%)	0 (0.0%)	1.000
Cephems			
Cefazolin (30μg)*	70 (48.3%)[b]	64 (67.4%)[a]	0.010
Cefuroxime (30μg)	20 (13.8%)	12 (12.6%)	1.000
Cefoxitin (30μg)	8 (5.5%)	13 (13.7%)	0.097
Ceftiofur (30μg)*	102 (70.3%)[a]	53 (55.8%)[b]	0.040
Cefotaxime (30μg)	20 (13.8%)	16 (16.8%)	0.558
Ceftazidime (30μg)	4 (2.8%)	3 (3.2%)	1.000
Cefepime (30μg)	6 (4.1%)	6 (6.3%)	0.516
Aminoglycosides			
Gentamicin (10μg)	50 (34.5%)	42 (44.2%)	0.193
Streptomycin (10μg)	93 (64.1%)	71 (74.7%)	0.091
Kanamycin (30μg)	74 (51.0%)	47 (49.5%)	0.888
Tetracyclines			
Oxytetracycline (30μg)	93 (64.1%)	50 (52.6%)	0.114
Tetracycline (30μg)	89 (61.4%)	51 (53.7%)	0.317
Tigecycline (15μg)	5 (3.4%)	1 (1.1%)	0.312
Phenicols			
Florfenicol (30μg)	136 (93.8%)	92 (96.8%)	0.306
Chloramphenicol (30μg)	142 (97.9%)	93 (97.9%)	1.000
Quinolones			
Nalidixic acid (30μg)	79 (54.5%)	61 (64.2%)	0.195
Ciprofloxacin (5μg)	62 (42.8%)	48 (50.5%)	0.257
Sulfonamides			
Sulfisoxazole (250μg)	104 (71.7%)	75 (78.9%)	0.250
Trimethoprim-sulfamethoxazole (23.75/1.25μg)	111 (76.6%)	67 (70.5%)	0.333
Lipopeptides			
Colistin (10μg)	2 (1.4%)	1 (1.1%)	1.000

Different superscript letters (a and b) and star marks (*) means statistically different group by chi-sqaure test (*p*<0.05).

tiamulin and lincomycin-spectinomycin (day 30), and penicillin G-streptomycin (day 35). On day 10, dry-feed group were administrated gamithromycin and ceftiofur however, liquid-feed group were administrated amoxicillin. These groups were monitored up to 70 days of age. The dry-feed group fed dry feed from the beginning of the weaning, and the liquid-feed group fed liquid feed during the whole experiment period.

Samples were collected from pigsties, including feces and dust, following the guidelines provided by the Animal and Plant Quarantine Agency, in order to isolate *Escherichia coli* (*E. coli*) from piglets aged 21 and 70 days (APQA, 2019). The intestinal contents and feces collected under aseptic conditions were cultured on MacConkey agar (BBL, USA). Suspected colonies were further identified using the VITEK II system (bioMérieux, France). Through this, 145 and 95 *E. coli* isolates were obtained from dry-feed group and liquid-feed group, respectively.

Antimicrobial susceptibility tests were conducted following the guidelines set by the Clinical and Laboratory Standards Institute (CLSI, 2020). The antimicrobial disks utilized in this study were bought from Becton-Dickinson. The piglets enrolled in the experiment were weighed upon their arrival at the facility and again at 70 days of age in order to determine the average daily gain (ADG). The statistical significance between groups was analyzed using a chi-square test, with significance considered at $p<0.05$.

RESULTS AND DISCUSSION

Table 1 shows the growth performance of the experimental groups. "The growth rates (No. of final pigs / No. of initial pigs, %) were same between dry-feed group and liquid-feed group. There was no significant difference on the initial weight of piglets however, final body weight was significantly higher in liquid-feed group (27.6±1.14 kg). Also, ADG in the liquid-feed group (394.5±165.99g) was significantly higher compared to that in the dry-feed group (342.7±158.39g). Additionally, during the experimental period, clinical signs including diarrhea and cough scoring were significantly lower in liquid-feed group (2.3±4.6) compared to that of dry-feed group (5.1±5.9). These results suggest that liquid-feeding affects the performance parameters of weaned piglets.

Significantly higher weight gain and ADG indicated that pigs are able to extract more nutrients from liquid feed than from dry feed. Liquid diets have a tendency to result in increased effluent volume, and they may also lead to higher water consumption rates (Byrgesen *et al*., 2021). It is known that increasing the water content of swine diets can improve their digestibility (Byrgesen *et al*., 2021).

The antimicrobial resistance patterns of *E. coli* isolates in each experimental group are presented in Table 2. Overall, antimicrobial resistance rates showed a similar trend among the experimental groups. We found that resistance rates of ceftiofur was significantly lower in liquid-feed group (55.8%) compared to dry-feed group (70.3%). This may be because ceftiofur are less administered to the liquid-feed group compared to dry-feed group. The third-generation cephalosporin, ceftiofur is considered a critically important class of antimicrobials, and has been used therapeutically in swine to treat enteric colibacillosis (APQA, 2019). Several studies reported that liquid-feeding could reduce the number of coliform bacteria such as *E. coli* in the lower small intestine, and suggested a strategy for the management of diseases (Brooks *et al*., 2001; Brooks 2003). A decrease in coliforms in the lower small intestine could reduce the prevalence of enteric colibacillosis, and a reduction in disease prevalence is associated with a reduction in antimicrobial resistance (Do *et al*., 2020a, 2020b).

During the experimental period, the piglets in the liquid-feed group exhibited significantly lower clinical symptoms mainly including diarrhea, which resulted in a reduced need for antimicrobial prescription in comparison to dry-feed group.

Conclusions: We believe that liquid-feeding promotes better growth performance outcomes, and lower antimicrobial resistance. This could contribute to the reduced development of antimicrobial resistance. These findings suggest that liquid-feeding is a favorable approach to manage diseases in pig production.

Acknowledgements: This work was supported by the Basic Research Lab Program (2022R1A4A1025557) through the National Research Foundation (NRF) of Korea, funded by the Ministry of Science and ICT.

Authors contribution: Wan-Kyu Lee, and Kwangwon Seo conceived and planned the study. Chang Min Jung, Seong Won Lee, and Kyung-Hyo Do carried out the experiment, performed the analysis and drafted manuscript. Chang Min Jung wrote the manuscript in consultation with Wan-Kyu Lee and Kwangwon Seo.

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