# Effects of feed trough positioning height on growth performance, feed loss, feeding environment, and behavior of geese

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**ABSTRACT** In the traditional feeding pattern of geese, the feed trough will be placed on the ground for a long time and hurts the living environment. This research aimed to investigate the effect of 4 different feed trough positioning heights on growth performance, blood parameters, feed loss, water consumption, feeding environment, and behavior of geese and determine the optimal trough positioning height for 28 to 70-d geese. A total of one hundred ninty-two 28-d male Yuzhou white geese were allocated randomly to 4 groups with 6 replicate pens per group according to the trough positioning height (on the ground [D], one-third [L], two-thirds [M], and the same height of geese's beak above the ground [H], respectively). The results show that the growth performance and blood biochemical parameters have no significant difference among groups ($P > 0.05$). The average daily feed loss and water consumption presented the lowest value in group H ($P < 0.01$). The hygienic condition index of the feed and feed trough increased as trough positioning height. Feed from group H had a higher cleanliness score than other groups ($P < 0.001$). The count of microbes (total bacteria, *Staphylococcus aureus*, and *Escherichia coli*) on the surface of the feed trough from group H was lower than other groups ($P < 0.001$). Geese from group H had shorter daily feeding and drinking time than other groups ($P < 0.05$). Overall, these data indicate the same trough positioning height with geese's beaks could lower feed loss, and water consumption and improve hygienic conditions without damage to growth performance and will be the optimal choice for geese.

**Key words:** feed trough, goose, growth performance, feeding environment, behavior

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## INTRODUCTION

With the steady development of animal husbandry, standardized feeding pattern has been gradually realized, and animal welfare and health attract more attention. Feed intake is an important indicator reflecting the growth performance and health of animals, which is affected by many variables such as enclosure design (including feeding apparatus and drinking water equipment and so on), physiological state, and environment (Dorminey et al., 1972; Garner et al., 2012; Li et al., 2017; Putri et al., 2022). Among these factors, the effects of appropriate feed trough parameters on animal growth, behavior, and welfare cannot be ignored. Decreasing the feeder gap can improve feed efficiency as finishing pigs approach market weight (Smith et al., 2004; Myers et al., 2012). The type of cage front and feed trough partitions affected productivity and ingestive, agonistic, and fearful behaviors of egg-type hens (Anderson and Adams, 1991). Expanded feeder space allowance can enhance the productivity of broilers, particularly in early life (Purswell et al., 2021), and increased feeder number can accommodate more broilers to eat simultaneously provided the same feeding space (Li et al., 2021). Square-shaped feed troughs with more available space than circular and rectangular-shaped feed troughs are more suitable for feeding birds to reduce agonistic behavior (Sogunle et al., 2014). Too deep feed trough resulted in low hen-day egg production and poorer feed conversion and did not affect body weight gain, feed consumption, and egg quality (Nakaue et al., 1984). A recent investigation found that the trough is generally placed on the floor where animals live or fixed at the same level as the bottom of the cage in livestock and poultry breeding, which has led to poor hygiene and feed waste. In the prolonged Inluenza and COVID-19 situation, the price rise caused by the supply of feed



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materials has hindered the healthy and stable development of the breeding industry (Beaudoin and Isaac, 2022; Obese et al., 2022). It is particularly important to reduce the waste of feed resources caused by feeding devices and management. In addition to the depth and shape, adjusting the positioning height of the animal's trough will be another factor to affect animal growth, welfare, health, and feed wastage. When the horse is feeding in groups, elevating feeding height under suitable feeding space can reduce added behavioral frequencies of kicks and occurrences of pinned back ears behavior (Luz et al., 2015). These studies provide some evidence that elevated feeding can reduce competition (Zobel et al., 2011; Neave et al., 2018). Unfortunately, little research has been done in this area.

China, is the main production area for geese, accounting for more than 90% of the world's total amount, and the development of geese breeding is crucial to the development of animal husbandry in China (Hou and Liu, 2021). In geese production, some problems such as feed waste and pollution caused by placing the trough on the ground for a long time are very serious, and the appropriate height of trough for geese at different growth stages and how to affect geese' growth and behavior have not been explored. Therefore, the main objective of the present study is to investigate the effect of feed trough positioning height on growth performance, feed loss, water consumption, blood parameters, feed and trough sanitation, and feeding and drinking behavior of geese from 28 to 70 d of age.

## MATERIALS AND METHODS

### Housing, Animals, and Management

The experiment was approved by the Laboratory Animal Management Committee of Chongqing Academy of Animal Sciences (**CAAS**) and reviewed by the Ministry of Science and Technology of the People's Republic of China (approval number 2006-398). The experiment was performed in the poultry scientific research base of the CAAS, and the geese for the experiment were provided by the geese-breeding center of the CAAS.

One hundred ninety-two 28-d old male Yuzhou white geese with similar weight were allocated randomly to 4 groups with 6 replicates per group and 8 birds per replicate. Then, different feed trough positioning were provided for each treatment. The trough in the control group (Group D) was placed on the ground during the whole experiment period, and the other 3 groups were set as one-third (group L), two-thirds (group M), and the same as the height of geese's beak above the ground (group H), respectively, and the trough height was shown in Table 1. Six geese were randomly selected from each group twice a week to measure the height of their beak from the ground in the natural standing state, which was used as the basis for adjusting the height of the geese' trough.

Each pen measured 300 cm long and 150 cm wide, and was equipped with the same trapezoidal plastic trough with 80 cm long × 21 cm wide × 8 cm deep. In addition to the control group, the pens were equipped with a silent lifting device that can adjust the height of the feed trough and a trough fixing device angled with the trough to ensure the geese can reach the food. The height setting can be completed quickly through touch screen operation on the main screen, and the lifting can be carried out immediately. All groups were supplied the same corn-soybean meal-based diet and water from drip-nipple water lines for geese, feed and water were freely available at all times on either side of the pens. All geese were kept in plastic-wire floored pens from a goose house with a window between every two pens. The same ambient conditions were provided throughout the experiment for all geese, the light program was 16 h of light per day, temperature ranged from 21°C to 26°C, and humidity ranged from 65 to 81%.

**Table 1.** Feed trough positioning height of geese from 28 to 70 d of age.

| | Feed trough positioning height (cm) | | | |
|---|---|---|---|---|
| Days of age | D | L | M | H |
| 28−30 | 0 | 10 | 20 | 30 |
| 31−33 | 0 | 11 | 22 | 33 |
| 34−36 | 0 | 12 | 24 | 36 |
| 37−39 | 0 | 13 | 26 | 39 |
| 40−42 | 0 | 14 | 28 | 42 |
| 43−49 | 0 | 15 | 30 | 45 |
| 50−57 | 0 | 16 | 32 | 48 |
| 58−70 | 0 | 17 | 34 | 51 |

D=the trough was always placed on the ground; L, M, H= one-third, two-thirds, and the same as the height of a goose's beak above the ground.

### Sample Collection and Analytical Determination

***Growth Performance*** Geese deaths were recorded daily, and the body weight (**BW**) on day 28, 49, and 70 and feed intake (**FI**) for 28 to 49 d and 50 to 70 d for each replicate were measured by electronic scale (YH-T1, Yingheng., Guangdong, China) with a range of 70kg and accuracy of 1g for the determination of average daily gain (**ADG**) and average daily feed intake (**ADFI**) at all stages of growth (28−49 d, 50−70 d, and 28−70 d). Feed conversion rate (FCR) was obtained by calculating the ratio of feed intake to body weight gain. At the same time, Actual average daily feed intake (**A-ADFI**) was obtained using the collected data on feed intake and feed loss.

***Feed Loss*** The feed loss that feeds sputtered from the trough was determined in each pen for 7 consecutive days from day 35 and 57, respectively, and to calculate the average daily feed loss at each stage.

***Water Consumption*** The water consumption of geese in each group during this test was determined by providing each pen with a separate water line connected to a high-precision flowmeter. The water consumption was obtained by calculating the

difference value of the flowmeters before and after each period.

***Feed and Feed Trough Cleanliness*** Scoring criteria were developed to measure the hygiene of the feed based on the fieldwork (Table 2). Feed cleanliness of trough were visually evaluated, and scored on a 4-point scale (1 = severe; 2 = moderate; 3 = mild; 4 = clean). Score 1 feeds contained 2 or more pieces of feces, score 2 feeds contained 1 piece of feces or 2 or more pieces of feathers, score 3 feeds contained no feces and 1 feather, score 4 feeds contained no faces and feathers. All feeds were scored by the same trained experimenter.

Samples on the trough surface were collected. A cotton swab soaked in sterilized peptone water (BPW) was wiped back and forth on the surface of the sampling site (5 cm × 5 cm) approximately 20 times, and then put into the corresponding centrifugal tube with BPW and sent to the laboratory in time for analysis. The count of microbes (total bacteria, *Staphylococcus aureus,* and *Escherichia coli*) was determined by the colony counting methods, and the result was expressed as colony-forming unit Log (CFU)/$cm^2$.

***Blood Parameters*** Blood samples from three geese per replicate with a weight close to the average weight of the replicate were collected from the wing vein into an anticoagulant vacuum tube at the end of the feeding trial for the determination of blood parameters.

The activity of alanine aminotransferase (**ALT**), aspartate aminotransferase (**AST**), and the concentration of total protein (**TP**), albumin (**ALB**), globulin (**GLO**), total bilirubin (**TBIL**), direct bilirubin (**DBIL**), indirect bilirubin (**IDBIL**), total cholesterol (**CHOL**), triglycerides (**TG**), and glucose (**GLU**) were determined by the automatic biochemical analyzer (AU680, Beckman Coulter., Tokyo, Japan) with corresponding commercial kits (Nanjing Jiancheng Bioengineering Institute, Nanjing, China) following the manufacturer's guides.

***Behavioral Observation*** All pens (n = 6 per treatment group) were used to monitor the feeding and drinking behavior, and all geese in each pen were tracked. Before the trial started, the HD surveillance cameras were positioned precisely above the pens, to ensure that every corner of the pen can be seen clearly. Automatic shooting for 3 consecutive days a week, monitoring 24 hr a day. The memory cards were brought back for observation, analysis, and statistics at the end of the experiment. Feeding and drinking behavior for consecutive 5 s was counted once, and the total feeding and drinking times of all geese in each pen were recorded and converted into time (min/ bird/day).

**Table 2.** The scoring standard for feed cleanliness.

| Score | Grade | Feed cleanliness |
|---|---|---|
| 1 | Severe | Contains 2 or more pieces of feces |
| 2 | Moderate | Contains 1 piece of feces or 2 or more feathers |
| 3 | Mild | Contains no feces and 1 feather |
| 4 | Clean | No feces or feathers |

## Statistical Analysis

All data calculations as averages and standard error of the mean (**SEM**) were performed in Microsoft Excel 2016. Statistical analyses were carried out using Analysis of one-way variance (ANOVA) in Software SPSS 20.0 (SPSS Inc., Chicago, IL) including Bartlett's test for homogeneity of variances analysis and LSD's test for differences between means. All statements of differences were based on a significance level of $P < 0.05$.

# RESULTS

## Growth Performance, Feed Loss, and Water Consumption

The effects of feed trough positioning height on the growth performance of male White Yuzhou geese for 28 to 49, 50 to 70, and 28 to 70 d are shown in Table 3. Different trough positioning heights of geese did not significantly impact growth performance including BW, ADG, ADFI, A-ADFI, and FCR at all stages ($P > 0.05$). Among all groups, group H had the highest BW on day 49 and 70, ADG for 28 to 49 d and 28 to 70 d, ADFI and A-ADFI for 28 to 49 d, and the lowest FCR for 28 to 70 d ($P > 0.05$). Group D had the lowest BW on day 70, ADG for 50 to 70 d, and the highest FCR for 50 to 70 d in all groups ($P > 0.05$).

The average daily feed loss (ADFL) in each group for 28 to 49, 50 to 70, and 28 to 70 d is shown in Table 4. Significant differences in ADFL were observed during three phases ($P < 0.01$). Compared with the control group, the feed loss was reduced in the height positioning of troughs from group H at all stages ($P < 0.001$). In addition, raising the trough height also increased the spatter of feed as the geese feed. ADFL from the L group was significantly higher than control group at all stages ($P < 0.001$).

Table 5 shows the average daily water consumption from 4 groups for 28 to 49, 50 to 70, and 28 to 70 d. The elevation of the feed trough significantly reduced water consumption of geese ($P < 0.01$), and the average daily water consumption of group H was significantly lower than that of group L and M in all three phases ($P < 0.01$).

## Feed and Feed Trough Cleanliness

Feed cleanliness was evaluated by scoring feed with specific evaluation criteria (Table 2). Different feed trough heights had a significant influence on feed cleanliness ($P < 0.001$) (Table 6). The feed cleanliness score of group L, M, and H was significantly higher than that of group D ($P < 0.001$), and the feed cleanliness score of group H was significantly higher than that of group L ($P < 0.001$).

**Table 3.** Effect of trough positioning height on growth performance of geese.[1]

| Treatment | Body weight (g) | Average daily gain (g) | Average daily feed intake (g) | Actual-average daily feed intake (g) | Feed conversion rate |
|---|---|---|---|---|---|
| | | | 28−49 d of age | | |
| D | 3293 | 97.06 | 276.91 | 274.95 | 2.86 |
| L | 3233 | 93.25 | 272.95 | 270.07 | 2.93 |
| M | 3282 | 95.59 | 282.07 | 280.01 | 2.95 |
| H | 3314 | 97.81 | 283.20 | 282.42 | 2.90 |
| SEM | 20.34 | 0.90 | 2.25 | 2.07 | 0.02 |
| *P*-value | 0.575 | 0.303 | 0.358 | 0.117 | 0.388 |
| | | | 50−70 d of age | | |
| D | 4189 | 42.68 | 280.69 | 277.70 | 6.62 |
| L | 4199 | 46.01 | 281.24 | 276.43 | 6.17 |
| M | 4195 | 43.47 | 270.90 | 266.68 | 6.25 |
| H | 4223 | 43.30 | 268.44 | 267.30 | 6.25 |
| SEM | 32.76 | 1.00 | 4.80 | 4.77 | 0.13 |
| *P*-value | 0.987 | 0.680 | 0.729 | 0.794 | 0.607 |
| | | | 28−70 d of age | | |
| D | - | 68.51 | 278.46 | 275.98 | 4.07 |
| L | - | 68.45 | 280.20 | 275.86 | 4.10 |
| M | - | 68.22 | 276.21 | 273.07 | 4.05 |
| H | - | 69.19 | 275.45 | 274.49 | 3.98 |
| SEM | - | 0.70 | 2.40 | 2.38 | 0.03 |
| *P*-value | - | 0.971 | 0.907 | 0.974 | 0.605 |

[1]Each value represents the mean of 6 replicates.D = the trough was always placed on the ground; L, M, H = one-third, two-thirds, and the same as the height of a goose's beak above the ground.

**Table 4.** Effect of trough positioning height on feed loss.[1]

| Treatment | 28−49 d average daily feed loss (g/bird) | 50−70 d average daily feed loss (g/bird) | 28−70 d average daily feed loss (g/bird) |
|---|---|---|---|
| D | 1.33[c] | 1.96[b] | 2.99[b] |
| L | 3.00[b] | 3.88[a] | 4.81[a] |
| M | 2.83[ab] | 2.06[b] | 4.22[a] |
| H | 3.83[a] | 0.78[c] | 1.14[c] |
| SEM | 0.26 | 0.28 | 0.27 |
| *P*-value | < 0.001 | < 0.001 | < 0.001 |

[a-c]Means with different superscripts within the same row significantly ($P < 0.05$).
[1]Each value represents the mean of 6 replicates.D = the trough was always placed on the ground; L, M, H = one-third, two-thirds, and the same as the height of a goose's beak above the ground.

**Table 5.** Effect of trough positioning height on water consumption.[1]

| Treatment | 28−49 d average daily water consumption (liters/bird) | 50−70 d average daily water consumption (liters/bird) | 28−70 d average daily water consumption (liters/bird) |
|---|---|---|---|
| D | 1.72[a] | 1.82[a] | 1.77[a] |
| L | 1.59[b] | 1.63[b] | 1.61[b] |
| M | 1.61[b] | 1.57[b] | 1.59[b] |
| H | 1.42[c] | 1.44[c] | 1.43[c] |
| SEM | 0.03 | 0.02 | 0.03 |
| *P*-value | 0.001 | < 0.001 | 0.001 |

[a-c]Means with different superscripts within the same row significantly ($P < 0.05$).
[1]Each value represents the mean of 6 replicates.D = the trough was always placed on the ground; L, M, H = one-third, two-thirds, and the same as the height of a goose's beak above the ground.

**Table 6.** Effect of trough positioning height on feed and feed trough cleanliness.[1]

| | | Feed trough | | |
|---|---|---|---|---|
| Treatment | Feed cleanliness scoring | *Staphylococcus aureus* lg (CFU/cm$^2$) | *Total bacteria* lg (CFU/cm$^2$) | *Escherichia coli* lg (CFU/cm$^2$) |
| D | 1.33[c] | 6.48[a] | 6.77[a] | 4.56[a] |
| L | 3.00[b] | 5.55[c] | 5.73[c] | 3.71[b] |
| M | 2.83[ab] | 5.67[b] | 6.20[b] | 3.67[b] |
| H | 3.83[a] | 5.15[d] | 5.41[c] | 3.35[c] |
| SEM | 0.26 | 5.23 | 5.57 | 2.59 |
| *P*-value | < 0.001 | < 0.001 | < 0.001 | < 0.001 |

[a-d]Means with different superscripts within the same row significantly ($P < 0.05$).
[1]Each value represents the mean of 6 replicates.D = the trough was always placed on the ground; L, M, H = one-third, two-thirds, and the same as the height of a goose's beak above the ground.

Table 6 also shows the count of microbes (total bacteria, *Staphylococcus aureus,* and *Escherichia coli*) on the surface of the trough at different positioning heights. Elevating the feed trough can effectively improve the sanitary condition of the trough. The number of 3 types of microbes in group L, M, and H was reduced significantly compared to group D ($P < 0.001$). The count of total bacteria, *Staphylococcus aureus*, and *Escherichia coli* from group H were lower than that of group L and M ($P < 0.05$). While the trough surface from group M had more bacteria than that of group L and H ($P < 0.05$). Overall, the height same as the height of a geese's beak above the ground helps keep the trough clean.

### Blood Parameters

Blood parameters of geese from different groups are shown in Table 7. The positioning height of the feed trough had no significant effect on the blood parameters of geese including ALT, AST, TP, ALB, GLO, TBIL, DBIL, IDBIL, CHOL, TG, and GLU ($P > 0.05$).

### Behavioral Observation

Table 8 shows the average daily feeding and drinking time that is converted from the feeder and drinker visits of geese from 4 groups. Meanwhile, the variation trend of feeding and drinking time of geese in each group during different periods of one day is also shown in Figure 1 and 2. Overall, raising trough positing height reduced feeding and drinking daily time for geese, and improved feeding efficiency. Geese from group H spent less time feeding at 0:00 to 6:00, 18:00 to 24:00, and 0:00 to 24:00 than that of other groups ($P < 0.05$), geese of group L and M spent less time than group D at 18:00 to 24:00 and 0:00 to 24:00, and similar time was spent on feeding between group L and M. Geese from group H spent less time feeding at 6:00 to 12:00, 12:00 to 18:00 than that of group D and L ($P < 0.05$), and similar time was spent on feeding among group D, L, and M.

Geese from group H spent less time drinking at 0:00 to 6:00 than that of group D, L, and M ($P < 0.05$), and similar time was spent on drinking among group D, L and M. Geese from group L, M, and H spent less time drinking at 6:00 to 12:00, and 0:00 to 24:00 than that of group D ($P < 0.05$). Geese from group M and H spent less time drinking at 18:00 to 24:00 than group D and L ($P < 0.05$).

## DISCUSSION

The purpose of this study was to verify the hypothesis that different feed trough positioning heights improve the growth, behavior, and welfare of geese.

### Growth Performance, Blood Parameters, Feed Loss, and Water Consumption

In our study, the positioning height of the feed trough does not affect the growth performance of geese (final weight, weight gain, feed intake, and feed conversion), which was consistent with the finding of Nakaue, H (Nakaue et al., 1984) that dwarf layers with or without perches and with 25.4 cm and 20.3 feed trough height had similar body weight gain, daily feed consumption, and egg weight. This study also indicated that adjusting trough height did not improve the liver function and substance metabolism reflected by the blood parameters of geese. It seems that it is difficult for geese to improve feed intake and body weight to achieve their growth development by adjusting the height of the trough when the geese have free access to the diet.

However, adjusting trough height can improve feed loss. Feed wastage can be affected not only by the consummatory activities of animals, but also by the appearance design, size, and positioning of the trough, which could represent a substantial economic loss in poultry production (Hurnik et al., 1973; Myers et al., 2012; Tesfay et al., 2019). In some large animals, such as sheep, a half round-bale feeder design reduce feed wastage

**Table 7.** Effect of trough positioning height on blood biochemical parameters of geese.[1]

| | Treatment | | | | | |
|---|---|---|---|---|---|---|
| Item | D | L | M | H | SEM | *P*-value |
| ALT(U/L) | 10.83 | 12.83 | 10.83 | 11.83 | 0.59 | 0.606 |
| AST(U/L) | 27.83 | 31.17 | 25.00 | 30.50 | 1.07 | 0.155 |
| AST/ALT | 2.59 | 2.24 | 2.37 | 2.71 | 0.13 | 0.578 |
| TP(g/L) | 44.23 | 40.85 | 43.75 | 43.50 | 0.52 | 0.080 |
| ALB(g/L) | 18.85 | 18.57 | 19.67 | 18.88 | 0.21 | 0.295 |
| GLO(g/L) | 25.38 | 22.28 | 24.08 | 24.62 | 0.43 | 0.053 |
| ALB/GLO | 0.75 | 0.80 | 0.83 | 0.78 | 0.01 | 0.247 |
| TBIL($\mu$mol/L) | 1.30 | 1.37 | 1.48 | 1.27 | 0.08 | 0.780 |
| DBIL($\mu$mol/L) | 0.33 | 0.35 | 0.37 | 0.32 | 0.01 | 0.683 |
| IDBIL($\mu$mol/L) | 0.97 | 1.02 | 1.12 | 0.95 | 0.11 | 0.952 |
| CHOL(mmol/L) | 4.45 | 4.31 | 4.08 | 4.25 | 0.07 | 0.306 |
| TG(mmol/L) | 0.96 | 1.02 | 0.71 | 0.74 | 0.06 | 0.136 |
| GLU(mmol/L) | 10.20 | 9.79 | 10.00 | 9.64 | 0.17 | 0.709 |

[1]Each value represents the mean of 6 replicates.D = the trough was always placed on the ground; L, M, H = one-third, two-thirds, and the same as the height of a goose's beak above the ground.ALT, alanine aminotransferase; AST, aspartate aminotransferase; CHOL, total cholesterol; DBIL, direct bilirubin; GLO, globulin; GLU, glucose; IDBIL, indirect bilirubin; TBIL, total bilirubin; TG, triglycerides; TP, total protein.

**Table 8.** Effect of trough positioning height on feeding and drinking behavior.[1]

| Treatment | 0:00−6:00 | 6:00−12:00 | 12:00−18:00 | 18:00−24:00 | 0:00−24:00 |
|---|---|---|---|---|---|
| | | | Drinking time(min) | | |
| D | 8.25[a] | 14.63[a] | 10.35 | 12.02[a] | 45.23[a] |
| L | 8.06[a] | 11.20[b] | 10.09 | 10.53[a] | 39.87[b] |
| M | 8.70[a] | 12.06[b] | 10.74 | 8.11[b] | 39.36[b] |
| H | 6.62[b] | 12.59[b] | 8.92 | 8.42[b] | 36.53[b] |
| SEM | 0.28 | 0.47 | 0.31 | 0.50 | 1.08 |
| *P*-value | 0.036 | 0.044 | 0.192 | 0.004 | 0.018 |
| | | | Feeding time(min) | | |
| D | 6.72[a] | 7.44 | 6.43[a] | 6.71[a] | 27.30[a] |
| L | 5.65[a] | 7.03 | 5.72[a] | 5.31[b] | 23.70[b] |
| M | 5.67[a] | 5.63 | 4.79[ab] | 5.13[b] | 21.21[b] |
| H | 3.32[b] | 4.76 | 3.46[b] | 3.13[c] | 14.66[c] |
| SEM | 0.41 | 0.43 | 0.41 | 0.37 | 1.31 |
| *P*-value | 0.008 | 0.089 | 0.034 | < 0.001 | < 0.001 |

[a-c]Means with different superscripts within the same row significantly ($P < 0.05$).

[1]Each value represents the mean of 6 replicates.D = the trough was always placed on the ground; L, M, H = one-third, two-thirds, and the same as the height of a goose's beak above the ground.

(Kischel et al., 2019). Or horses, too low trough positioning height increases the risk and frequency of trough toppling, and the high positioning of troughs reduces the frequency of kicks regardless of social stability (Cozzi et al., 2010). For poultry, thick wooden troughs, plastic troughs, or solid steel troughs are generally used to avoid excessive feed waste caused by being trampled over. In our study, the same height of trough with geese's beaks above the ground had the lowest feed loss than other positioning heights and we recommend this height for geese production to decrease feed wastage. Interestingly, our results showed that feed loss did not have a linear relationship with trough positioning height during feeding, and the trough height with one-third of geese's beaks height was more likely to waste feed than other heights and on the ground in two stages of growth. The reason may be that the middle height is more convenient and energy-saving for geese, resulting in the formation of random feeding and easy to spatter feed from the trough.

In addition, we also found that feed waste increased with the increase in geese age. To reduce feed wastage, it can be considered that the feed trough size of geese at different growth stages may need to be adjusted to adapt to the change in their body size. Feeder adjustment could be an effective method of reducing feed loss and improving feed efficiency (Myers et al., 2012).

Friend (1971) reported that when sows consumed both feed and water ad libitum, feed consumption paralleled water intake during pregnancy. In our study, the average daily water consumption of geese from group H was significantly lower than that of group L and M in all three phases. This is consistent with the results of feeding and drinking behavior. In addition, the elevation of the feed trough reduced water consumption without affecting feed intake and growth performance in our study. It is speculated that this may be related to the change in feeding behavior caused by elevated feeding. However, this discovery can reduce water consumption, thereby reducing sewage production (Leibbrandt et al., 2001). This contributes to the healthy and efficient development of geese breeding.

## Feed and Feed Trough Cleanliness

With the rapid development of the poultry industry, more attention has been paid to the welfare of poultry (Jones and Dawkins, 2010a; Jones and Dawkins, 2010b). Improving the feeding environment and dietary health status of geese is beneficial for their healthy growth and welfare. Studies have reported that feed and water in

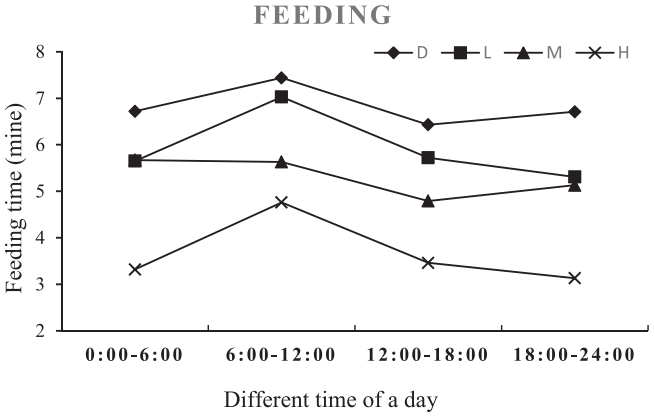


**Figure 1.** Time spent on feeding at different time of the day for each group.

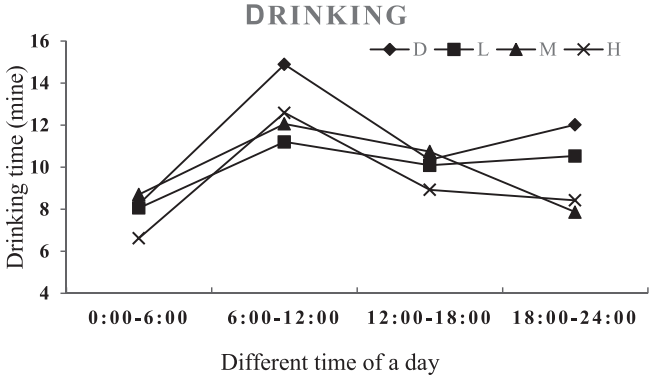


**Figure 2.** Time spent on drinking at different time of the day for each group.

broiler houses are risk factors significantly related to the flock status, and the role of feed in the spread of *Salmonella* through the poultry industry has received a great deal of attention (Marín et al., 2011). If the trough is placed too low, some pollutants produced by geese (feces and feathers) and dust in the air are more likely to enter the trough and pollute the feed. This also explains that the feed placed in the ground trough had more contaminants and had a lower score, while the feed placed in the highest trough was the cleanest. A similar result was found for the count of microbes (total bacteria, *Staphylococcus aureus* and *Escherichia coli*) on the surface of the trough. The good news is that no *salmonella* was found in the investigation.

However, we found the number of *Staphylococcus aureus* on the ground of the trough with two-thirds geese' beak height was higher than that with one-third geese' beak height, which may be related to the frequent contact between geese' abdomen and trough. Close contact and friction in the geese's abdomen with the ground containing feces and other pollutants increase the risk of attachment of harmful microorganisms, this may reduce feather cleanliness and feather quality (Tauson, 1984; Freire et al., 1999).

### Behavioral Observation

Changes in the drinking and feeding behavior of animals may indicate health, welfare, or productivity problems (Maselyne et al., 2016). Geese had various feeding behavior responses among the trough location height treatments, and we focused on the effective feeding and drinking time (touching the trough and waterline and completing feeding and drinking actions). When the positioning height of the trough was increased from the ground to the height of geese's beaks off the ground, the feeding time (14.6 min/bird/d) was reduced by 46.3%, which was similar to the daily feeding time (11.8 min/bird/d) of ducks of a previous study (Howie et al., 2010). However, there are different opinions about the study. Neave and Zobel (2020) found that elevated feeding with head- and elevated-level feeders can reduce competition, and increase the feeding time of goats compared to the floor-level feeder.

Geese in group D (trough placed on the floor) showed more daily feeding time than those in other groups (L, M, and H), probably because they had more chances to arrive at the feed trough when they wanted and were attracted to eat. Waterfowl spend much of their day sitting on the floor preening and resting (Abdel-Hamid et al., 2020). Geese sitting on the floor can reach the feed and complete the feeding process when the trough is placed on the floor, but the feeding process was slower, resulting in less efficient feeding. The results showed that the higher feed trough resulted in lower feeding time, probably because the geese wanted to improve their feeding efficiency and save the energy of craning to feed. It may also be explained by that the trough was fixed at any attainable height, and the motivation to approach the trough for the geese was consistent (Seaman et al., 2008; Buijs et al., 2011). That did not change the actual food intake, even if it took a different amount of time. Casazza et al. (2020) pointed out that wild waterfowl tend to avoid or reduce predation risk, such as in familiar ways, or in familiar places. It is not clear whether this has a connection with the feeding behavior of geese in our study.

Similar results were found in the variation of drinking and feeding time, which may be related to geese's habit of drinking water after feeding. In addition, we hypothesized that there is a positive relationship between drinking time and water consumption based on the same trend of drinking time and water consumption caused by the elevation of the feed trough. Moreover, the feeding and drinking behavior of geese is more frequent during the day (6:00−18:00), which is related to the feeding habits of the animals formed by long-term regular management patterns, such as adequate light during the day and fixed feeding times (Siegel et al., 1962; Cain and Wilson, 1974). In this study, feeding and drinking behaviors of geese are often done in groups, and these same social behaviors have also been presented in commercial Pekin ducks (Cherry and Morris, 2005; Rice et al., 2014).

## CONCLUSIONS

1. Raising feed trough positioning height appropriately can effectively reduce water consumption and feed loss caused by feed spatter and improve the sanitary condition of the feed trough and feed, decrease the average daily feeding and drinking time of geese, and improve feeding efficiency without affecting the growth performance of geese.
2. In conclusion, these data indicate that the same height of feed trough with geese's beaks above the ground is an optimal choice for geese from 28 to 70 d of age.

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## DISCLOSURES

The authors declare no conflicts of interest.

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