**Effects of Feeding Condensed Tannin-containing Plants on Natural Coccidian Infection in Goats**

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**ABSTRACT :** Twelve Korean native goats, spontaneously infected with mixed species of *Eimeria* were used to study the possible direct anticoccidial effect of feeding condensed tannin-containing plants on the production of *Eimeria* oocysts. The effects of feeding pine (*Pinus densifora*) needles, oak (*Quercus acutissima*) leaves and lucerne chaff on coccidia oocyst output were studied for a period of 10 days post-feeding. The results indicate that feeding fresh pine needles (40 g condensed tannins (CT) dry matter (DM)/day/goat) and oak leaves (40 g CT DM/day/goat) in combination with lucerne chaff had rapid anticoccidial activities in goats as demonstrated by a sharp decrease in oocyst production. Two days after feeding, the numbers of oocysts per gram of faeces (OPG) from the goats fed pine needles with lucerne chaff, and from goats fed oak leaves reduced by 40% and 44% compared to pre-feeding, respectively. On the sixth day after commencing feeding pine needles and oak leaves, the reduction was 81% and 72%, respectively. Ten days after feeding pine needles and oak leaves, the OPG was reduced by 93% and 85%, respectively compared to pre-feeding. Statistical analysis showed that feeding pine needles and oak leaves to goats naturally infected with coccidia significantly (p<0.001) reduced the numbers of oocysts compared to the control group fed lucerne chaff only. Four clinically important species of coccidia, *Eimeria parva, Eimeria ninakohlyakimovae, Eimeria christenseni* and *Eimeria arloingi* were identified in Korean native goats. *(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 9 : 1262-1266)*

**Key Words :** *Eimeria*, Goats, Pine Needles, Oak Leaves, Anticoccidial Activity

**INTRODUCTION**

Coccidiosis, caused by infection with *Eimeria* species affects cattle, deer, sheep, goats, pigs, horses, rabbits, turkeys, ducks and poultry (Cox, 1998), is probably the most important parasitic disease of veterinary importance throughout the world. This disease costs the US poultry industry more than $1.5 billion in annual losses (Yun et al., 2000).

The signs of damage in lambs can range from loose diarrheic faeces to severe dysentery and death (Samizadeh et al., 1979). Scanning electron microscopic observations of the small intestine of lambs infected with *Eimeria* species showed disturbed intestinal surfaces and the villi were short and flat with sloughing of the epithelium (Samizadeh et al., 1979).

Currently, chemotherapy is used extensively to control coccidiosis, but the worldwide and rapid development of drug resistance (Greif et al., 1996; Haberkorn, 1996), coupled with the increasing costs of developing new drugs and the public’s distrust of drug-treated meat demonstrate the urgent need to explore alternative methods of controlling this disease.

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**MATERIALS AND METHODS**

**Experimental design**

A total of 12 male and female naturally parasitised...
Korean native goats from Chonbuck National University farm were selected and *Eimeria* infections were confirmed by faecal oocyst counts. Goats were weighed and faecal samples were collected (for determining oocyst counts) on two consecutive days before the goats were treated (baseline data). The goats were then divided into three equal groups based on oocyst counts and sex. The goats in the first group were fed lucerne chaff only (1,750 g DM/day), to serve as a control group. The goats in the second group were fed lucerne chaff (1,278 g dry matter (DM)/goat/day) and fresh pine needles (472 g/goat/day; equivalent to 40 g CT/day/goat) whilst the goats in the third group were fed lucerne chaff (205 g DM/day) and dry oak leaves (1,545 g DM/goat/day; equivalent to 40 g CT/day/goat). The amount of feed intake was not changed during the trial and the palatability of feed was high in the order of fresh pine needles, dry oak leaves, and Lucerne chaff. The goats were fed at 0900 and 1700 h each day and had free access to water. Faecal samples for oocyst counts were collected 2, 4, 6, 8 and 10 days after commencing the nutritional treatments.

**Faecal examinations**

In order to determine the level of infection, faecal samples were collected from the rectum of each goat and the numbers of oocysts were determined within 3 h of collection using a modified McMaster method where a count of one oocyst was equivalent to 50 oocysts/gram faeces.

**Speciation**

The procedure of Harper and Penzhorn (1999) was followed with slight modifications. Briefly, faecal samples with more than 3,000 OPG were thoroughly mixed with at least 20× their volume of an aqueous 2.5% (w/v) potassium dichromate solution, placed in thin layers in Petri-dishes and the oocysts allowed to sporulate for 10-14 days at room temperature. To recover oocysts, the solution was centrifuged at 1,200 rpm for 10 minutes, the supernatant discarded and the sediment placed into a vials filled with 2 M sucrose solution. A cover slip was placed on the top of the vials for about 10 minutes to allow oocysts to float onto the underside of the cover slip which was carefully removed, placed on a microscope slide and the edges sealed with nail polish. The slide was scanned in parallel sweeps and the first 100 oocysts seen were identified. Measurements (length and width) were made using Scenscan, Scientific Measurement System at the Faculty of Veterinary Science, Chonju National University, Chonju, Korea. Species identification was based on descriptions and illustrations by Levin (1985), Craig (1986), O’callaghan (1989), Al-Yousif et al. (1992) and Rhee (1999).

**Determination of the level of condensed tannins**

The extractable, protein-bound and fibre-bound CT concentrations in pine needles, oak and lucerne chaff were determined by the butanol-HCl method (Jackson et al., 1996).

**Calculation of data and statistical analysis**

The efficacy of treatment was determined by using the formula:

$$\frac{A-B}{A} \times 100$$

Where A and B are the numbers of oocysts per gram of faeces at pre- and post-treatment, respectively. Data were analyzed using SAS ver. 6.11 (1991).

**RESULTS**

All the goats were infected with one or more species of *Eimeria*. Cultures of pooled faecal material revealed the presence of four species of *Eimeria*, *Eimeria parva* (Kotlan, Mocsy, and Vajda, 1929) (7% of total oocysts), *E. ninakohiyakimovae* (Yakimoff and Rastegaieff, 1930) (16%), *E. christenseni* (Levine, Ivens and Fritz, 1962) (23%) and *E. arloingi* (Martin, 1909) (54%; Table 1).

Table 2 shows the extractable, protein-bound and fibre-bound CT concentration in pine needles, oak leaves and lucerne chaff. Pine needles had the highest CT concentration (81 g/kg DM) followed by oak leaves (26 g/kg DM), and lucerne chaff (2 g/kg DM). The effects of feeding fresh pine needles, dry oak leaves and lucerne chaff on the natural coccidian infection in Korean native goats are shown in Table 3 and Figure 1. Feeding fresh pine needles had anticoccidial activity as evidenced by the reduction in the numbers of oocysts exceeded by 40% two days post-feeding, 71% four days...
post-feeding, 81% six days post-feeding, 92% eight days post-feeding and by 93% ten days post-feeding relative to the numbers of oocysts shed pre-feeding (Table 3 and Figure 1A). The differences were highly significant (p<0.001) in comparison to control group fed Lucerne chaff only.

Feeding dried oak leaves to the goats reduced the numbers of oocysts by 44%, 70%, 72%, 81% and 85% on days 2, 4, 6, 8 and 10 post-feeding, respectively, compared to the numbers of oocysts shed before feeding oak leaves. These differences were also highly significant in comparison to controls.

**DISCUSSION**

All the goats used in this study were infected with coccidia and four species were identified. This high percentage of positive specimens is consistent with the findings of Alyousif et al. (1992) who found that 90% of the goats in Saudi Arabia were positive for *Eimeria* and, Balicka-Ramisz (1999) who showed that of 110 Polish goats 81% of adults and 100% of the kids were infected with up to nine different species of *Eimeria*. Moreover, Harper and Penzhorn (1999) found that 89-100% of adult goats in South Africa were infected with up to seven species of *Eimeria*.

Published data indicate that *E. christenseni, E. arloingi, E. ninakohlyakimovae, E. caprina* and *E. caprovina* are the most pathogenic species in goats (Alyousif et al., 1992; Balicka-Ramisz, 1999; Harper and Penzhorn, 1999). The data reported here indicate that these *Eimeria* species are also among the most common in the Korean goats (Table 1) with *Eimeria arloingi* the most prevalent species. Harper and Penzhorn (1999) similarly reported that *E. arloingi* was the most prevalent species of *Eimeria* in South African goats. The absence of symptoms such as diarrhoea in adult goats may indicate a well-developed immunity against coccidiosis (Craig, 1986; Alyousif et al., 1992).

In this study we showed that feeding goats naturally infected with *Eimeria*, with diet containing pine needles and oak leaves had a profound anticoccidial activity as evidenced by their ability to reduce the numbers of oocysts by up to 93% during the trial period of 10 days. This anticoccidial activity may be related to the CT contents in both pine needles and oak leaves.

It is well known that CT can react and form complexes with proteins in a pH-dependent manner (Jones and Mangan, 1977) and that these reactions are highly specific for different tannins as well as different proteins (Asquith and Butler, 1986; Butler et al., 2000). Condensed tannins found in pine needles and oak leaves fed to goats might therefore interact with the dietary proteins and protect them from microbial degradation in the rumen so that more protein would reach the small intestine and the ability of the host to respond to reduce parasite establishment could be achieved by better protein nutrition. It has been clearly

### Table 3. Comparative anticoccidial activities of fresh pine needles, dried oak leaves in combination with lucerne chaff or lucerne chaff only fed to goats naturally infected with different species of *Eimeria* based on oocysts per gram faeces (OPG) counts

<table>
<thead>
<tr>
<th>Group</th>
<th>Feed</th>
<th>Pretreatment mean OPG</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>OPG reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>PN</td>
<td>6,300</td>
<td>3,800</td>
<td>1,813</td>
<td>1,200</td>
<td>538</td>
<td>463</td>
<td>75.24</td>
</tr>
<tr>
<td>B</td>
<td>OK</td>
<td>4,463</td>
<td>2,488</td>
<td>1,363</td>
<td>1,263</td>
<td>863</td>
<td>625</td>
<td>70.44</td>
</tr>
<tr>
<td>C</td>
<td>LC</td>
<td>3,813</td>
<td>5,250</td>
<td>4,300</td>
<td>4,625</td>
<td>3,725</td>
<td>4,513</td>
<td>0</td>
</tr>
</tbody>
</table>

LC: lucerne chaff; OK: oak leaves; PN: pine needles.
established that feeding diets containing low concentrations of CT in forage (usually less than 50 g CT/kg DM), benefit ruminants by reducing degradation of dietary protein and increasing the supply of amino acids to the small intestine (Waghorn et al., 1987; McNabb et al., 1993).

Although the CT present in pine needles and oak leaves may increase bypass protein supply to the goats, it is proposed that the decrease in the production and shedding of *Eimeria* oocysts in this short-term study was more likely to have been due to direct effects of the CT on different stages of the parasite’s life cycle, rather than via improved protein nutrition of the goats. This is because Molan et al. (1999) found that exposure of the eggs and first-stage (L1) larvae of the sheep nematode, *Trichostrongylus colubriformis* to low concentrations of CT extracts from different forages resulted in a reduction in the rate of egg hatching and the development of eggs and L1 larvae to infective larvae under *in vitro* conditions. Athanasiadou et al. (2000) drenched sheep experimentally infected with *T. colubriformis* with quebracho extract and found that in the treated sheep the worm burdens and number of eggs per gram faeces per worm were reduced by 30% compared with the undrenched controls. In contrast, many short-term studies have shown that increased protein supply to the small intestine does not influence parasite establishment in sheep infected with *Haemonchus contortus* (Abbott et al., 1985, 1986) and *Trichostrongylus colubriformis* (van Houtert et al., 1995; Kyriazakis et al., 1996).

In view of the results of the present study and the fact that goats like eating fresh pine needles and dry oak leaves, these feedstuff could be used as an alternative method for controlling coccidial infection in goats in order to reduce a dependence on chemotherapeutics as the sole method for controlling coccidial infection in goats.

Further studies are clearly needed both to determine the minimal concentration of CT required to stop the production of oocysts and to investigate the effects of feeding pine needles and oak leaves on the productive performance of goats.

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**REFERENCES**


