

## The Administration of Garlic Extract on *Eimeria stiedai* Oocysts and the Hematological Profile of the Coccidia Infected Rabbits

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### ABSTRACT

This research aimed to examine the potential of garlic as the coccidiosis control in rabbits either *in vitro* or *in vivo*. During *in vitro*, observed variables were rabbits oocysts that were sporulated, unsporulated, and abnormal in incubation for 3 days with the addition of garlic extract. The treatments were doses of garlic extract administration (0%, 1%, 2%, 4%, and 8%) and sulfaquinoxalline as a standard anticoccidiosis. Meanwhile during *in vivo*, the variables observed were the hematological profile of the experimental rabbits naturally infected with coccidia. The doses of garlic extract was administered orally to the experimental rabbits infected with coccidia were 0 mg, 10 mg, 20 mg, 40 mg, and 80 mg/rabbit. As a standard coccidiosis drugs, the combination of sulfadiazine and trimethoprim was used. The treatments were given for 6 days. The variables observed were the hematological profile of the coccidiosis rabbits, including the erythrocytes, hemoglobin, hematocrits, MCV, MCH, MCHC, and thrombocytes. The research employed a completely randomized design, with 5 repetitions. The data were further analyzed using the honestly significant difference test. The results showed that garlic extract administration significantly decreased ( $P < 0.01$ ) both the number of the sporulated and unsporulated oocysts ( $P < 0.05$ ), yet did not significantly influence the abnormal oocysts, but there was no significant difference within the entire hematological variables except in thrombocytes ( $P < 0.05$ ). Garlic extract administration decreased the excretion number of oocysts in the feces either *in vitro* or *in vivo* and influenced some hematological variables which provided a new prospect for controlling coccidiosis naturally in rabbits.

*Keywords: coccidia, rabbits, garlic extract, oocyst, hematology*

### ABSTRAK

Penelitian ini bertujuan untuk menguji potensi bawang putih sebagai anti koksidiosis pada kelinci secara *in vitro* dan *in vivo*. Secara *in vitro*, peubah yang diamati adalah ookista kelinci yang bersporulasi, tidak bersporulasi, dan abnormal pada inkubasi selama 3 hari dengan penambahan ekstrak bawang putih. Perlakuan yang digunakan adalah 0%, 1%, 2%, 4%, dan 8% bawang putih, serta penggunaan sulfaquinoxalline sebagai obat standar koksidiosis. Pada penelitian *in vivo*, peubah yang diamati adalah profil hematologi kelinci yang terinfeksi koksidia secara alami. Ekstrak bawang putih diberikan secara per oral pada kelinci yang terinfeksi koksidia sebesar 0 mg, 10 mg, 20 mg, 40 mg, dan 80 mg/ekor, serta kombinasi sulfadiazin dan trimethoprim sebagai obat standar koksidiosis. Perlakuan diberikan selama 6 hari. Peubah yang diamati adalah profil darah kelinci koksidiosis yang meliputi sel darah merah (eritrosit), hemoglobin (Hb), hematokrit, MCV, MCH, MCHC, dan trombosit. Rancangan yang digunakan adalah rancangan acak lengkap (RAL), dengan pengulangan sebanyak 5 kali. Analisis data menggunakan analisis variansi dengan uji lanjut beda nyata jujur (BNJ). Hasil analisis variansi menunjukkan bahwa pemberian ekstrak bawang putih berpengaruh sangat nyata menurunkan ( $P < 0,01$ ) jumlah ookista yang bersporulasi, berpengaruh nyata pada ookista yang tidak bersporulasi ( $P < 0,05$ ), namun tidak berpengaruh nyata pada ookista yang abnormal. Hasil analisis statistik menunjukkan hasil yang tidak berbeda nyata pada semua peubah hematologi, kecuali trombosit ( $P < 0,05$ ). Pemberian ekstrak bawang putih dapat menurunkan jumlah ekskresi ookista dalam feces secara *in vitro* dan *in vivo* dan mempengaruhi beberapa peubah hematologi sehingga memberikan harapan baru bagi pengendalian koksidiosis secara alami pada kelinci.

*Kata kunci: koksidia, kelinci, ekstrak bawang putih, ookista, hematologi*

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## INTRODUCTION

Rabbit is one of potential livestock commodities for alternative meat supplies beside as a pet and a laboratory animal. Rabbit meat has a highly nutritious protein content, low fat and cholesterol, rich of calcium and phosphorus, as well as high linoleic acid. Rabbit meat is healthier for human consumption than chicken, beef, and pork due to its high protein and low fat contents (Nistor, *et al.*, 2013). Coccidiosis is an infection caused by *Eimeria spp* protozoa and this infection and disease is considered as a major obstacle in raising rabbits. Coccidiosis in rabbits may be caused by 11 species of *Eimeria spp.* in which 10 species may invade the digestive tract and 1 species may invade the liver (Pakandl, 2009). Coccidiosis is associated with anorexia, decreased feed intake and feed utilization, anemia, dehydration, and diarrhea (Abbas *et al.*, 2010; Srinivasan *et al.*, 2015)

The anticoccidiosis drug in rabbits is a relatively inexpensive medicine. However, there are several weaknesses, such as the fecal excretion which still may pollute the environment, especially when utilized as a fertilizer. Anticoccidiosis drug is also absorbed and retained within the meat that results in resistance to the anticoccidiosis drugs for those who consume the rabbit meat. Unwisely and irrationally use of antibiotics may trigger the antimicrobial resistance (AMR) (Pakandl, 2009). Alternative approaches to control coccidiosis by medicinal plants extracts have promising prospects for anticoccidiosis agents (Ogbu and Onuh, 2015; Abbas *et al.* 2017). For example, the development of herbal plants as the natural coccidiostat is necessary to be conducted since those herbals may provide great opportunities for Indonesian regions with the tropical climate which is rich in natural resources.

Garlic (*Allium sativum*) is considered as one of the most essential and useful herbs used for medicinal purposes (Adulugba *et al.*, 2017). Garlic can be used as antibacterial (Tipu *et al.*, 2002; Safithri *et al.*, 2011), antiparasitic, and anticoccidial agents in sheep (Worku, 2009) and chickens (Pourali *et al.*, 2014; El-Khtam *et al.*, 2014). Garlic and its sulfur compounds, allicin, aliin, ajoene, diallyl sulfide, dithiin, and allylcysteine are reported to have broad antimicrobial activities which can eliminate the negative factor of microbial infections. *In vitro* study in chicken shows that allicin inhibits sporulation of *Eimeria tenella* (Muthamilselvan *et al.*, 2016).

In rabbits, garlic administration may reduce the number of the oocysts in rabbits which are infected with the hepatic coccidia (Toulah and Al-Raw, 2007; Abu-Akkada *et al.*, 2010). Blood is one of physiological parameters used to determine the health of livestock animals. Garlic extract administration may prevent anemia in sheep which are infected by the coccidia (Worku *et al.*, 2009). Research conducted on coccidiosis in rabbits is still very rare in Indonesia. Thus, this research aims at determining the influence of garlic extract on the excretion of oocysts either *in vitro* or *in vivo* on the hematological profile of the coccidian-infected rabbits.

## MATERIALS AND METHODS

The research materials consisted of garlic (*Allium sativum*), oocysts of *Eimeria stiedai*, post weaning male rabbits (3 months of age, cross Rex breed, with average body weight of 600 g) that naturally infected with coccidia. The equipment and materials were required for oocyst sporulation, fecal examination, macerately produced garlic extract, and cultivation of rabbits during the research period. This research was approved by Research and Public Service Institution as well as Animal Science Faculty of Jenderal Soedirman University, Purwokerto. The research was conducted at the Livestock Health Laboratory of Jenderal Soedirman University (Unsoed), Research Laboratory of Unsoed, Experimental Farm of Unsoed, and in collaboration with the Animal Health Laboratory Type B of Central Java Province in Purwokerto.

### Preparation of Garlic Extract

Preparation of garlic extract was conducted with a maceration method using 70% of ethanol solvent. Two kilograms of garlic were thinly sliced and dried using a dryer with a temperature of 55-60°C for 4 days. The dried garlic was then crushed using a grinder to turn it into a powder. Each 100 gram of the garlic powder was subsequently immersed within 1 liter of 70% of ethanol solvent for 24 hours and then filtered. The rest fixing bath was re-filtered with 500 g of solvent for 24 hours. The filtrate was evaporated using a rotary evaporator. The extract was further evaporated in a waterbath to produce a concentrated extract. The concentrated extract was then stored at the temperature of 5°C and ready to use (Islam *et al.*, 2008; Iqbal *et al.*, 2013; Indrasanti *et al.*, 2015).

### Preparation of *Eimeria stiedai* Isolates

The propagation of *E. stiedai* isolates was conducted *in vivo* by orally infecting *E. stiedai* at a dose of 10<sup>3</sup> in 5 post-weaning cross Rex breed rabbits. The experimental rabbits used were at the age of 3 months with the body weight of ± 600 g and free of coccidiosis. The feces was collected and examined using Whitlock method with the floating test and then the oocysts were calculated using Mc. Master method. In the isolate, 2% of potassium dichromate (K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>) was added and washed 3 times using the distilled water. The calculated oocysts were equal to 5000 opg (Coudert *et al.*, 1993).

### *In Vitro* Mixing of Garlic Extract with *E. stiedai* Oocysts

The 5000 opgs of oocysts were mixed with 0.5% of Na CMC (Natrium Carboxy Methyl Cellulose) and garlic extract with the concentration of 0 mg per 100 mL (0%), 1 mg per 100 mL (1%), 2 mg per 100 mL (2%), 4 mg per 100 mL (4%), 8 mg per 100 mL (8%), and then added with distilled water up to 15 mL. The positive control used was Coxy® (sulfaquinoxalline). The incubation was conducted for 3 days at 26°C (Coudert *et al.*,

1993). The calculated oocysts covered the quantity of the sporulated, unsporulated, and abnormal oocysts after incubation.

**Preparation of Experimental Rabbits for *in Vivo* Study**

The experimental animals were naturally infected rabbits. The feces of the experimental rabbits was taken before the treatment to know the amount of rabbits using Whitlock method with the floating test. On the 21st day after treatment, blood samples were taken through auricularis vena or cor 3 mL.

**Administration of Garlic Extract to Experimental Rabbits**

The garlic extract with various dosages were orally administered once a day for 3 days, 2 resting days, and 3 re-medical administration days. Meanwhile, aquaprim® was intramuscularly administered for 3 respective days. The doses of garlic extract administration were 0, 10, 20, 40, and 80 mg/rabbit and the aquaprim® (per mL contains 200 mg sulfadiazine and 40 mg trimethoprim) was used as a positive control administered at 0.1 mL/kg BW for 3 respective days. Feces examination was conducted before and 21 days after treatment. Blood collection was made on day 21.

**Experimental Design and Analysis**

The experiment was arranged in a Completely Randomized Design and the data collected were analyzed with the analysis of variance followed by further Honestly Significant Difference Test (Steel and Torrie, 1980). Phytochemical and proximate analyses of garlic powder were also respectively conducted at Indonesian Spice and Medicinal Crops Research Institute and Animal Feed Material Laboratory, Faculty of Animal Sciences, Jenderal Soedirman University. The hematological analyses covering the erythrocytes, hemoglobin, hematocrits, MCV, MCH, MCHC, and thrombocytes were conducted at Biofit in Purwokerto by The Sysmex XP-100 automated hematology analyzer (Ike *et al.*, 2010; Karem *et al.*, 2016).

**RESULTS**

***In Vitro* Observation of Garlic Extract Effect on Oocysts**

The effectivity test of garlic extract on *Eimeria stiedai* oocyst sporulation isolated from the naturally infected rabbits was conducted *in vitro*. Parameters observed were the number of sporulated, unsporulated, and abnormal oocysts during 3 days incubation period. A root transformation was also conducted on the data shown in Table 1.

The number of the sporulated and unsporulated oocysts are presented in Figure 1. The highest number of abnormal oocysts was found in the treatment of administration of garlic extract at a dose of 4%. The number of abnormal oocysts may be seen in Figure 2.

The result of variance analysis showed that the administration of garlic extract significantly decreased ( $P < 0.01$ ) the number of the sporulated and unsporulated oocysts ( $P < 0.05$ ), yet did not significantly influence the number of abnormal oocysts. In further test conducted with the honestly significant difference test showed that the administration of 4% of garlic extract was the most significant dose to decrease the number of sporulated oocysts among the doses of garlic extract used (0%) and standard coccidostat of sulfaquinoxalline.

**The Phytochemical Test**

Qualitative phytochemical tests were conducted on saponin, tannin, alkaloid, phenolic, flavonoid, triterpenoid, steroid, and glycoside, while the quantitative tests were conducted on tannin, flavonoid, and saponin. The results of nutrient composition and phytochemical compound on garlic powder are shown in Table 2 and Table 3.

**Observation on Hematological Profiles of the Experimental Rabbits**

In this study, the hematological profile of rabbits infected with the widely open coccidia with various doses of garlic extract administration included the

Table 1. The number of sporulated, unsporulated, and transformed oocysts incubated for 3 days with the administration of various doses of garlic extract

Variables	Treatments					
	A0	A1	A2	A3	A4	A5
Sporulation	11.18 <sup>a</sup>	10.32 <sup>a</sup>	10.13 <sup>a</sup>	6.08 <sup>b</sup>	10.47 <sup>a</sup>	9.85 <sup>ab</sup>
No Sporulation	6.01 <sup>a</sup>	4.42 <sup>a</sup>	2.97 <sup>b</sup>	2.83 <sup>b</sup>	1.98 <sup>b</sup>	3.78 <sup>a</sup>
Abnormal	0.71	4.06	3.27	4.15	3.18	2.92

Note: A0: *Eimeria stiedai* oocysts with the administration of garlic extract at a dose of 0 mg per 100 mL (0%), A1: *Eimeria stiedai* oocysts with the administration of garlic extract at a dose of 1 mg per 100 mL (1%) to the coccidia-infected rabbits, A2: *Eimeria stiedai* oocysts with the administration of garlic extract at a dose of 20 mg per 100 mL (2%) to the coccidia-infected rabbits, A3: *Eimeria stiedai* oocysts with the administration of garlic extract at a dose of 40 mg per 100 mL (4%) to the coccidia-infected rabbits, A4: *Eimeria stiedai* oocysts with the administration of garlic extract at a dose of 80 mg per 100 mL (8%) to the coccidia-infected rabbits, and A5: medical control, coccidia-infected rabbits administered with Coxy (sulfaquinoxalline 1 g). The same number was not significantly different in Honestly Significant Difference 5%

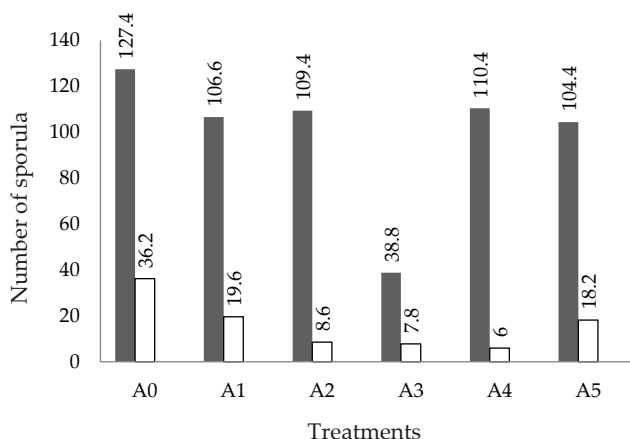


Figure 1. The numbers of the sporulated (■) and unsporulated (□) oocysts due to the various dosages of garlic extract administration. A0: *Eimeria stiedai* oocysts with the administration of garlic extract at a dose of 0%, A1: *Eimeria stiedai* oocysts with the administration of garlic extract at a dose of 1% to the coccidia-infected rabbits, A2: *Eimeria stiedai* oocysts with the administration of garlic extract at a dose of 2% to the coccidia-infected rabbits, A3: *Eimeria stiedai* oocysts with the administration of garlic extract at a dose of 4% to the coccidia-infected rabbits, A4: *Eimeria stiedai* oocysts with the administration of garlic extract at a dose of 8% to the coccidia-infected rabbits, and A5: medical control, coccidia-infected rabbits administered with sulfaquinoxalline.

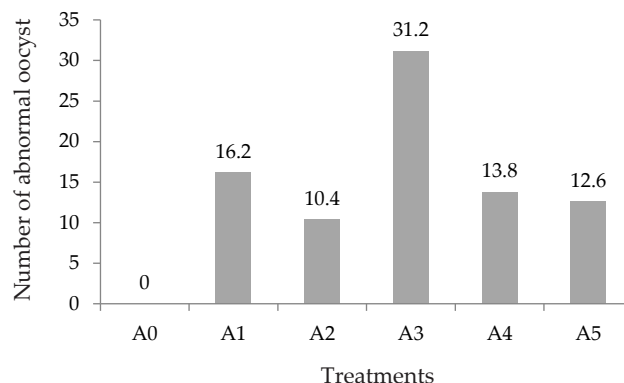


Figure 2. The number of abnormal oocysts on the administration of various dosages of garlic extract. A0: *Eimeria stiedai* oocysts with the administration of garlic extract at a dose of 0%, A1: *Eimeria stiedai* oocysts with the administration of garlic extract at a dose of 1% to the coccidia-infected rabbits, A2: *Eimeria stiedai* oocysts with the administration of garlic extract at a dose of 2% to the coccidia-infected rabbits, A3: *Eimeria stiedai* oocysts with the administration of garlic extract at a dose of 4% to the coccidia-infected rabbits, A4: *Eimeria stiedai* oocysts with the administration of garlic extract at a dose of 8% to the coccidia-infected rabbits, and A5: medical control, coccidia-infected rabbits administered with sulfaquinoxalline.

Table 2. Nutrient compositions of garlic powder (% DM)

Nutrient composition (%)	Percentage
Dry matter	94.03
Ash	3.53
Ether extract	1.06
Crude fiber	0.50
Crude protein	27.05
Nitrogen Free Extract	67.85

measurement on erythrocytes, hemoglobin, hematocrit, Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), Mean Corpuscular Hemoglobin Concentration (MCHC), and thrombocytes. The average hematological profile are presented in Table 1.

The results of variance analysis showed that there was no significant difference in hematological parameters in experimental rabbits administered with different doses of garlic extract. It proved that the administration of various doses of garlic extract had no significant effects on the coccidiosis in infected rabbits. The research showed that the highest level of average thrombocytes was found in the rabbits administered with 20 mg of garlic extract while the lowest level was found in the experimental rabbits administered with 0 mg of garlic extract. The results of variance analysis showed that there was a significant increases ( $P < 0.05$ ) in thrombocyte number in all treatments. However, the levels of thrombocytes found in this experiment were still in the normal

Table 3. Phytochemical compounds of garlic powder

Compounds	
Saponin	+
Tannin	+
Alkaloid	+
Phenolic	-
Flavonoid	+
Triterpenoid	-
Steroid	-
Glycoside	-

Note: + = detected; - = not detected.

range. The Honestly Significant Difference Further Test showed that the administration of garlic extract at a dose of 20 mg gave the most significant increase in thrombocyte level when compared to the other treatments. The administration of garlic extract at a dose of 80 mg showed higher average results of hematological parameters (except thrombocyte) compared to the other treatments.

## DISCUSSION

The administration of garlic extract at doses of 2%, 4%, and 8% showed significantly different influences when compared to the other treatment with the administration of 0% of garlic extract and control



Table 4. The hematological profile of coccidia-infected rabbits after administration with various dosages of garlic extract

Variables	Treatments					
	D0	D1	D2	D3	D4	D5
RBC (x10 <sup>6</sup> /μL)	4.48 ± 0.47	4.97 ± 0.62	4.05 ± 1.20	4.43 ± 0.71	5.11 ± 1.33	5.10 ± 0.29
HGB (g/dl)	11.20 ± 0.57	10.80 ± 0.78	9.60 ± 2.36	10.18 ± 1.76	11.80 ± 2.40	11.24 ± 0.67
HCT (%)	35.58 ± 1.75	34.98 ± 2.48	31.32 ± 7.64	32.88 ± 4.68	37.14 ± 6.31	35.04 ± 2.15
MCV (fl)	76.60 ± 7.59	62.12 ± 24.74	79.48 ± 13.88	74.86 ± 8.09	74.62 ± 10.22	68.74 ± 3.11
MCH (pg)	23.64 ± 1.38	21.90 ± 2.44	24.22 ± 3.58	23.04 ± 1.52	23.44 ± 1.84	22.04 ± 0.66
MCHC (%)	31.04 ± 1.34	30.88 ± 0.83	30.62 ± 0.90	30.88 ± 2.67	31.62 ± 1.90	32.06 ± 0.68
PLT(x10 <sup>3</sup> /μL)	298.20 ± 54.44 <sup>b</sup>	317.20 ± 145.67 <sup>ab</sup>	566.80 ± 143.07 <sup>a</sup>	509.20 ± 153.74 <sup>ab</sup>	417.40 ± 162.90 <sup>ab</sup>	352.00 ± 92.95 <sup>ab</sup>

Note: D0: coccidian-infected rabbits without administration of garlic extract, D1: coccidia-infected rabbits administered with garlic extract at a dose of 10 mg, D2: coccidia-infected rabbits administered with garlic extract at a dose of 20 mg, D3: coccidia-infected rabbits administered with garlic extract at a dose of 40 mg, D4: coccidia-infected rabbits administered with garlic extract at a dose of 80 mg, D5: coccidia-infected rabbits administered with aquaprim at a dose of 0.1 mL/kg body weight. Means with the same superscript were not significantly different in Honestly Significant Difference 5%. RBC: red blood cells (erythrocytes), HGB: hemoglobin, HCT: hematocrit, PLT: platelets; thrombocytes, MCV: mean corpuscular volume, MCH: mean corpuscular hemoglobin, MCHC: mean corpuscular hemoglobin concentration.

sulfaquinoxalline. In *in vitro* study, *E. stiedai* oocysts were incubated for 72 hours (3 days) to ensure that the oocysts were completely sporulated. The lowest average number of sporulated oocysts was found in the experimental oocyst administered with 4% of garlic extract, while the highest number of the unsporulated oocysts was found in the oocyst administered with 0% of garlic extract. The administration of garlic extracts to *E. stiedai* oocysts infecting the rabbits might provide influences by inhibiting the sporulation of oocysts and production of abnormal oocysts which are probably due to the anticoccidiosis effect of garlic active substance. The active substances contained in garlic extract might greatly be responsible for the anticoccidia activities.

Proximate analysis on garlic powder was conducted to determine the number of substances in order to identify the nutrient of a food substance contained in the feed materials. The results of proximate analysis showed that the protein level was high, in which protein has an important role for growth. High protein contained in feed materials requires further study whether garlic may be used as the substance administered in the rabbit ration to improve its performance and as a controlling agent against coccidiosis. The phytochemical qualitative test showed that garlic contained saponin, tannin, alkaloid, and flavonoid. Meanwhile, the phytochemical quantitative test on garlic powder to saponin was by 0.56%, tannin by 0.73%, and flavonoid by 0.46%. This *in vitro* study conducted on garlic supported the previous research that garlic might be used as anticoccidiosis. Garlic has several active compounds including allicin, alliin, ajoene, diallyl sulfide, dithiin, and allylcystein, in which allicin may inhibit *E. tenella* sporulation in chickens (El-Khtam *et al.*, 2014; Pourali *et al.*, 2014). The other natural plant functioning as an anticoccidiosis is banana stem. Our previous *in vitro* test showed that banana stem extract might decrease *E. stiedai* oocysts (Indrasanti *et al.*, 2015). The existing tannin contained in garlic and banana stem, as contained in pine stem extract, might significantly decrease the oocyst sporulation ability by inhibiting the enzyme activity contributing in the sporulation process, by penetrating through the oocystic cell

walls and destroying the cytoplasm (sporont) that resulted in abnormal oocysts (Molan *et al.*, 2009; Indrasanti *et al.*, 2015).

The normal standard of erythrocytes count, hemoglobin, hematocrit, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and thrombocytes are 6.24 ± 0.24x10<sup>6</sup>/μL, 13.4 ± 0.5 g/dL, 42.5 ± 1.6%, 68.1 ± 1.9fL, 21.5 ± 0.6pg, 31.4 ± 0.9%, and 200-1000x10<sup>3</sup>/μL, respectively (Weiss & Wardrop, 2010). The research showed that the highest average of erythrocytes, hemoglobin, and hematocrite were at the administration of 80 mg of garlic extract, while the lowest levels were found at the administration of 20 mg of garlic extract. The highest average of MCV level was found in the experimental rabbits administered with garlic extract at a dose of 20 mg while the lowest was found in the experimental rabbits administered with garlic extract at a dose of 10 mg. The highest average of MCH level was found in the experimental rabbits administered with garlic extract at a dose of 20 mg while the lowest was found in the experimental rabbits administered with aquaprime. The highest average of MCHC level was found in the experimental rabbits administered with aquaprim while the lowest level was found in the experimental rabbits without administration of garlic extract (0 mg).

Akhtar *et al.* (2012) stated that infection of coccidia might influence the whole hematological parameters. The hematological changes on the coccidia-infected rabbits were proven with the significantly decreasing number of erythrocytes, hemoglobin, and hematocrit as well as the increasing number of leukocytes, especially eosinophils, and neutrophils (Al-Saeed *et al.*, 2017). In the present experiment, the whole experimental rabbits still suffered from anemia, in which all erythrocytes, hemoglobin, and hematocrit numbers were below the normal standard levels although they had been administered with the garlic extract during the treatments. However, only thrombocytes (P<0.05) and leukocytes that showed significant increases (P<0.01), but without correlation with the increasing doses of garlic extract administration. In addition, the number of oocyst in rab-

bits treated with banana stem extract decreased significantly ( $P < 0.01$ ) as published in our previous research.

The clinical symptoms of the coccidian-infected rabbits were depression, anorexia, brown watery diarrhea, weakness, coarse hair, hardening of abdomen, and continuously thinning (Al-Saeed *et al.*, 2017). In the present research, the rabbits had the possibility of undergoing a subclinical coccidiosis that most rabbits in Banyumas Regency were sub-clinically infected, in which the clinical symptoms were not clearly visible, yet due to the hematological profile, there was anemia.

In the present research, the administration of garlic extract as the treatments for those coccidia-infected rabbits was indirectly unable to overcome the anemic problems. Thus, further researches on the administration of garlic extract in feed to control coccidiosis in rabbit should be conducted as well as to strengthen the statement of Abu-Akkada *et al.* (2010) who explained that oral administration of crude garlic was effective for reducing the excretion of oocysts and might increase the body weight of the hepatic coccidia-infected rabbits. El-Khtam *et al.* (2014) also described that garlic and turmeric powder as one of animal feed supplements was effective for the treatment of coccidiosis. Similarly, Nosal *et al.* (2016) stated that garlic and oregano administration in animal feed might function as the prophylaxis, in case of the sub-clinically coccidia-infected rabbits. Toulah and Al-Raw (2007) also stated that the administration of crude garlic before the coccidia infection might reduce the excretion of oocysts more effectively as a prophylaxis than as a medication.

Effectiveness of the garlic extract on prevention of coccidiosis is related to the bioactive compound of garlic. Garlic is rich in organosulfur compounds (OSC) whose precursors (allicin, diallyl sulfide, and diallyl trisulfide) are believed to play key roles in antioxidant and anti-inflammatory effects (Pourali *et al.*, 2014). Therefore, in the present experiment, garlic probably eliminated the negative effect of coccidial infection in the experimental rabbits. The anticoccidial mechanism of garlic and its sulfur compounds remains elusive. However, one of phytochemicals that interferes with life cycle of *Eimeria sp* is allicin that inhibits the development of sporozoites *Eimeria spp.* Whereas, propyl thiosulfinate can be beneficial as an immunity protector (Muthamilselvan *et al.*, 2016).

## CONCLUSION

*In vitro* analysis showed that the administration of garlic extract might decrease the excretion number of oocysts at the dosage of 20 mg and influenced some hematological parameters in *in vivo*. This research provided new hope for the natural coccidiosis control in rabbits.

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