Introduction

Antibiotic growth promoters have been helpful in improvement of growth performance and feed conversion ratio in poultry (Miles et al., 2006; Dihner and Buttin, 2002; Izat et al., 1990). However, constant treatment by antibiotic may result in residues of these substances in poultry products and bacteria resistance against treatments in human body. Due to such threats to human health, use of antibiotics in poultry is banned (Owens et al., 2008; Alcicek et al., 2004; Botsoglou and Fleitouris, 2001; Hinton, 1988).

Many studies have been carried out on using additives, including herbs, as alternatives to antibiotics, with direct or indirect effects on intestinal microflora, in poultry products (Taylor, 2001). Several studies have shown antimicrobial properties of herb extracts (Cowan, 1999; Hammer et al., 1999) which can improve intestinal microflora population and enhance health in birds’ digestive systems through reduction in number of disease-making bacteria (Mitsch et al., 2004). In addition, modified harmful microbial population in intestines will change intestinal morphology. Intestinal health is of great importance in poultry for improved performance and reduced feed conversion ratio (Montagne et al., 2003). However, properties of other herbs, such as antioxidant, antiviral, or immunomodulatory properties and their effects on performance and digestive health can not be ignored.

In this study, Aloe vera gel has been examined. With numerous properties, Aloe vera is among the most well-known herbs. This member of Liliaceae is similar to cactus in appearance and mostly grows in arid regions of Asia and Africa (Boudreau and Beland, 2006). The middle major parts of Aloe vera leaves consist of the gel. Previous studies discovered different properties of Aloe vera gel, including wound healing, anti-parasitic, anti-viral, antifungal and anti-bacterial properties (Boudreau and Beland, 2006; Reynolds and Dweck, 1999). An important Aloe vera gel complex which has received attention from researchers is the polysaccharide acemannan – a mannose polymer (Reynolds and Dweck, 1999). Studies revealed that properties of Aloe vera gel, including wound healing, immunomodulatory, and anti-bacterial properties, may stem from acemannan (Mascolo et al., 2004).

Studies performed on the effects of Aloe vera gel and of polysaccharide contained in Aloe vera (acemannan) on the broilers have shown that Aloe vera gel can improve the immune response in broilers (Chinnah et al., 1992; Valle-paraso et al., 2005). In addition, Lin et al. (2005) reported improved intestinal microflora in broilers as a result of acemannan treatment. The process reduced E. coli count and increased lactobacillus count.

Based on the results obtained in previous studies regarding the positive effects of Aloe vera gel and acemannan on immune system and intestinal microflora of broilers, here we try to study the effects of Aloe vera gel mixed with broilers’ feed and on performance and morphological changes in intestines and to find out whether Aloe vera gel can be a suitable alternative to antibiotic growth promoters.

Materials and methods

Dietary treatments and animal management

The experiment has been approved by Islamic Azad University Committee of Animal Ethics and complied with Iranian guidelines for animal welfare. Three hundred one-day old Ross 308 male broilers were studied here. The chickens were devided into five groups with four replicates (15 chickens each) on a completely randomized design. The control group was treated with basal diet without additives mixed with feed. For the next three groups, the diet was mixed with 1.5%, 2% and 2.5% Aloe vera gel, respectively. Finally, the diet for the
last group was mixed with 15 ppm virginiamycin. Experimental diets were fed from 1 to 42 days of age. Nutritional needs of broilers in different experimental periods: data on the starter (days 0 to 10), grower (days 11 to 24) and finisher (days 25 to 42) were extracted from tables provided for farming Ross 308 chickens. Experimental diets were formulated by using UFFDA (User-friendly feed formulation, done again) software. Table 1 shows ingredients and chemical composition of the basal diets.

All chickens were placed in 1.5 m x 1 m pens. Each pen was equipped with wood shavings. During the study, the birds received a lighting regimen of 23 h light: 1 h darkness. Automatic heaters were used to raise the temperature in the halls. The initial temperature was 33°C gradually reduced according to breeding standards. Control parameters, such as temperature, humidity, light, ventilation and vaccination, were the same for all groups. Feed and water were available to broilers in all pens. Aloe vera gel was purchased from Barij Essence Company. The pH of Aloe vera gel was 4.49. It was a colorless gel with negative microbial load. It should be mentioned that the feed was mixed with Aloe vera gel, then they were fed to the chickens at the beginning of each farming period (starter, grower and finisher). First, Aloe vera gel was mixed with soybean meal, later on, corn and other additives were added.

**Measurement of performance parameters**

In order to determine the performance of broilers, feed intake, body weight gain and feed conversion ratio were measured for starter, grower and finisher, as well as for the total experiment period. In cases where mortalities were observed, the numbers and weights of such mortalities were recorded accurately to make necessary corrections in calculating feed intake and feed conversion ratio. At the end of the experiment period (day 42) two birds were randomly selected from each replicate, slaughtered by bleeding for 90 sec from a single cut that severed the carotid artery and jugular vein and then their dressing percentages were measured.

**Measurement of ileum morphological parameters**

On day 42, two birds from each replicate were randomly selected and killed by cervical dislocation. In order to examine ileum morphology, a 1.5 cm piece was cut from the middle of ileum and washed in a solution of 0.9% NaCl. Clean ileum samples were fixed in a buffered 10% formal solution for 8 h, washed three times in a 70% ethanol solution and stored at 48°C until use. A 0.5 cm² subsample of each ileum sample was then stained by the Feulgen method using Schiff reagent (Catalá-Gregori et al., 2008; Feulgen and Rossenbeck, 1924). At least 10 villi and 10 crypts from each subsample were dissected under a stereo microscope and then photographed. Villus height and crypt depth were measured using the image analysis software Visilog 6.3 Viewer Lite (Noesis, Saint Aubin, France) (Catalá-Gregori et al., 2008).

**Statistics**

The data were analyzed by GLM procedure for the completely randomized design with five treatments and four replicates using the SAS software (SAS, 1997) and the means were compared using Duncan’s Multiple Range test at the level of P<0.05.

### Table 1. Ingredients and chemical composition of starter, grower and finisher diets.

| Ingredients | Starter, 1-10 d | Composition of basal diet | Grower, 11-24 d | Finisher, 25-42 d |
|-------------|-----------------|---------------------------|-----------------|------------------|
| Corn, g/kg  | 557.8           | 595.8                     | 654.1           |                  |
| Soybean meal, g/kg | 323.0        | 313.5                     | 259.3           |                  |
| Corn gluten meal, g/kg | 35.9        | 0                          | 0                |                  |
| Soybean oil, g/kg | 27.2         | 46.7                      | 43.9            |                  |
| Dicalcium phosphate, g/kg | 21.9         | 19.4                      | 18.0            |                  |
| Calcium carbonate, g/kg | 13.3         | 10.8                      | 10.6            |                  |
| Sodium bicarbonate, g/kg | 1.4          | 0.8                       | 2.3             |                  |
| Salt, g/kg  | 2.2             | 2.7                       | 1.9             |                  |
| Vitamin Premix, g/kg | 2.5          | 2.5                       | 2.5             |                  |
| Minerals Premix, g/kg | 2.5          | 2.5                       | 2.5             |                  |
| L-Ly HCl, g/kg | 3.3           | 1.9                       | 1.8             |                  |
| DL-Met, g/kg  | 3.0             | 2.9                       | 2.5             |                  |
| L-Thr, g/kg   | 0.8             | 0.6                       | 0.6             |                  |
| Calculated composition | | | | |
| Metabolizable energy, kcal/kg | 3334        | 3150                      | 3200            |                  |
| Crude protein, % | 25.12        | 22.10                     | 19.76           |                  |
| Calcium, %   | 0.16            | 0.99                      | 0.94            |                  |
| Available phosphorous, % | 0.55         | 0.49                      | 0.46            |                  |
| Met-vCys, %   | 1.08            | 0.90                      | 0.80            |                  |
| Lysine, %    | 1.40            | 1.21                      | 1.07            |                  |

### Table 2. Effect of Aloe vera gel and antibiotic on feed intake (g) of broilers.

| Item               | Dietary treatment | SEM |
|--------------------|-------------------|-----|
|                    | CON               | 1.5% AV | 2% AV | 2.5% AV | 15 ppm VM |     |
| starter, 1-10 d    | 243.75±         | 268.33± | 283.66± | 294.67± | 285.82± | 4.85 |
| grower, 11-24 d    | 1154.47±        | 1218.43± | 1226.78± | 1234.12± | 1240.09± | 9.76 |
| finisher, 25-42 d  | 2830.20±        | 2873.86± | 3007.87± | 3021.52± | 2851.39± | 31.44 |
| total period       | 4228.43±        | 4360.65± | 4518.32± | 4450.32± | 4377.32± | 35.79 |

CON, control; AV, Aloe vera gel; VM, virginiamycin; “±” means within a row with the same or no letter do not differ (P>0.05).
grower and finisher, as well as the total experiment period. In the starter period, significant increase in body weight gain was observed in the antibiotic group compared to Aloe vera gel groups. However, in the grower and finisher periods, there was no significant difference among the antibiotic group and Aloe vera gel groups. Finally, the results on body weight gain in the total period (day 42) showed no significant difference among the antibiotic group and the 2% and 2.5% Aloe vera gel groups. In addition, the Aloe vera gel groups experienced enhanced body weight gain compared to the control group. The 2% Aloe vera gel group showed significant difference than the control group in the starter and grower periods as well as in the total experiment period.

Table 4 shows the results of the treatments on the feed conversion ratio in broilers. Here, no significant difference among the 1.5% and 2% Aloe vera gel groups, the antibiotic and the control groups can be seen. Among all groups, the 2.5% Aloe vera gel group had the greatest feed conversion ratio. During the grower period, there was no significant difference between experiment groups regarding feed conversion ratio. In the finisher, the lowest feed conversion ratio was observed in the antibiotic group showing significant difference from other groups. And finally, during the total period (42 days), the lowest feed conversion ratio (1.755) was that of the antibiotic group showing significant difference than other groups. And this leads to increased body weight gain in these groups in comparison to the control group. Olupona et al. (2010) reported increased feed intake in groups which were treated by Aloe vera gel solved in water (15, 20, 25 and 30 cm²/dm³) as body weight gain. Similarly, the present study shows increased feed intake in the 2% Aloe vera gel group with raised level of body weight gain. Increased feed intake in Aloe vera gel groups can be attributed to changes in feed taste and stimulated appetite since, as reported by Windisch et al. (2008), phytotherapeutic substances (as additives to birds’ feed) can improve taste of diet. Furthermore, Wenk (2002) argued that herbs can stimulate appetite and endogenous secretions which, in turn, improve performance. On the other hand, our experiments showed that Aloe vera gel groups consumed more feed compared to the antibiotic group both in the grower period (days 25 to 42) and during the total experiment period.

### Table 3. Effect of Aloe vera gel and antibiotic on body weight gain (g) of broilers.

| Item            | CON  | 1.5% AV | 2% AV | 2.5% AV | 15 ppm VM | SEM  |
|-----------------|------|---------|-------|---------|-----------|------|
| Starter, 1-10 d | 184.08<sup>b</sup> | 198.33<sup>b</sup> | 204.50<sup>bc</sup> | 203.08<sup>b</sup> | 215.68<sup>a</sup> | 1.74  |
| Grower, 11-24 d | 702.34<sup>b</sup> | 730.76<sup>bc</sup> | 744.71<sup>a</sup> | 755.54<sup>a</sup> | 762.84<sup>a</sup> | 10.47 |
| Finisher, 25-42 d | 1417.65<sup>b</sup> | 1467.76<sup>bc</sup> | 1538.77<sup>a</sup> | 1469.65<sup>ab</sup> | 1515.35<sup>a</sup> | 20.81 |
| Total period   | 2304.08<sup>c</sup> | 2396.90<sup>c</sup> | 2478.90<sup>d</sup> | 2428.28<sup>bc</sup> | 2493.88<sup>a</sup> | 23.29 |

CON, control; AV, Aloe vera gel; VM, virginiamycin; <sup>a</sup>-<sup>c</sup> means within a row with the same or no letter do not differ (P>0.05).

### Table 4. Effect of Aloe vera gel and antibiotic on feed conversion ratio of broilers.

| Item            | CON  | 1.5% AV | 2% AV | 2.5% AV | 15 ppm VM | SEM  |
|-----------------|------|---------|-------|---------|-----------|------|
| Starter, 1-10 d | 1.324<sup>b</sup> | 1.335<sup>b</sup> | 1.337<sup>ab</sup> | 1.345<sup>a</sup> | 1.323<sup>b</sup> | 0.236 |
| Grower, 11-24 d | 1.645<sup>b</sup> | 1.667<sup>a</sup> | 1.647<sup>b</sup> | 1.635<sup>b</sup> | 1.626<sup>b</sup> | 0.288 |
| Finisher, 25-42 d | 1.996<sup>a</sup> | 1.961<sup>ab</sup> | 1.934<sup>ab</sup> | 1.988<sup>a</sup> | 1.881<sup>a</sup> | 0.231 |
| Total period   | 1.835<sup>a</sup> | 1.821<sup>b</sup> | 1.816<sup>b</sup> | 1.833<sup>a</sup> | 1.755<sup>a</sup> | 0.018 |

CON, control; AV, Aloe vera gel; VM, virginiamycin; <sup>a</sup>-<sup>c</sup> means within a row with the same or no letter do not differ (P>0.05).

### Ileum morphology

Table 6 shows the effects of the treatments on ileum morphology in broilers on day 42. Villus height in the 2% and 2.5% Aloe vera gel groups was significantly different from that of other groups so that the highest villi were seen in the 2.5% Aloe vera gel. However, no significant difference was observed between the 1.5% Aloe vera gel group and the antibiotic group regarding villus height. The smallest crypt depth was seen in the 2% Aloe vera gel group showing no significant difference from the 2.5% Aloe vera gel group and the antibiotic group. The deepest crypts were those of the control group. Villus height/crypt depth ratio in the 2% and 2.5% Aloe vera gel groups was significantly different from other groups, with the 2% Aloe vera gel group having the highest ratio.

### Table 5. Effect of Aloe vera gel and antibiotic on dressing percentage in broilers.

| Item            | CON  | 1.5% AV | 2% AV | 2.5% AV | 15 ppm VM | SEM  |
|-----------------|------|---------|-------|---------|-----------|------|
| Dressing percentage | 67.236<sup>c</sup> | 67.850<sup>c</sup> | 69.375<sup>a</sup> | 68.330<sup>bc</sup> | 70.045<sup>a</sup> | 0.372 |

CON, control; AV, Aloe vera gel; VM, virginiamycin; <sup>a</sup>-<sup>c</sup> means within a row with the same or no letter do not differ (P>0.05).

### Table 6. Effect of Aloe vera gel and antibiotic on ileum morphology of broilers.

| Item            | CON  | 1.5% AV | 2% AV | 2.5% AV | 15 ppm VM | SEM  |
|-----------------|------|---------|-------|---------|-----------|------|
| Villus height, μm | 687.84<sup>a</sup> | 706.24<sup>b</sup> | 718.64<sup>b</sup> | 721.94<sup>a</sup> | 708.41<sup>a</sup> | 1.06  |
| Crypt depth, μm  | 138.98<sup>a</sup> | 135.04<sup>a</sup> | 132.60<sup>b</sup> | 133.70<sup>a</sup> | 133.72<sup>a</sup> | 0.59  |
| Villus height: Crypt depth | 4.95<sup>a</sup> | 5.23<sup>a</sup> | 5.42<sup>a</sup> | 5.39<sup>a</sup> | 5.29<sup>a</sup> | 0.02  |

CON, control; AV, Aloe vera gel; VM, virginiamycin; <sup>a</sup>-<sup>c</sup> means within a row with the same or no letter do not differ (P>0.05).
experiment period (days 0 to 42). Guo et al. (2004a) observed that feed consumption level in chickens treated by Chinese herbs added to their diet was higher than this level in chickens fed by virginiamycin mixed with their feed. The findings of another study on effects of herbs on the performance of broilers suggested an increased feed intake in groups whose feed were supplemented by essential oil of oregano, plant extract of hop and a mixture of oregano and hops compared to control group or the group treated by antibiotic growth promoters on the days 22-42 and 0-42 (Bozkurt et al., 2009).

In general, increased body weight in different periods shows larger body weight gains in the antibiotic group compared to other groups. Among the experimental groups, the 2% Aloe vera gel group had better body weight gain compared to other Aloe vera gel groups and the control group, showing no significant difference from the antibiotic group. Moreover, findings obtained in studies on treatment of broilers with virginiamycin and other antibiotic growth promoters suggest that antibiotic growth promoters can increase broilers’ body weight gain compared to control group (Bafundo et al., 2003; Miles et al., 2006), which is in line with the findings of the present study.

In the present study, on feeding broilers with Aloe vera gel added to diet, we observed that although Aloe vera gel groups showed improved body weight gain compared to the control group, no significant difference was observed in feed conversion ratio. Moreover, the Aloe vera gel groups had higher feed conversion ratio than the antibiotic group. Olupona et al. (2010) reported that Aloe vera gel added to water (15, 20, 25 and 30 cm/dm²) resulted in significant final body weight gain as well as in weekly body weight gain compared to control group. In addition, Aloe vera groups showed higher feed conversion ratio than the control group, but they showed no significant difference from each other. Reports from other studies on herbs revealed that supplementing feed with essential oils, plant extracts and herbs powders did not improve feed conversion ratio compared to control group or the group treated by antibiotic growth promoters (Toghiani et al., 2010; Buzkurt et al., 2009; Jang et al., 2007; Sarica et al., 2005).

Studies on the effects of Aloe vera powder, alcohol and water extracts as well as on the effects of mixture of alcohol and water extracts of Aloe vera gel and chlortetracycline on broilers have shown that 600 mg of Aloe vera gel water extract presented higher feed conversion ratio compared to broilers treated by 150 ppm chlortetracycline. In addition, in a study to compare Chinese herbal medicine to virginiamycin, Guo et al. (2004a) reported higher feed conversion ratio in broilers treated with Chinese herbs on the days 21 through 28. This improved feed conversion ratio in the antibiotic group may be explained as follows: antibiotic growth promoters reduce level of competition between nutritional substances and the host. They also increase absorption and consumption of nutritional compounds by thinning intestinal wall (Garcia et al., 2007; Waibel et al., 1991). Therefore, although herbs can improve body weight gain compared to antibiotic growth promoters, in case of herbs, feed consumption can also increase body weight gain. This can result in higher feed conversion ratio for herbal medicine than for antibiotic growth promoters. More significantly, the present study suggests that the antibiotic group has not only higher level of body weight gain and lower feed conversion, but also it exhibits heavier dressing percentage compared to other groups which show significant difference from other groups. Except for the 2% Aloe vera gel group, regarding the dressing percentage.

It should be mentioned, however, that while studying the effects of herbal medicine, as broiler’s feed supplements on performance, different parameters such as plant parts, physical properties, genetic variation, age, different dosage used, extraction method, harvest time and compatibility with the other ingredients, can influence performance differently (Yang et al., 2009).

Herbs and their extracts were not the only substances studied, but polysaccharides contained in herbs also received attention from researchers and various studies on these substances report that polysaccharides contained in herbs and mushrooms have immunomodulatory, in some cases, even antimicrobial activities (Xia and Cheng, 1988; Xue and Meng, 1996). Such effects of herbs and polysaccharides on performance are attributable to effects on stimulation of immune system, therefore, on reduction in bacterial and viral infections (Sohn et al., 2000). Other researchers reported properties in herbal medicine which are similar to those of prebiotics (Verstegen and Schaafsma, 1999; Cummings and Macfarlane, 2002; Guo et al., 2004b). Prebiotics are defined as nondigestible food ingredients that beneficially affect the host by selective stimulation of growth or activity of one or a limited number of bacterial species in the colon, thus benefiting host health (Gibson and Roberfroid, 1995).

Since the main polysaccharide contained in Aloe vera gel is acemannan, the enhanced body weight gain in groups treated by Aloe vera gel compared to the control group may be attributable to antibacterial properties of Aloe vera gel which can improve intestinal microflora. Furthermore, the acemannan contained in Aloe vera gel can stimulate immune system and improve body resistance against bacteria and viruses. This, in turn, improves growth performance.

Ileum morphology

Structure of intestinal mucosa can reflect the health condition of intestine (Xu et al., 2003). Changes in intestinal morphology, such as reduced villus height or increased crypt depth, can indicate the presence of toxins (Yason et al., 1987; Anonymous, 1999). Short-chain fatty acids, as the final product of fermentation by lactobacillus, may reduce intestinal pH and make the environment unfavorable for pathogens and increase in useful bacteria count can improve intestinal health by reduction in the level of damage to intestine mucosa and in level of repairs (Farthing, 2004). As mentioned earlier, Lin et al. (2005) reported increased lactobacillus count and reduced E. coli count through supplementing the feed by acemannan (polysaccharides contained in Aloe vera gel). Furthermore, our experiment on microflora showed that the increase in Aloe vera gel contained in the feed resulted in significant linear reduction in number of E. coli colonies as well as significant linear increase in number of lactobacillus colonies compared to the antibiotic and control groups (P<0.05); moreover, the increase in the number of lactobacillus bacteria in Aloe vera gel groups confirmed antibacterial effects of Aloe vera, which stimulate the growth of useful intestinal flora and reduced the presence of gram-negative bacteria (data not shown). Therefore, it is likely that longer villi in the groups treated by 2% and 2.5% Aloe vera gel are the result of larger lactobacillus count because short-chain fatty acids, as the final product of fermentation by lactobacillus, may reduce intestinal pH and make the environment unfavorable for pathogens and these longer villi can increase capable surface area and elevate the absorption of nutritionals (Caspy, 1992). As mentioned before, the control group had the smallest villus height resulting in reduced surface area and absorption of nutritionals (Xu et al., 2003).

In the present study, crypt depth in the Aloe


**Conclusions**

Finally, it can be concluded that the groups treated by Aloe vera gel showed better performance and heavier dressing percentage compared to the control group. Furthermore, among the different groups, the antibiotic group experienced higher level of body weight gain, lower feed conversion ratio and heavier dressing percentage compared to other groups, showing no significant difference from the 2% Aloe vera gel group, although the groups treated by Aloe vera gel consumed more feed than the antibiotic group. On the other hand, increased villus height, reduced crypt depth and raised villus height/crypt depth ratio in the 2% Aloe vera gel suggest that Aloe vera gel mixed with broiler’s diet at the 2% level can provide a suitable alternative to virginiamycin for improving performance.

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