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ORIGINAL ARTICLE

Prevalence and antimicrobial sensitivity of *Escherichia coli* and *Salmonella* species in field cases of rabbit intestinal coccidiosis treated with prebiotic

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ABSTRACT. Coccidian infection may promote the proliferation of gut bacteria of the family Enterobacteriaceae. Bacterial infections by members of this family in rabbits can induce a negative impact on their health and lead to high mortality, especially in young individuals. This study aimed to investigate the effect of prebiotic treatment on *Escherichia coli* and *Salmonella* species during natural intestinal coccidiosis in rabbits. Forty-five rabbits were selected from a rabbit farm in Beni-Suef, Egypt. Out of the 45 rabbits, 15 were coccidia-free and used as the negative control group (NC group) and 30 were naturally infected with coccidia. The infected rabbits were randomly divided into two equal groups, the positive control group (PC) and the prebiotic treated group (PT) which was orally treated with prebiotic for 8 successive days. Faecal oocyst count was assessed daily during the course of treatment. At 8 days post-treatment, 5 rabbits from each group were euthanised for the microbiological examination of the intestinal tract. On day 8 post-treatment, the PT group showed a significant ($P \leq 0.05$) reduction in the oocyst count ($5.33 \times 10^3 \pm 0.89$) with a significant ($P \leq 0.05$) decline in the prevalence of *E. coli* and *Salmonella* (66.7 % and 26.4%, respectively). The PC group showed highly a significant oocyst count ($21.67 \times 10^3 \pm 0.82$ OPG), with a significant increase in the prevalence of *E. coli* and *Salmonella* (86.7 % and 46.7 %, respectively). The NC group remained coccidian free and exhibited only *E. coli* with no *Salmonella* infection. The *in vitro* susceptibility test showed that *E. coli* isolates were highly resistant to most of the tested antimicrobials while *Salmonella* isolates showed variable resistance profiles. In conclusion, the prebiotic treatment significantly reduced the prevalence of *E. coli* and *Salmonella* infections coexisted with intestinal coccidiosis naturally infected rabbits.

Key words: rabbits, prebiotic, coccidiosis, *Salmonella*, *E. coli*, antimicrobial sensitivity.

INTRODUCTION

Rabbit production is a fast growing livestock industry worldwide. Rabbit meat is considered a source of animal protein that can solve the problem of the red meat shortage all over the world (Dalle and Szendro 2011). Digestive infections represent one of the main pathological problems and are responsible for significant economic losses in rabbit breeding facilities (Saravia *et al* 2017). Domestic rabbits are susceptible to a number of infectious diseases: parasitic, bacterial and viral (Langan *et al* 2000, Lennox and Kelleher 2009).

Rabbit coccidiosis is a disease caused by protozoan parasites of the genus *Eimeria* (Apicomplexa: Eimeriidae) (Pakandl 2009). Coccidiosis is mainly detected in young rabbits aged one to three months, especially after weaning, and it causes enteritis and diarrhoea and in severe cases infection may lead to death (Pakandl and Hlaskova 2007, Pakandl 2009, Papeschi *et al* 2013, El-Ashram *et al* 2019). Previous literature reported that coccidiosis has been associated with secondary bacterial and viral infections, which were common causes of mortality (Taylor *et al* 2003, Dorota *et al* 2012, Aboelhadid *et al* 2021). Rashwan and Marai (2000), Bortoluzzi et al (2019) and Madlala *et al* (2021) postulated that the coccidian infection may enhance the proliferation of Gram-negative bacteria of the family Enterobacteriaceae in the gut. Bacterial infections in rabbits can negatively affect the body condition and cause high mortality, especially at young ages (Zahraei *et al* 2010).

Escherichia coli (*E. coli*) is a common commensal bacterium of the gastrointestinal tract of warm-blooded animals. However, in an immune-suppressed host, certain *E. coli* strains become virulent and cause diarrheal and extraintestinal diseases (Croxen *et al* 2013). Hamed *et al* (2013) reported hemorrhagic colitis and diarrhoea in newborn New Zealand rabbits infected with *E. coli.* Also, *Salmonella enterica* infection in rabbits is considered a potential risk associated with this animal species (Suelam and Reda 2015). Its occurrence among domestic rabbits is probably variable (Rodriguez-Calleja *et al* 2006). According to Lim *et al* (2012), the prevalence of *Salmonella* species in rabbits ranged from 6 to 9%. It can occasionally cause a severe disease condition with a high mortality rate (Suelam and Reda 2015).

Antimicrobial therapy is one of the worldwide primary controls for the reduction of both incidence and mortality associated with bacterial diseases including colibacillosis and Salmonellosis in poultry (Hassan *et al* 2018, Radwan *et al* 2021). *In-vitro* antimicrobial susceptibility tests

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provide valuable guidance in the choice of appropriate drug treatment (Radwan *et al* 2021) and are very useful for detecting the MDR isolates. Recently, the phenomenon of antimicrobial resistance has evolved and spread out in large geographic areas. Therefore, the appropriate antimicrobials should be selected based on their susceptibility which could be detected by laboratory examination. Also, the challenge of antimicrobial resistance has increased the importance of searching for new compounds as alternative antimicrobials. Therefore, considerable effort has been devoted to investigating natural products to discover and develop new antimicrobial agents that are effective, easily accessible and affordable, with less side effects.

Prebiotics are non-digestible food components that promote the growth of beneficial bacteria in the digestive system and the host defence against infections (El-Abasy 2002, Sohail *et al* 2012). It was also observed that prebiotic consumption reduced the establishment of *Salmonella* in the course of hen moulting (Donalson *et al* 2008). Abdelhady and El-Abasy (2015) found that dietary supplementation of prebiotic and probiotic reduced mortality and overcame the adverse clinical signs in rabbits experimentally infected with *Pasteurella multocida*. Bio-Mos®, a prebiotic used in the animal husbandry industry, exhibited a suppressing effect on enteric pathogens and modulated the immune response of chickens and turkeys (Waldroup *et al* 2003, Kocher *et al* 2005). Mannan-oligosaccharide is now widely accepted as one of the most effective alternatives to antibiotics and growth promoters (Ferket *et al* 2002).

The present study aimed to investigate the effects of mannan-oligosaccharide (MOS) prebiotic supplementation on the coexistence of *E. coli* and *Salmonella* species in rabbits naturally infected with intestinal coccidiosis.

MATERIAL AND METHODS

The study was carried out on a rabbit farm at Sedes Station of Animal Production and Agriculture Research, Beni-Suef, Egypt. A total of 45 V-Line breed weaned rabbits, male and female, aged 30 to 35 days were selected for the experiment. Out of the 45 rabbits, 30 were naturally infected with intestinal coccidiosis (with the same average of oocyst count) and 15 were coccidian free. The infected rabbits showed the clinical signs of intestinal coccidiosis, e.g. diarrhoea, inappetence, abdominal bloating, and weight loss. These signs of coccidiosis were confirmed by detection and counting the oocysts in faeces by McMaster slide. All rabbits were examined individually and rabbits with oocyst count over 2.5×10^4 oocysts per gram faeces (OPG) were considered diseased according to Ogolla *et al* (2018). Each rabbit was housed in an individual wire mesh cage with optimum conditions and fed *ad libitum* with commercial rabbit feed (anticoccidial free). The clinically infected rabbits (n=30) were divided into two groups of 15 rabbits each; the first group was kept with no treatment and served as the positive control group (PC) while the second group was treated with prebiotic and served as the prebiotic treated group (PT) at a dose of 2 g/L for 8 successive days. The uninfected rabbits (n=15) served as the negative control group (NC). On day 8 post treatment, 5 rabbits from each group were humanely slaughtered for microbiology examination. The rabbits were handled and euthanised with the least distressful method which was cervical dislocation because they were not heavy weight (Walsh *et al* 2017). Death was verified by lack of breathing, lack of palpable heartbeat and fixed dilated pupil.

The study was approved by the ethical committee of Beni-Suef University (BSU- 0365/2018), Egypt. The used prebiotic was mannan-oligosaccharide (MOS) which derived from the cell wall of *Saccharomyces cerevisiae* (Bio-Mos®, Alltech, Nicholasville, USA).

FAECAL SAMPLE COLLECTION AND ESTIMATION OF OOCYST COUNT

Fresh faeces of each rabbit were collected daily during the course of treatment in all groups and the faecal oocyst count was estimated per gram of faeces using McMaster chamber according to Schito *et al* (1996). In brief, faecal pellets were weighed and diluted 10- fold in 2.5% potassium dichromate (w/v). For oocyst flotation, the mixture was vortexed and diluted in saturated sodium chloride. Finally, 300-µl of this dilution was loaded into the McMaster chamber, where the oocysts were allowed to float free of debris for 3-5 minutes before being counted. The diagnosis of different encountered *Eimeria* species was based on the descriptions mentioned by Eckert *et al* (1995). The following coccidian species were confirmed in the infected rabbits; *E. media, E. magna, E. intestinalis, E. flavescens and E. perforans.*

INTESTINAL SAMPLES AND BACTERIOLOGICAL EXAMINATION

Samples. Intestinal swabs were collected from the jejunum, ileum, and cecum of all euthanised rabbits (15 in total, 5 from each group). Accordingly, a total of 45 intestinal swab samples (15 from each group) were collected aseptically for bacteriological examination and screening of the presence of *E. coli* and *Salmonella* spp. The collected samples were transferred promptly, in an ice tank, to the microbiology laboratory.

Bacteriological isolation. Escherichia coli was isolated according to the protocol described by Radwan *et al* (2021). The collected samples were aseptically inoculated into MacConkey's broth and incubated aerobically at 37˚C for 24 hrs. Then, a loopful of each broth cultures was streaked onto tryptone soy agar and MacConkey's agar and incubated aerobically at 37˚C for 24-48hr. The lactose fermenting (pink) colonies were inoculated onto

eosin methylene blue (EMB) agar medium and incubated at 37˚C for 18-24 hrs.

Salmonella was isolated according to the protocol described by Hassan *et al* (2018). The collected samples were inoculated into selenite-F broth and incubated at 37C for 18-24 hrs. Then, a loopful of each culture was streaked out onto MacConkey's agar then the non-lactose fermenter (pale) colonies were streaked onto xylose lysine deoxycholate (XLD) and Salmonella-Shigella (SS) agar media and incubated at 37C for 18-24 hrs.

IDENTIFICATION OF *E. coli* AND *Salmonella* ISOLATES

Morphological and biochemical identification. All the recovered isolates were identified by microscopic examination of Gram's stained smears, colonial morphology and biochemical tests according to Collee *et al* (1996) and Quinn et al. (2002) using the following tests; oxidase, catalase, urease, H_2S production on TSI, and citrate utilisation. Moreover, a motility test in semisolid agar was applied.

Identification by using API20E kit. Escherichia coli and *Salmonella* isolates were also confirmed biochemically by using the API 20E system (BioMérieux, Marcy-l'Étoile, France) according to the manufacturer's instructions. Bacterial strains fully identified by the Department of Bacteriology, Mycology, and Immunology, Faculty of Veterinary Medicine, Beni-Suef University, Egypt were used as a positive control in API kits.

SEROLOGICAL IDENTIFICATION OF BACTERIAL ISOLATES

Serogrouping of E. coli isolates. Escherichia coli isolates were serogrouped by slide agglutination test using standard polyvalent and monovalent *E. coli* antisera according to Quinn *et al* (2002).

Serotyping of Salmonella. Salmonella isolates were serotyped by slide agglutination test using diagnostic polyvalent and monovalent O and H *Salmonella* antisera following the Kauffman-White- Le Minor scheme (Grimont and Weill 2007).

ANTIMICROBIAL SUSCEPTIBILITY TESTING

All *E. coli* and *Salmonella* isolates were tested for their antimicrobial susceptibility to 14 different antimicrobial discs (Oxoid, Basing Stoke, UK) including; amoxicillin (10 µg), neomycin (15µg), tetracycline (30µg), sulphamazole-trimethoprim (25µg), nalidixic acid (30 µg), gentamicin (10µg), levofloxacin (5µg), florfenicol (30µg), colistin sulphate (10µg), ciprofloxacin (5µg), amikacin (30µg) and flumequine (25µg). An antimicrobial susceptibility test was applied using the disc diffusion method on Muller Hinton agar according to CLSI (2016). The antimicrobial susceptibility was based on the induced inhibition zones according to the guidelines of the CLSI (2016). Resistance to three/or more antimicrobials of different categories was taken as multidrug resistance (MDR) according to Chandran *et al* (2008).

STATISTICS

The data were summarised using a descriptive frequency and percentage for quantitative values. The relationship between data were tested by the Chi-square test for quantitative variables, and *p*-values were calculated. The oocysts per gram of faeces (OPG) were statistically analysed using ANOVA tests and subsequent Duncan's multiple range tests. Results were expressed as means ± SE. Probability of values less than 0.05 ($P \leq 0.05$) was considered significant.

RESULTS

FAECAL OOCYST COUNT AND PREVALENCE OF *E. coli* AND *Salmonella* ISOLATIONS IN DIFFERENT GROUPS

Faecal oocyst count revealed a gradual reduction from day zero (day of treatment) until day 8 post treatment in PC and PT groups. There was a significant ($P \leq 0.05$) decrease in oocyst count ($5.33 \pm 0.89 \times 10^3$) in rabbits treated with prebiotic (PT) when compared with those non-treated (PC) ($21.67 \pm 0.82 \times 10^3$) (figure 1). Meanwhile, the NC group revealed no oocysts in the faeces (table 1). During the period of treatment, the clinical signs were less severe

Table 1. Prevalence of *E. coli* and Salmonellae isolation in the examined rabbit samples in different groups.

Group	No. of samples	*E. coli* isolation		*Salmonella* isolation		X^2 (df)	P*
		No.	%	No.	%	22.003 (2)	0.000
Negative control (NC)	15	7	46.7	0	0		
Positive control (PC)	15	13	86.7	7	46. 7		
Prebiotic treated (PT)	15	10	66.7	4	26.7		
Total	45	30	66.7	11	24.4		

%: was calculated according to the number (No.) of tested isolates (n=30).
X^2: Chi-square. df: degree of freedom. * $P \leq 0.05$ is significant.

in the PT group than in the PC group. Rabbits in the PT group suffered from watery diarrhoea. However, rabbits in the PC group displayed diarrhoea with mucus, bloating, inappetence, and dullness. The rabbits in the NC group appeared normal with no clinical signs of disease.

On the other hand, the overall prevalence of *E. coli* and *Salmonella* isolates was 66.7% and 24.4%, respectively (table 2). The results showed a significant reduction in the prevalence ($P \leq 0.05$) of *E. coli* and *Salmonellae* isolates in rabbits of the PT group when compared with those of the PC group. In the PC group, 13 *E. coli* and 7 *Salmonellae* isolates were recovered with a prevalence of 86.7% and 46.7%, respectively. Meanwhile, 10 *E. coli* and 4 *Salmonellae* isolates were detected in the PT group with a prevalence of 66.7% and 26.7%, respectively. Regarding the NC group, only 7 *E. coli* isolates with a prevalence of 46.7% were found with no detection of any *Salmonellae*.

SEROLOGICAL IDENTIFICATION OF BACTERIAL ISOLATES

Serogrouping of E. coli isolates and their distribution in different organs. Out of 30 *E. coli* isolates, 7 O-serogroups were identified and O_{78} was the most prevalent representing 36.7% (table 3). The distribution of *E. coli* serogroups (n=30) in the different organs in all groups is shown in table 4.

Serotyping of Salmonella isolates and their distribution in different organs. Out of 11 *Salmonella* isolates, 3 *Salmonella enterica* Subsp. enterica serotypes were identified. The serotype *S. Macclesfield* was the most prevalent with 5 isolates representing 45.5% (table 5). The distribution of *Salmonella enterica* serotypes (n=11) in different organs in all groups is shown in table 5. No *Salmonella* isolates were recovered from rabbits in the NC group.

ANTIMICROBIAL SUSCEPTIBILITY TESTING OF *E. coli* AND *Salmonellae* RECOVERED FROM THE RABBITS INTESTINAL SAMPLES

Results of *in vitro* susceptibility testing showed that *E. coli* isolates were highly resistant to most of the tested antimicrobials and completely resistant to neomycin (100%) (table 6). Meanwhile, moderate sensitivities were recorded against colistin sulphate (50%) followed by ciprofloxacin (43.3%) and amikacin (40%) (table 6). MDR was detected in 27 *E. coli* isolates (90%).

On the other hand, *Salmonella* isolates (n=11) were highly resistant to sulphamethoxazol-trimethoprim and

Table 2. Serogroups of *E. coli* recovered from the intestinal tissue samples of the examined rabbits.

E. coli serogroups	No. of isolates	%
O_{78}	11	36.7
O_{125}	6	20
O_{152}	4	13.3
O_{158}	3	10
O_{114}	2	6.7
O_{115}	2	6.7
O_{168}	2	6.7
Total	30	100

%: was calculated according to the total number (No.) of isolates (n=30).

Table 4. Serotypes of *Salmonellae* recovered from the intestinal tissue samples of the examined rabbits.

Salmonella serotypes	No. of isolates	%
S. Macclesfield	5	45.5
S. Canada	3	27.3
S. Kisangani	3	27.3
Total	11	100

%: was calculated according to the total number (No.) of isolates (n=11).

Table 3. Distribution of *E. coli* serogroups in different organs in different groups.

Group	*E. coli* serogroups	Organ of isolation	No. of isolates	%
NC	O_{152}	Ilium	4	13.3
	O_{115}	Caecum	2	6.7
	O_{125}	Jejunum, Ilium and caecum	1	3.3
PC	O_{78}	Jejunum and Ilium	7	23.3
	O_{158}	Jejunum	3	10
	O_{125}	Jejunum, Ilium and caecum	2	6.7
	O_{114}	Jejunum	1	3.3
PT	O_{78}	Jejunum and Ilium	4	13.3
	O_{125}	Jejunum, Ilium and caecum	3	10
	O_{168}	Caecum	2	6.7
	O_{114}	Jejunum	1	3.3
Total			30	100

%: was calculated according to the total number (No.) of isolates (n=30).

Table 5. Distribution of *Salmonella* serotypes in different organs in different groups.

Group	*Salmonella* serotypes	Organ of isolation	No. of isolates	%
NC	Negative	Negative	Negative	Negative
PC	*S.* Kisangani	Ilium	3	27.3
	S. Macclesfield	Caecum	2	18.2
	S. Canada	Ilium, Jejunum	2	18.2
PT	*S.* Macclesfield	Caecum	3	27.3
	S. Canada	Ilium, Jejunum	1	9.1
Total			11	100

%: was calculated according to the total number (No.) of isolates (n=11).

Table 6. Antimicrobial susceptibility testing of *E. coli* and Salmonellae recovered from the intestinal tissue samples of the examined rabbits.

Antimicrobial disc	Disc content (µg)	*E. coli* (n=30)						*Salmonella* (n=11)					
		R		I		S		R		I		S	
		No	%	No	No	%	No	No	%	No	%	No	%
Amoxicillin	10	20	66.7	7	23.3	3	10	8	72.7	3	27.3	0	0
Neomycin	15	30	100	0	0	0	0	3	27.3	8	72.7	0	0
Tetracycline	30	23	76.7	5	16.7	2	6.7	4	36.4	5	45.5	2	18.2
Sulfamethoxazole-trimethoprim	25	24	80	6	20	0	0	9	81.8	1	9.1	1	9.1
Nalidixic acid	30	20	66.7	7	23.3	3	10	7	63.6	4	36.4	0	0
Gentamicin	10	14	46.7	9	30	7	23.3	1	9.1	3	27.3	7	63.6
Levofloxacin	5	12	40	9	30	9	30	0	0	5	45.5	6	54.5
Florophenicol	30	25	83.3	4	13.3	1	3.3	9	81.8	2	18.2	0	0
Colistin sulphate	10	15	50	0	0	15	50	2	18.2	1	9.1	8	72.7
Ciprofloxacin	5	10	33.3	7	23.3	13	43.3	0	0	2	18.2	9	81.8
Amikacin	30	9	30	9	30	12	40	4	36.4	4	36.4	3	27.3
Flumequine	25	24	80	5	16.7	1	3.3	8	72.7	3	27.3	0	0

%: was calculated according to the corresponding number of the tested isolates.

florophenicol (81.2% for each) (table 6). Meanwhile, high sensitivity to ciprofloxacin (81.8%) was recorded (table 6). MDR was detected in 5 *Salmonella* isolates (45.5%).

DISCUSSION

Rabbits are highly susceptible to enteric pathogens mainly in the early days after weaning and that may be due to the unestablished intestinal microbiota and ill-developed digestive performance and the change in gut PH (Pakandl 2009).

Prebiotics are food ingredients that induce the growth or activity of beneficial microorganisms such as bacteria and fungi (Gibson *et al* 2010). Also, prebiotics and probiotics are well known for modulation of the immune system and improvement of gut health (Hess and Greenberg 2012, Raheel *et al* 2019). Therefore, the current study was planned to investigate the effects of mannan-oligosaccharide (MOS) supplementation on the coexistence of *E. coli* and *Salmonella* species in rabbits naturally infected with intestinal coccidiosis.

In the present work, at the 8th day post treatment with mannan-oligosaccharide (MOS), there was a significant ($P \leq 0.05$) decrease in both oocyst count ($5.33 \pm 0.89 \times 10^3$) prevalence of *E. coli* and *Salmonella* infections (66.7% and 26.7%, respectively) in rabbits treated with prebiotic (PT). Meanwhile, the infected untreated group (PC) displayed a significant increase in both oocyst count ($21.67 \pm 0.82 \times 10^3$) and the prevalence of *E. coli* and *Salmonella* infections (86.7% and 46.7%, respectively). On contrary, the negative control group (NC) displayed only *E. coli* infection with a prevalence of 46.7% with no detection for coccidian oocysts and *Salmonella*. Also, the clinical signs of intestinal coccidiosis were less severe in the PT group

than in the PC group. These results are consistent with Aboelhadid *et al* (2021) who found that the use of prebiotic as prophylaxis significantly reduced the prevalence of the *E. coli* and *salmonella* infection in rabbits experimentally infected intestinal coccidiosis and diminished the coccidian adverse effect. Pakandl (2009) reported that enteritis caused by coccidia is often accompanied by a marked increase in the number of *E. coli* and other pathogens in the host intestine and hence the interplay between pathogens may be important under field conditions. Similar findings were reported by Kimura *et al* (1976) as they found an increase in the number of Enterobacteriaceae members during caecal coccidiosis in chicken. Also, Baba *et al* (1992) suggested that infection with *E. tenella* can change the balance of competitive adherence of bacteria, allowing more colonisation of *S. Typhimurium* and *Clostridium perfringens*. Additionally, Taylor *et al* (2003) recorded a significant secondary bacterial infection following coccidian infection and subsequently the malabsorption syndrome caused damage to the intestinal mucosa.

MOS prebiotic was derived from the cell wall of *Saccharomyces cerevisiae* which have the ability to improve gastrointestinal health and performance when added to animal diets (Kocher *et al* 2004, Miguel *et al* 2004). Similarly, we found a significant reduction in the prevalence of *E. coli* and *Salmonella* in rabbits naturally infected with intestinal coccidiosis, with amelioration in the adverse effects of coccidiosis after administration of MOS prebiotic. Also, Szabóová *et al* (2012) observed a significant reduction in bacterial and *Eimeria* oocyst counts in the intestinal tract of rabbits administered a mixture of prebiotic and probiotic as dietary supplementation. In addition, El-Ashram *et al* (2019) found a significant reduction in the adverse effects of intestinal coccidiosis in rabbits after prebiotic supplementation. Brink *et al* (2006) found that the growth of many Gram-positive and Gram-negative bacteria was inhibited by the prebiotic treatment. Also, Tran *et al* (2018) demonstrated that prebiotic supplementation can inhibit enteropathogens such as *Salmonella* and *E. coli*. Interestingly, Murate *et al* (2015) realised that the prebiotic additive reduced the occurrence of *Salmonella* in laying hens but not for broilers. This means that the effects of prebiotic are not constant and more studies are needed to report longitudinal load measure for establishing that prebiotic treatment can decrease the prevalence of *E. coli* and/or *Salmonella*.

The serogrouping studies of *E. coli* isolates (n=30) revealed that the serogroup O_{78} was the most predominant with a prevalence of 36.7%, followed by serogroups O_{1125}, O_{152}, O_{158} with a prevalence of 20%, 13.3% and 10%, respectively, and then the serogroups O_{114}, O_{115} and O_{168} with a prevalence of 6.7% for each. These results were similar to those reported by Hassan and Abd Al Azeem (2009), Shahin *et al* (2011) and Hamed *et al* (2013).

In the current study, *E. coli* isolates were completely resistant to neomycin and highly resistant to most of the tested antimicrobials especially florophenicol, sulphamethoxazol-trimethoprim, flumequine, tetracycline, amoxicillin and nalidixic acid. Meanwhile, they were moderately sensitive to colistin sulphate, ciprofloxacin and amikacin. Regarding the high incidences of antimicrobial resistance of *E. coli* isolates in this study, these findings provided more support to the reports of many authors in Egypt (El-Shazly *et al* 2017, El-Seedy *et al* 2019, Radwan *et al* 2021) and worldwide (Makhol *et al* 2011, Xiaonan *et al* 2018). Therefore, no single antimicrobial drug was effective by 100% against *E. coli* isolates, which might be due to the development of resistance as a result of indiscriminate use of antimicrobials. Moreover, MDR was detected in 90% of *E. coli* isolates which is in agreement with Radwan *et al* (2014) as they recorded MDR in 90.4% of isolates.

On the other hand, *Salmonella* isolates were highly resistant to sulphamethoxazol-trimethoprim, florophenicol, amoxicillin, flumequine and nalidixic acid and MDR was detected in 45.5% of the tested isolates. Meanwhile, it revealed high sensitivities against ciprofloxacin, colistin sulphate, gentamicin and levofloxacin. Similar findings were recorded by many authors in Egypt (Ahmed *et al* 2009, Hassan *et al* 2018) and worldwide (Kumar *et al* 2009, Camarda *et al* 2012, Kim *et al* 2012, Albuquerque *et al* 2014, Agrawal *et al* 2016, Lamas *et al* 2016). Increasing the occurrence of MDR strains led to antibiotic treatment failure in both humans and animals with the transmission of antibiotic resistance to other bacteria (Suelam and Reda 2015).

In conclusion, the use of Mann prebiotic induced a significant reduction in the prevalence of *E. coli and Salmonella* and at the same time mitigated the adverse effect of coccidiosis in rabbits. *E. coli* isolates were highly resistant to most of the tested antimicrobials while *Salmonella* isolates showed variable resistance profiles. In addition, MDR was detected in 90% of *E. coli* isolates and 45.5% of *Salmonella* isolates.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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