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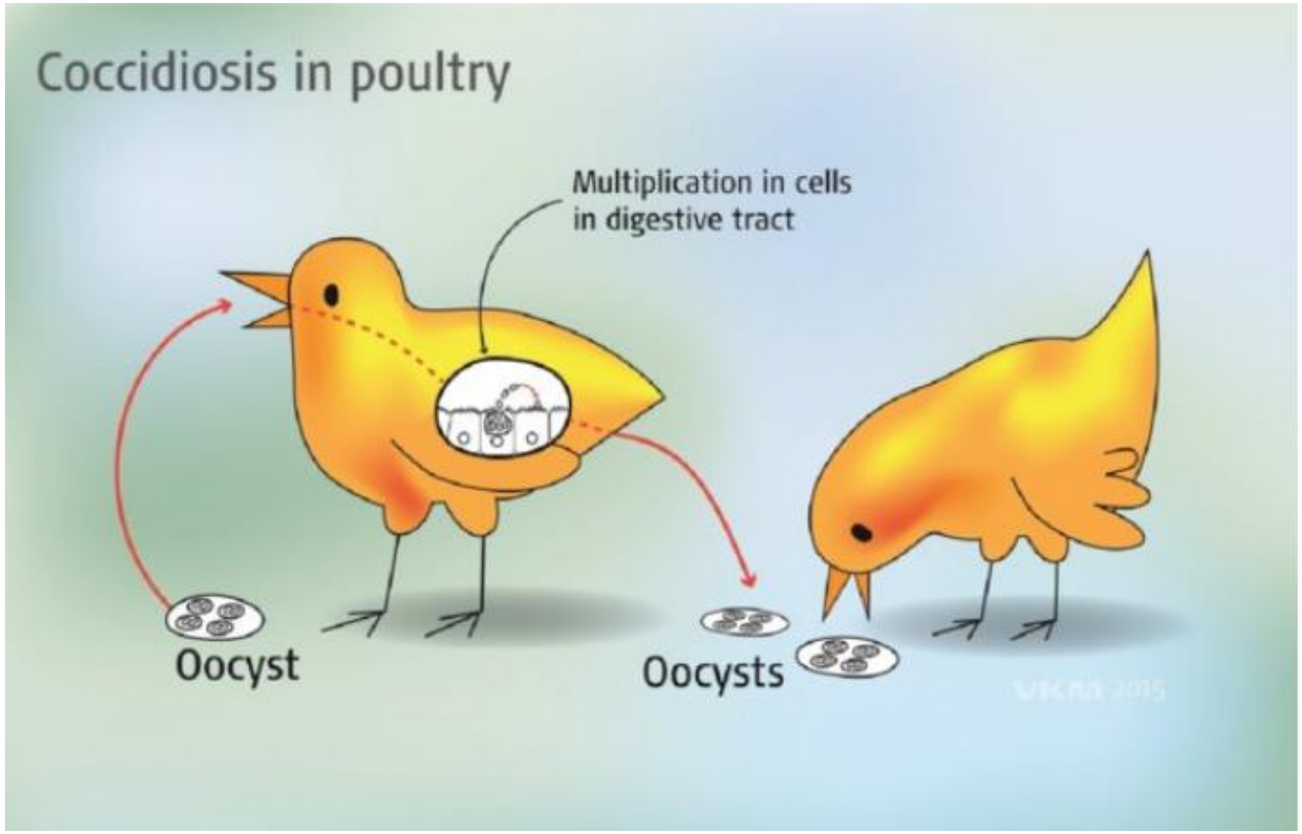
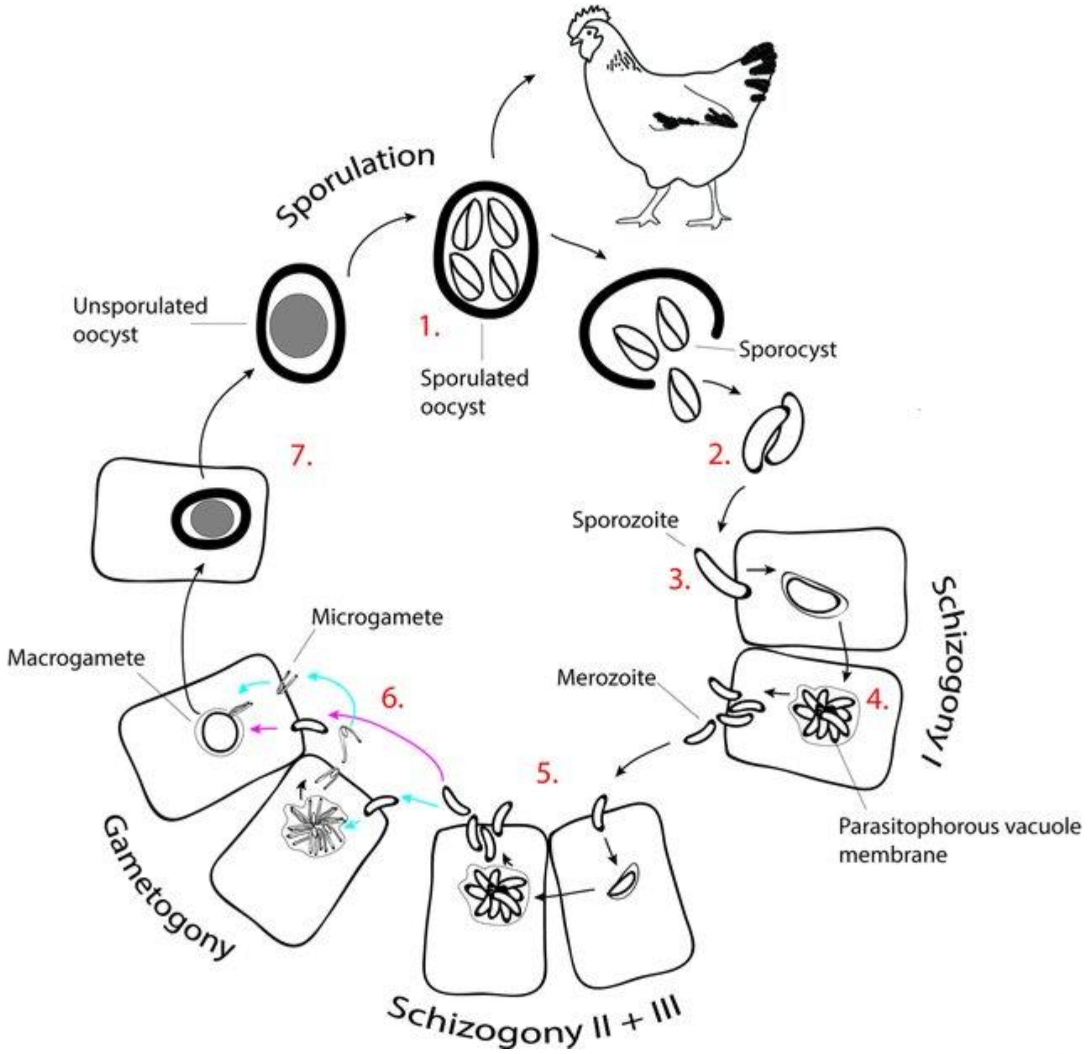
Coccidiostats in poultry – threats, challenges, and the future

Lidia Radko, DVM, Sci
Associate Professor at University of Life Sciences in Poznań

Coccidiosis



Life cycle of *Eimeria tenella*



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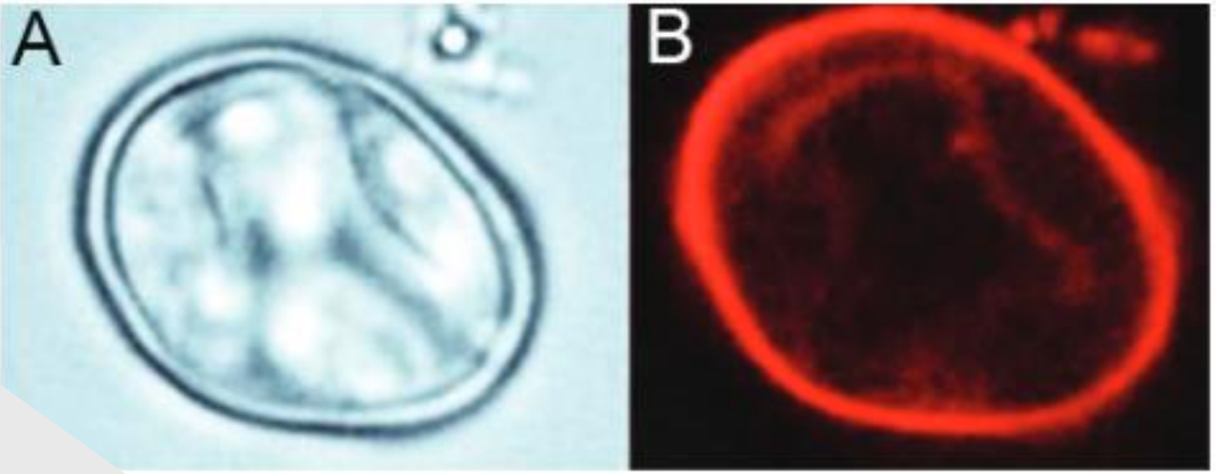
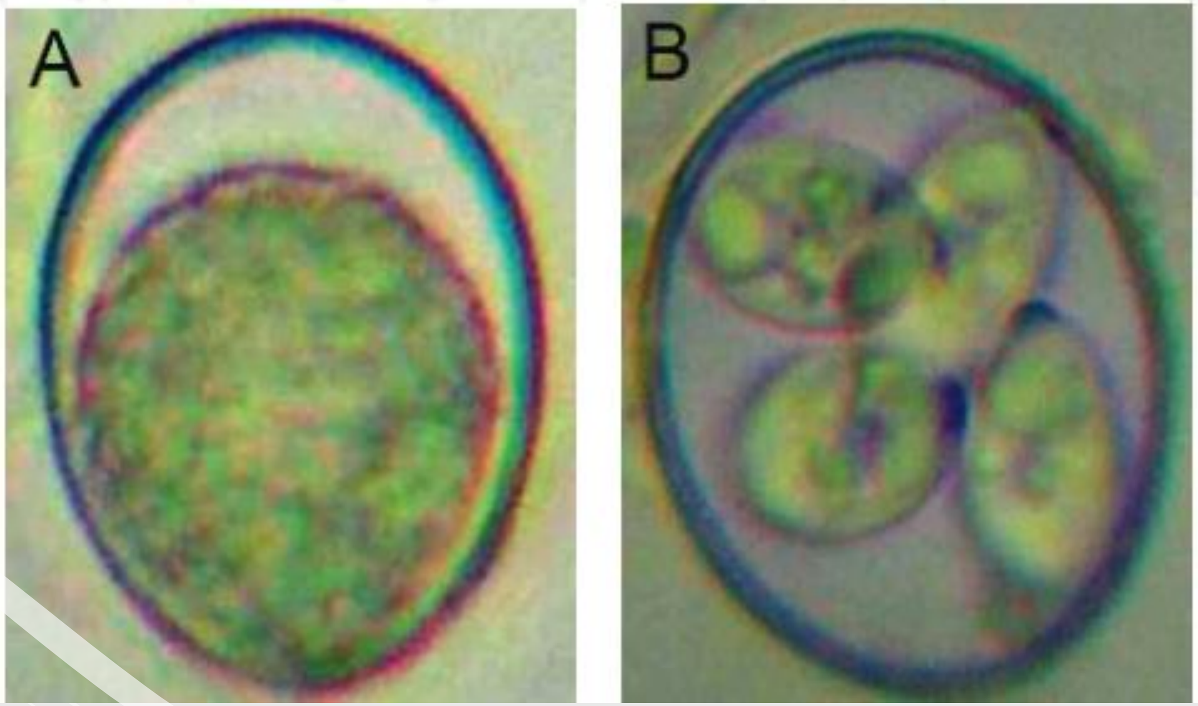
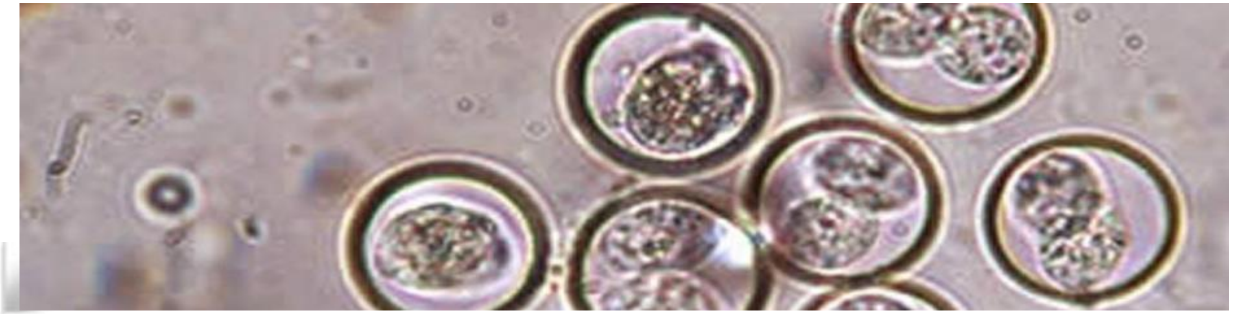
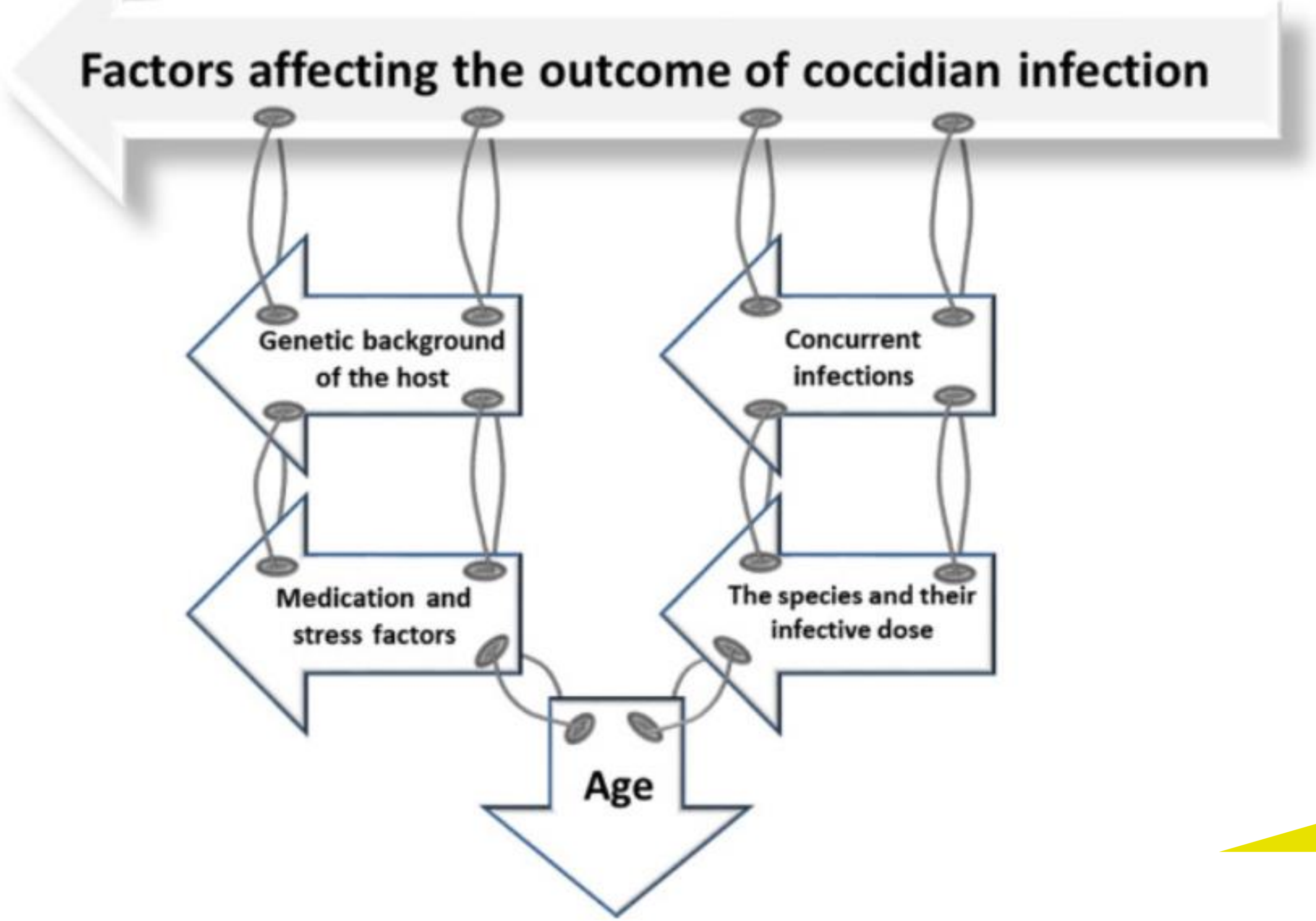
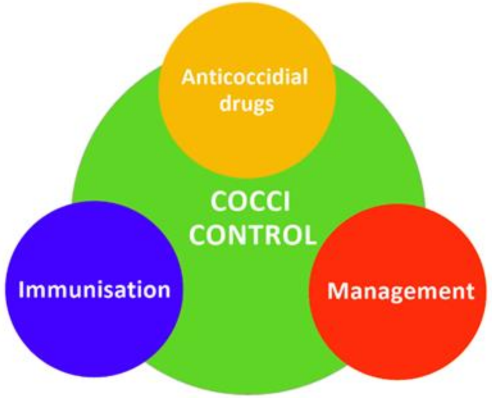

A
B


A
B

Coccidiosis







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Eimeria spp affecting chickens

Comparison of the seven known *Eimeria spp* affecting chickens

Species	Site of pathology	Lesion score	Oocyst morphology (size range = 15–30 μm)
E. tenella	Caeca 	High	Medium round
E. maxima	Mid small intestine 	Medium	Large oval
E. acervulina	Upper small intestine 	Medium	Small oval
E. necatrix	Mid small intestine 	High	Small-medium round
E. brunetti	Distal small intestine + colon 	High	Medium oval
E. mitis	Upper small intestine 	Low	Small round
E. praecox	Upper small intestine 	Low	Medium round

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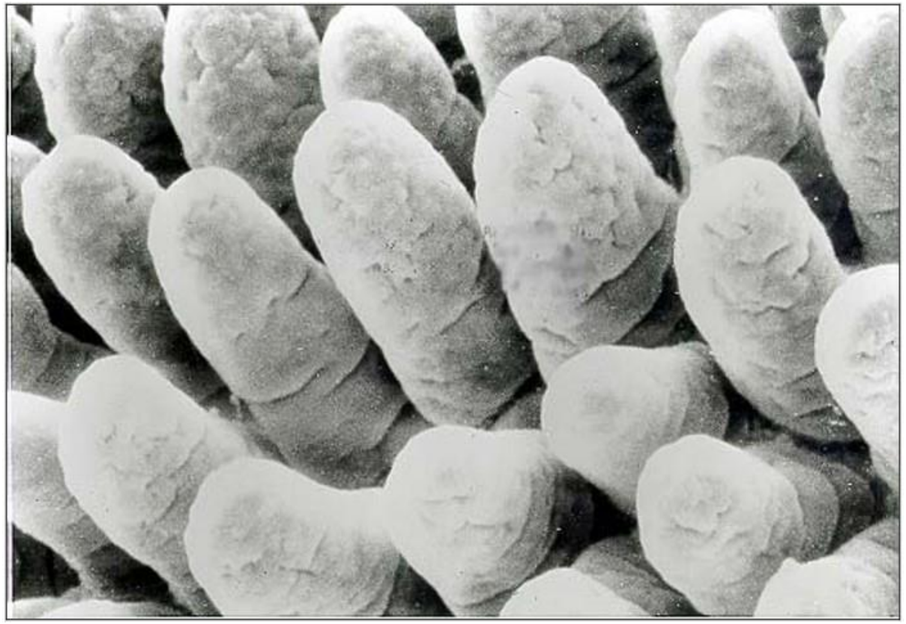
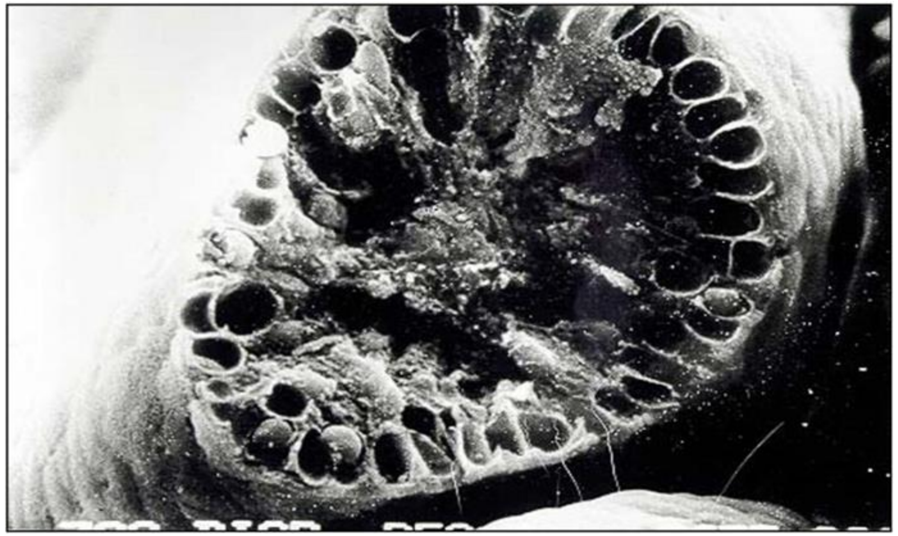


Scanning electron micrograph (approximately 650X) of ileum from uninfected 3-week-old turkey poult (photo provided by: P. Augustine)

Scanning electron micrograph (approximately 650X) of ileum from 3-week-old turkey poult infected with Eimeria adenoeides at 6 days post-inoculation (photo provided by: P. Augustine)



Scanning electron micrograph (approximately 650X) of intestine, fractured transversely, from 3-week-old turkey infected with Eimeria dispersa at 6 days post-inoculation

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Coccidiostat categories

Synthetic compounds

- decoquinate (DEC)
- diclazuril (DIC)
- halofuginone (HFG)
- nicarbazin (NIC)
- robenidine hydrochloride (ROB)

Ionophores

- monensin sodium (MON)
- lasalocid sodium (LAS)
- maduramicin ammonium (MAD)
- narasin (NAR)
- salinomycin sodium (SAL)
- semduramicin sodium (SEM)

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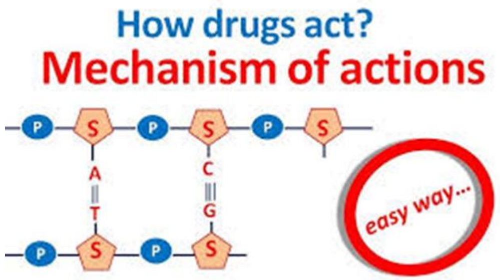
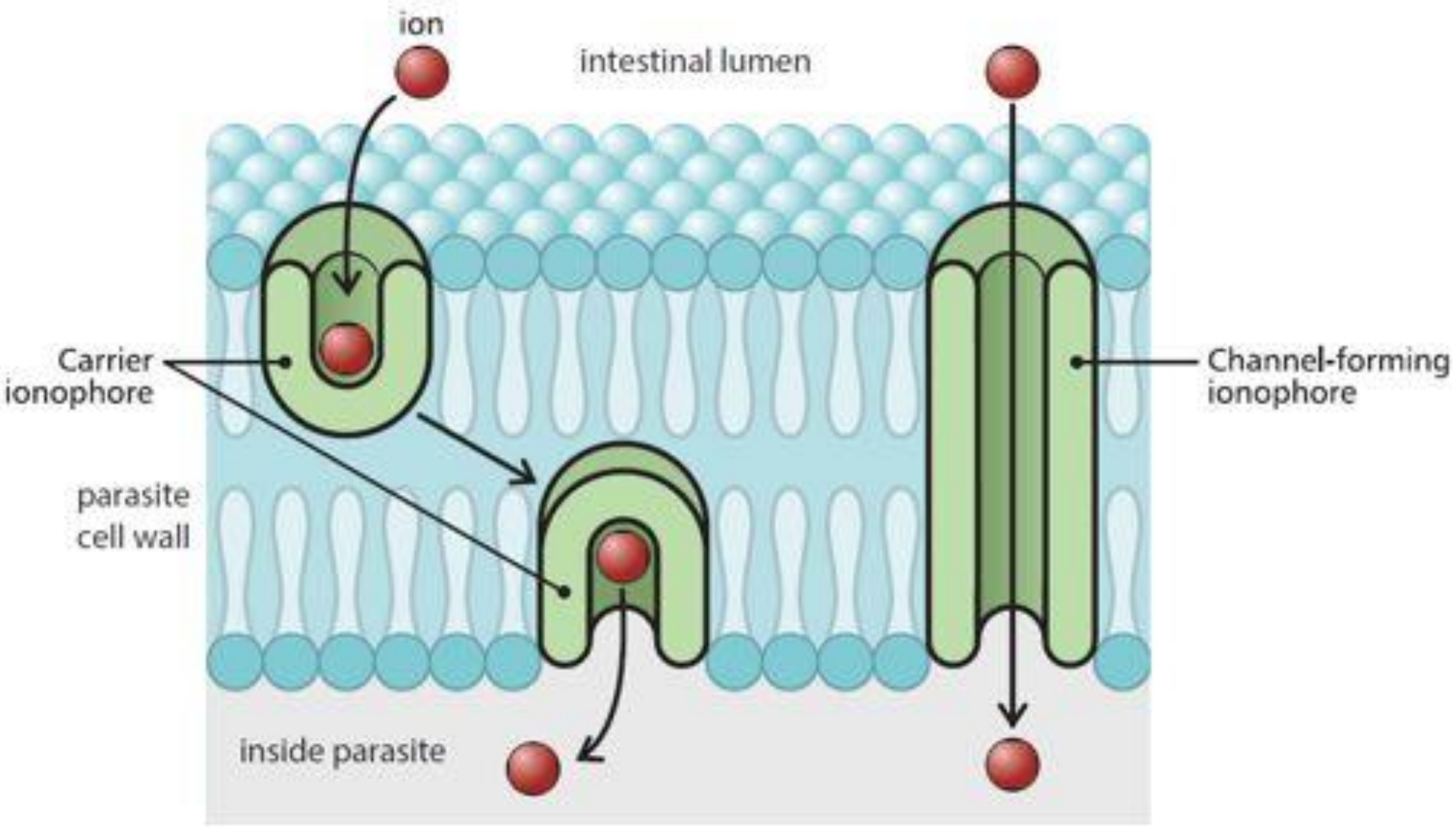
Coccidiosis treatment

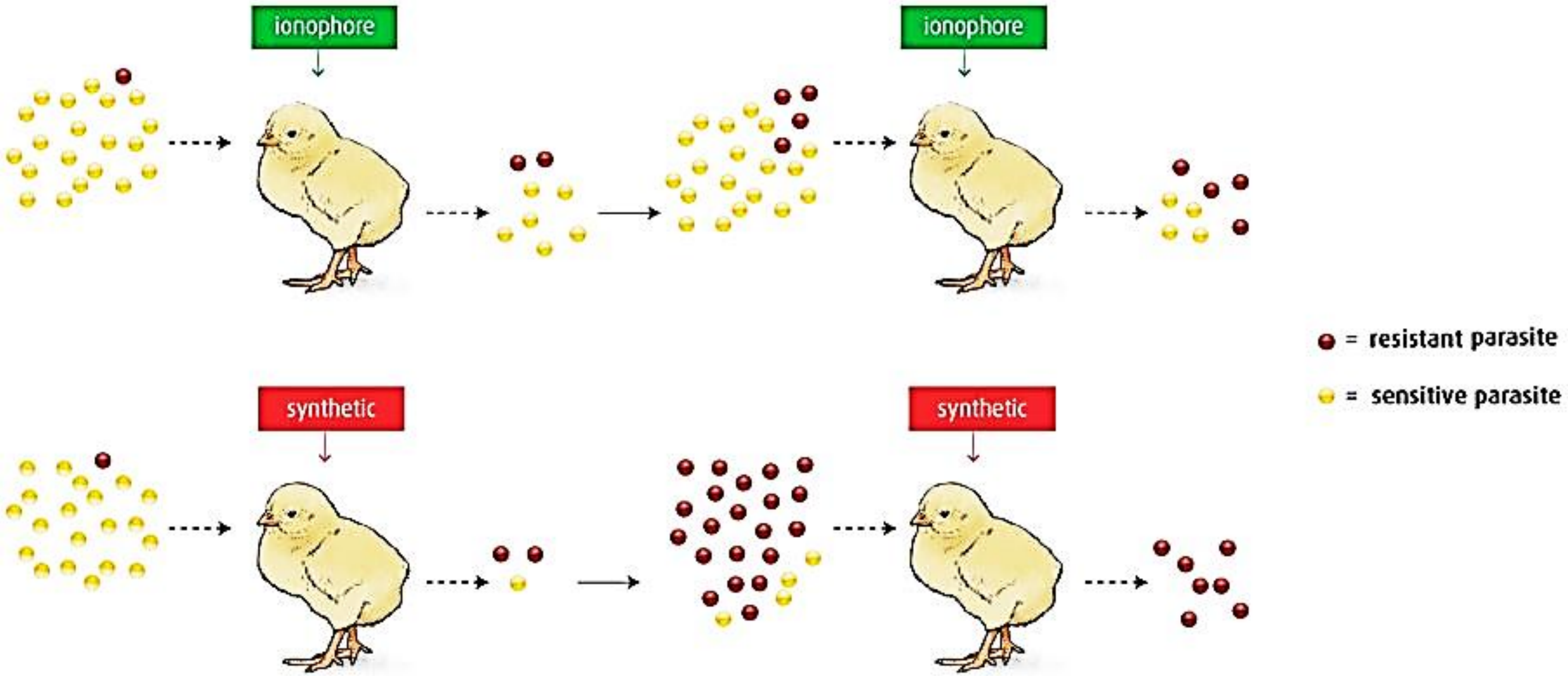


Treatment	Examples	Function
Ionophores	Lasalocid, Monensin, Narasinm Salinomycin, and Semduramicin	Disruption of ion gradient across the parasite cell membrane
Chemicals	Quinolone drugs (Decoquinate and nequinatem buquinolate).	Inhibition of parasite mitochondrial respiration
	Pyridones (Meticlorpindol)	
	Sulphonamides	Inhibition of the folic acid pathway
	Amprolium	Competitive inhibition of thiamine uptake
	Diclazuril, Halofuginone, and Robenidine	Mode of action unknown
	Nicarbazin	Inhibition of the development of the first and second generations of the schizont stage of the parasites

Ionophore


ion
intestinal lumen
Carrier
ionophore
Channel-forming
ionophore
parasite
cell wall
inside parasite

Resistance



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Resistance

Compound	Active substance	Antibacterial activity
Ionophores	Narasin	Mainly active against Gram-positive bacteria
	Lasalocid sodium	Active against Gram-positive bacteria, but not against Gram-negative bacteria.
	Monensin sodium	Mainly active against Gram-positive bacteria.
	Salinomycin sodium	Active against Gram-positive bacteria, but not against Gram-negative bacteria.
	Maduramicin ammonium	Active against Gram-positive bacteria, but not against Gram-negative bacteria.
	Semduramicin sodium	Has limited antibacterial activity against Gram-negative microorganisms tested, and a minimal activity against selected Gram-positive control organisms
Non ionophores	Robenidine hydrochloride	No known antibacterial effect
	Diclazuril	No substantial antibacterial activity
	Decoquinate	Most tested strains of bacteria appear resistant to the effects of decoquinate at concentrations of > 64 mg /-1, substantially higher than the concentration of decoquinate expected in the digestive tract
	Halofuginon	No known antibacterial effect
	Nicarbazin	No known antibacterial effect

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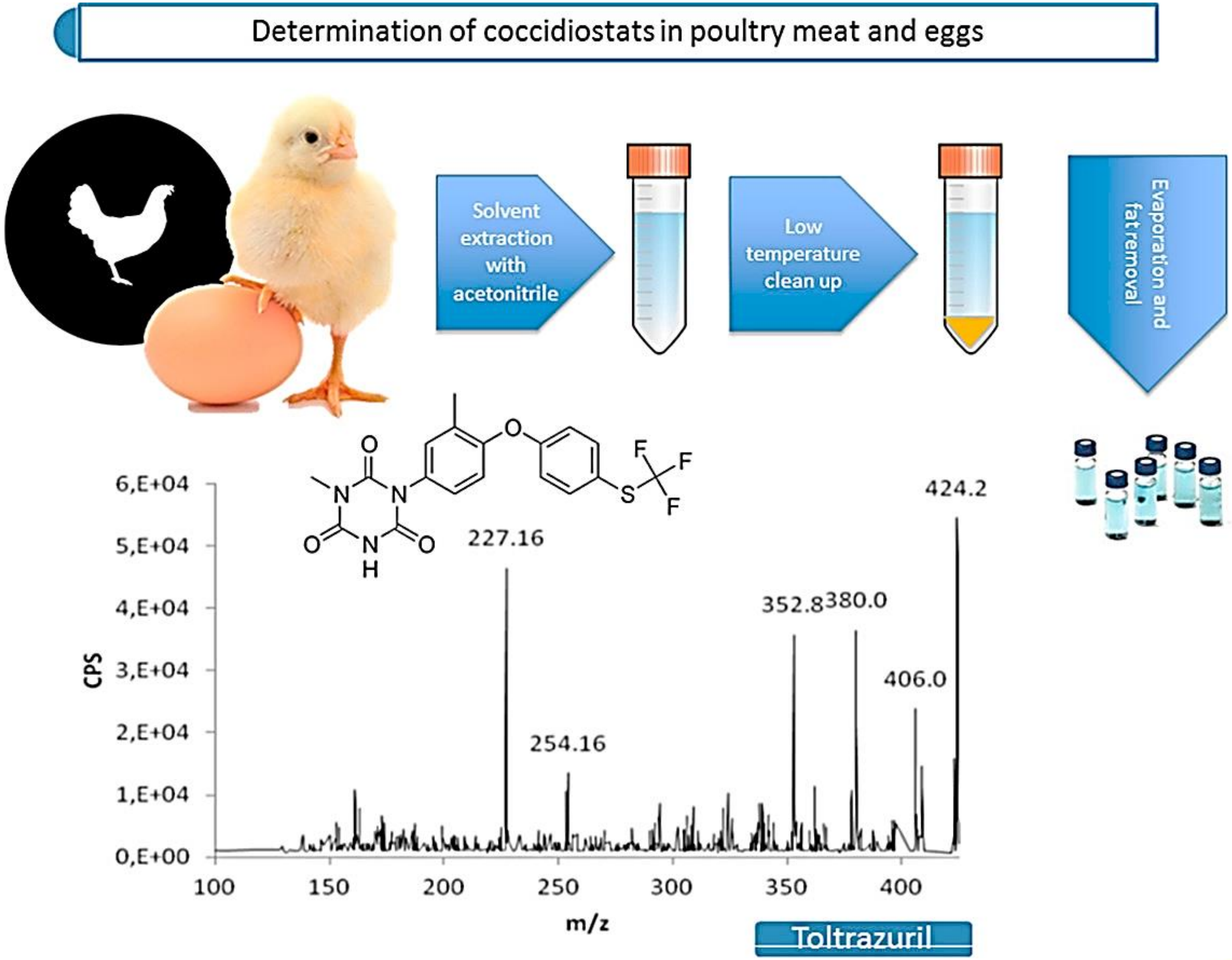
Residues


Determination of coccidiostats in poultry meat and eggs
Solvent extraction with acetonitrile
Low temperature clean up
Evaporation and fat removal
6,E+04
5,E+04
4,E+04
3,E+04
2,E+04
1,E+04
0,E+00
CPS
100
150
200
250
300
350
400
m/z
227.16
254.16
352.8
380.0
406.0
424.2
Toltrazuril

Residues

11.2.2009 L 40/7

Maximum levels in foodstuffs

Substance	Foodstuffs	Maximum content in µg/kg (ppb) wet weight
1. Lasalocid sodium	Food of animal origin from animal species other than poultry:	
	— milk;	1
	— liver and kidney;	50
	— other food,	5
2. Narasin	Food of animal origin from animal species other than chickens for fattening:	
	— eggs;	2
	— milk;	1
	— liver;	50
	— other food.	5
3. Salinomycin sodium	Food of animal origin from animal species other than chickens for fattening and rabbits for fattening:	
	— eggs;	3
	— liver;	5
	— other food.	2
4. Monensin sodium	Food of animal origin from animal species other than chickens for fattening, turkeys and bovine (including dairy cattle):	
	— liver;	8
	— other food.	2
5. Semduramicin	Food of animal origin from animal species other than chickens for fattening.	2
6. Maduramicin	Food of animal origin from animal species other than chickens for fattening and turkeys.	2

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Residues

Substance	Foodstuffs	Maximum content in µg/kg (ppb) wet weight
10. Nicarbazin	Food of animal origin from animal species other than chickens for fattening:	
	— eggs;	100
	— milk;	5
	— liver and kidney;	100
	— other food.	25
11. Diclazuril	Food of animal origin from animal species other than chickens for fattening, turkeys for fattening, rabbits for fattening and breeding, ruminants and porcine:	
	— eggs;	2
	— liver and kidney;	40
	— other food.	5
7. Robenidine	Food of animal origin from animal species other than chickens for fattening, turkey and rabbits for fattening and breeding:	
	— eggs;	25
	— liver, kidney, skin and fat;	50
	— other food.	5
8. Decoquinate	Food of animal origin from animal species other than chickens for fattening, bovine and ovine except dairy animals.	20
9. Halofuginone	Food of animal origin from animal species other than chickens for fattening, turkeys and bovine except dairy cattle:	
	— eggs;	6
	— liver and kidney;	30
	— milk;	1
	— other food.	3

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Toxicity of coccidiostats in poultry chicks and turkeys

	Max. licensed (mg/kg feed)	Chicken (mg/kg feed)	T/NT	Turkey	T/NT
Ionophoric coccidiostats					
Monensin	100–125	LOAEL 250	T	LOAEL 150	T
Lasalocid	125	NOAEL 150 LOAEL 345	T	NOAEL 375	T
Salinomycin	50–70	LOAEL 50[a]	T	LOAEL 13[b]	NT
Narasin	70	LOAEL 100	T	LOAEL 43[c]	NT
Maduramicin	5	LOAEL 5	T	LOAEL 10	T
Semduramicin	25	LOAEL 30	T	NOAEL 25	NT
Non-ionophoric coccidiostats					
Robenidine	36	LOAEL 300	T	LOAEL 750	T
Decoquinate	40	LOAEL 320	T	ND	NT
Nicarbazin	50	LOAEL 400	T	ND	NT
Diclazuril	1	NOAEL 25	T	NOAEL 25	T
Halofuginone	3	LOAEL	T	LOAEL 6	T

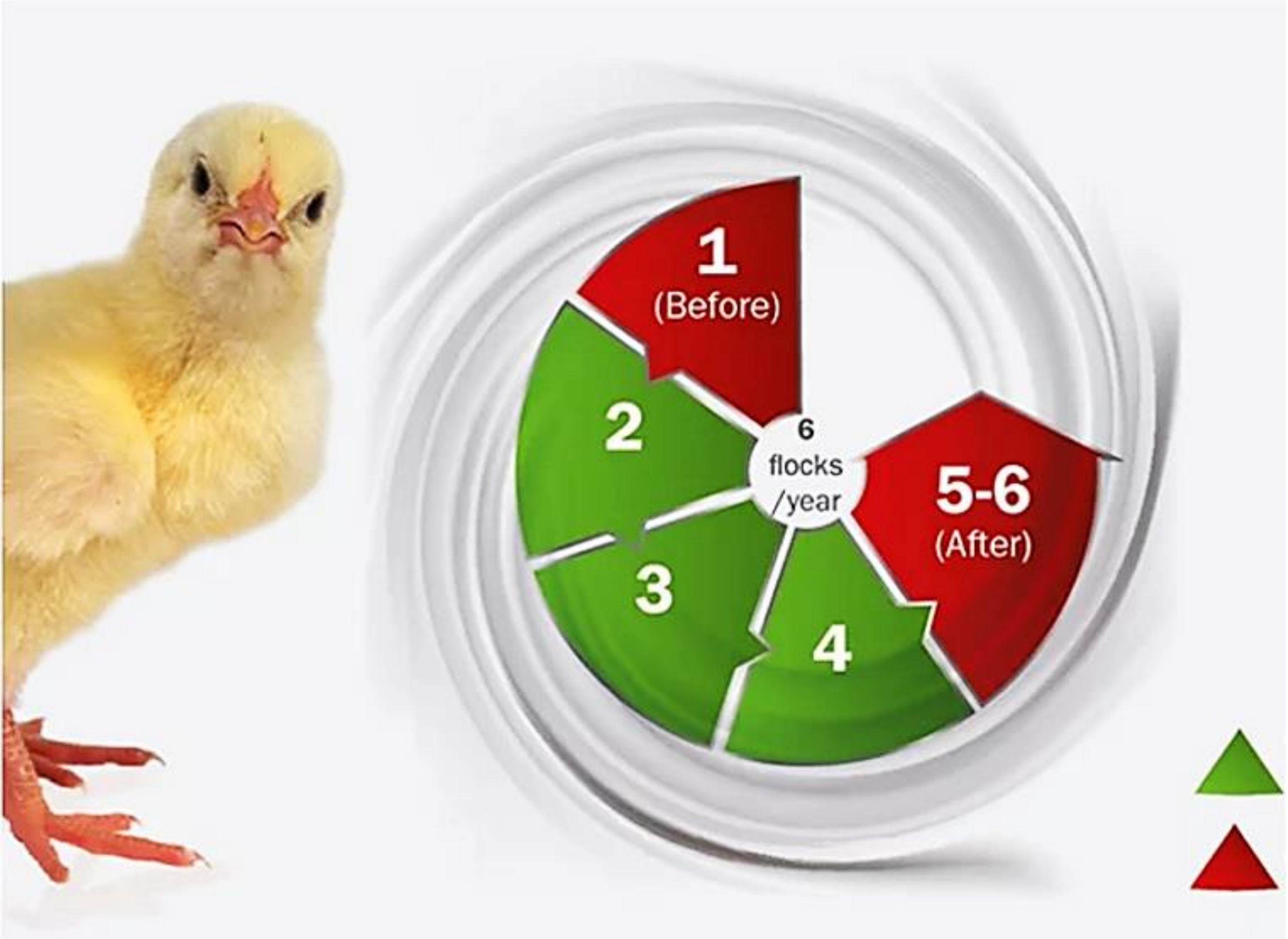
T — target animal species, NT non target animal species.

[a] Reduction of feed intake was the only adverse sign.

[b] At a concentration of 13–18 mg/kg feed mortality reached 16%.

[c] At a concentration of 43 mg/kg mg/kg feed, mortality exceeded 30%.

Vaccination



Vaccination

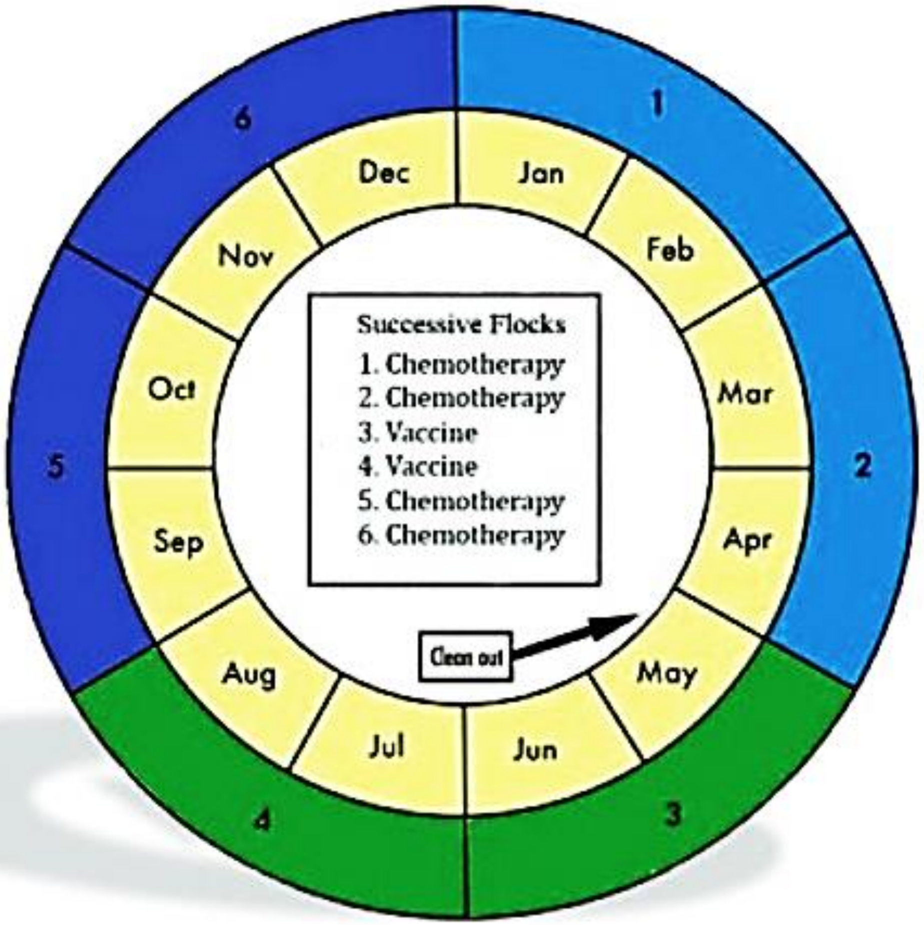


Figure 5. The proposal of use of chemotherapy and vaccines in a yearly chicken production. Figure taken from [17]. In the clean out period litter is removed. Chemotherapy comprises use of anticoccidial drugs.

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Recombinant vaccines against coccidiosis

Target Antigens	Source (*Eimeria* spp.)	Administration Route	Vectors	Immune Response or Effects on Chcikens
EF1-α/EF2 *	*E. acervulina*, *E. maxima*, *E. tenella*	Immunized subcutaneously	pcDNA3.1 (+)	Increased body weight gain, improved immune response, and decreased fecal oocyst shedding
SO7	*E. tenella*	Immunized intramuscularly	pcDNA3, pVR1012	Increased body weight gain, reduced oocyst shedding, and cecal lesion score
Gam82	*E. maxima*	Immunized intramuscularly	pET28a (+), pTRA-ERH	Improved immune responses, increased body weight gain, reduced oocyst shedding and gut pathology
Gam56	*E. maxima*	Immunized intramuscularly	pcDNA3.1(zeo)+	Improved immune responses, increased body weight gain, and decreased oocyst shedding
EtSAG4	*E. tenella*	Chest intramuscular injection	pET28a	Improved cell-mediated immunity, increased average body weight, and reduced oocyst output
α-tubulin	*E. acervulina*	Immunized subcutaneously	pGEM-T	Reduced duodenal lesions
GAPDH *	*E. acervulina*, *E. maxima* *E. tenella*	Immunized intramuscularly	pSDEP2AIMP1S	Improved immune response, reduced gut lesions, increased body weight gain, and decreased oocyst shedding
Em14-3-3 *	*E. maxima*	Immunized subcutaneously, oral immunization	pVAX1	Improved immune responses, decreased gut lesions, and increased body weight gain
IMP1	*E. maxima*	Oral immunization	pSDEP2AIMP1S, pGEMT	Increased body weight gain, reduced parasite replication and gut lesions
AMA1	*E. maxima*	Oral immunization	pSDEP2AIMP1S	Increased body weight gain, reduced *Eimeria* replication, and reduced gut lesions
Profilin (3-1E)	*E. acervulina*, *E. tenella*, *E. maxima*	in ovo immunization, immunized intramuscularly	pcDNA3.1 (+), pET32a (+), pSDEP2ARS,	Enhanced immunogenicity, increased body weight gain, and reduced gut pathology

* Indicates antigens that are common immunodominant proteins among *E. acervulina*, *E. tenella*, and *E. maxima*.

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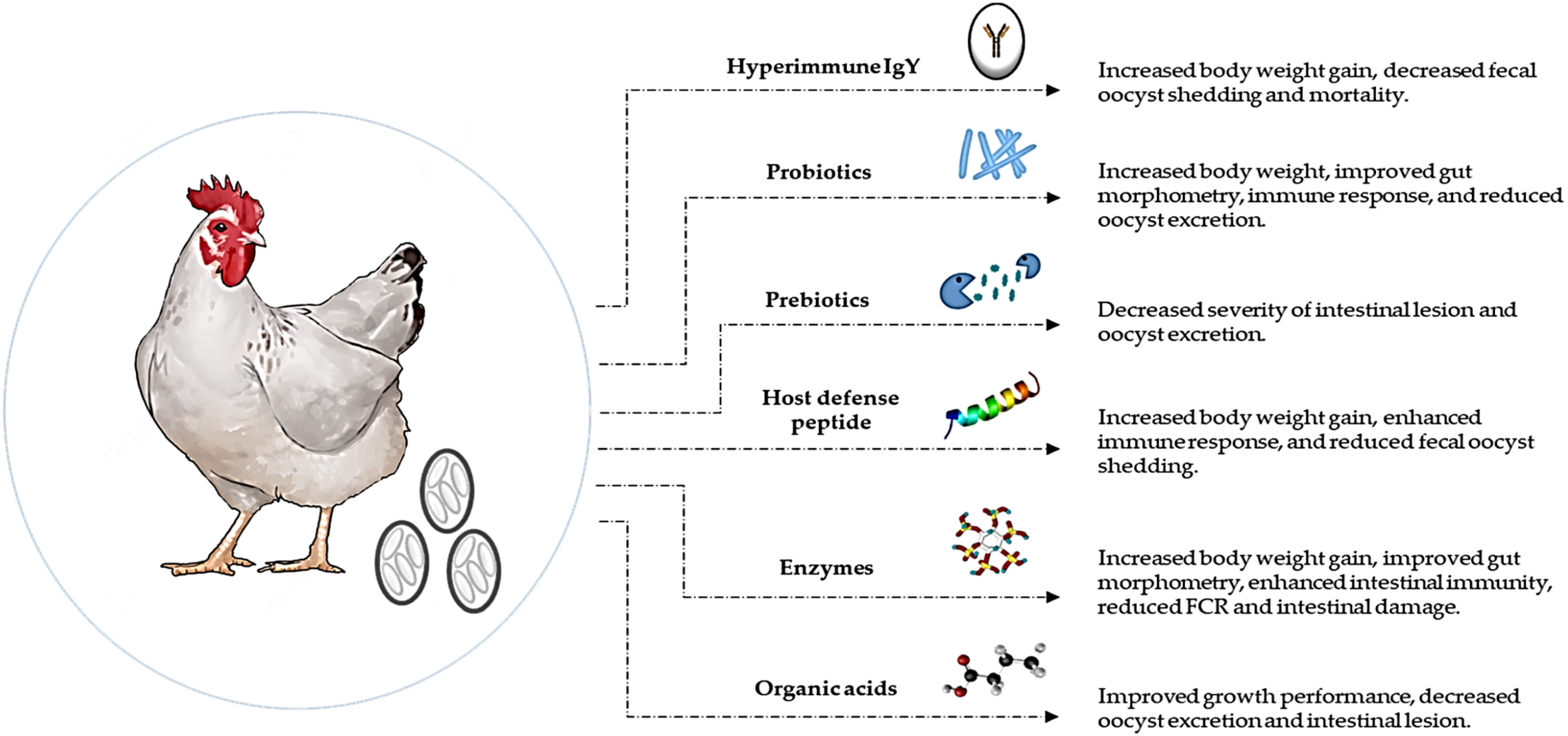
Alternatives to control coccidiosis in chickens



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Efficacy of *In Ovo* Delivered Prebiotics on Growth Performance, Meat Quality and Gut Health of Kuroiler Chickens in the Face of a Natural Coccidiosis Challenge

by Harriet Angwech [1,2,*], Siria Tavaniello [1], Acaye Ongwech [1,2], Archileo N. Kaaya [3] and Giuseppe Maiorano [1]

Coccidiosis: Recent Progress in Host Immunity and Alternatives to Antibiotic Strategies

by Youngsub Lee, Mingmin Lu and Hyun S. Lillehoj *

Animal Biosciences and Biotechnology Laboratory, United States Department of Agriculture, Agricultural Research Service, Beltsville, MD 20705, USA

ELSEVIER

The Effect of an in-feed Mannanoligosaccharide Preparation (MOS) on a Coccidiosis Infection in Broilers

M. A. Elmusharaf [1], H. W. Peek[2], L. Nollet[3], and A. C. Beynen[1]

[1]Department of Nutrition, Faculty of Veterinary Medicine, Utrecht University, the Netherlands
[2]Animal Health Service Ltd., Deventer, the Netherlands
[3]Alltech Biotechnology Centre, Dunboyne, Ireland

Animal Feed Science and Technology 134 (2007): 347-354.

Metabolism and Nutrition

Efficacy of in-feed preparations of an anticoccidial, multienzyme, prebiotic, probiotic, and herbal essential oil mixture in healthy and *Eimeria* spp.-infected broilers

M. Bozkurt *, N. Aysul †, K. Küçükyilmaz ‡, S. Aypak †, G. Ege *, A.U. Çatli *, H. Akşit §, F. Çöven #, K. Seyrek §, M. Çınar *

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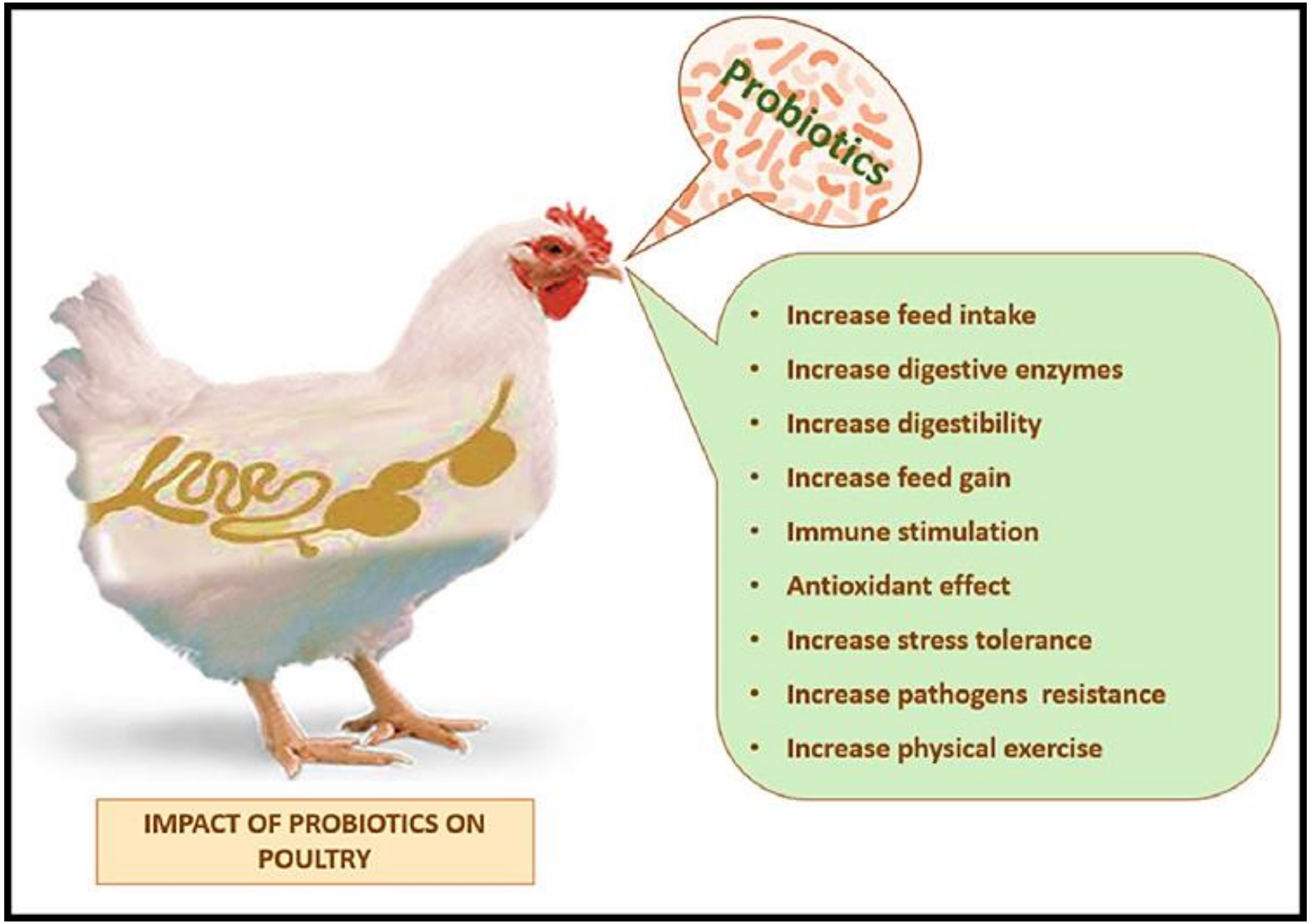
Probiotics



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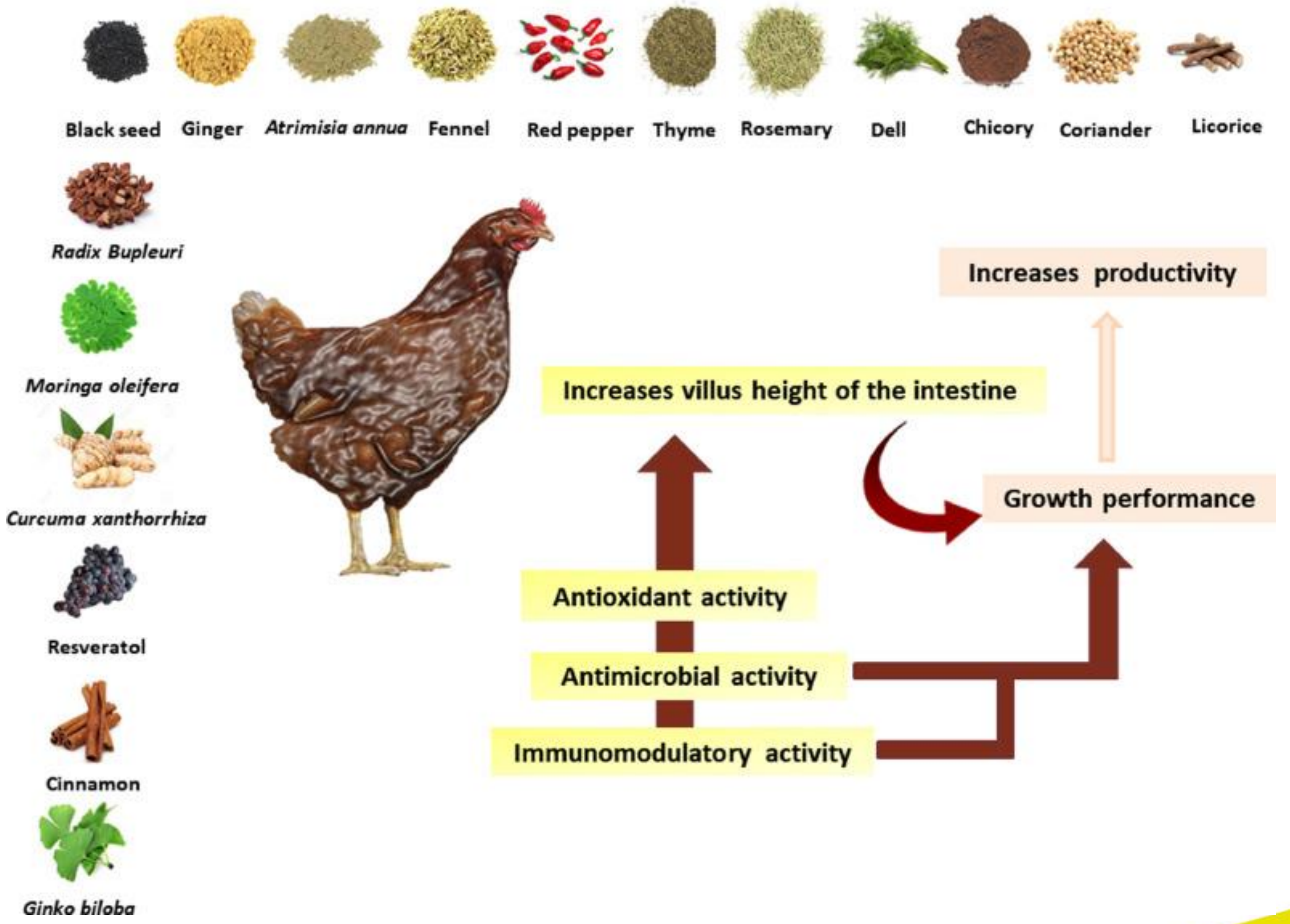
Herbs


Black seed
Ginger
Atrimisia annua
Fennel
Red pepper
Thyme
Rosemary
Dell
Chicory
Coriander
Licorice
Radix Bupleuri
Moringa oleifera
Curcuma xanthorrhiza
Resveratol
Cinnamon
Ginko biloba
Increases productivity
Increases villus height of the intestine
Growth performance
Antioxidant activity
Antimicrobial activity
Immunomodulatory activity

Plants – life cycle of Eimeria spp

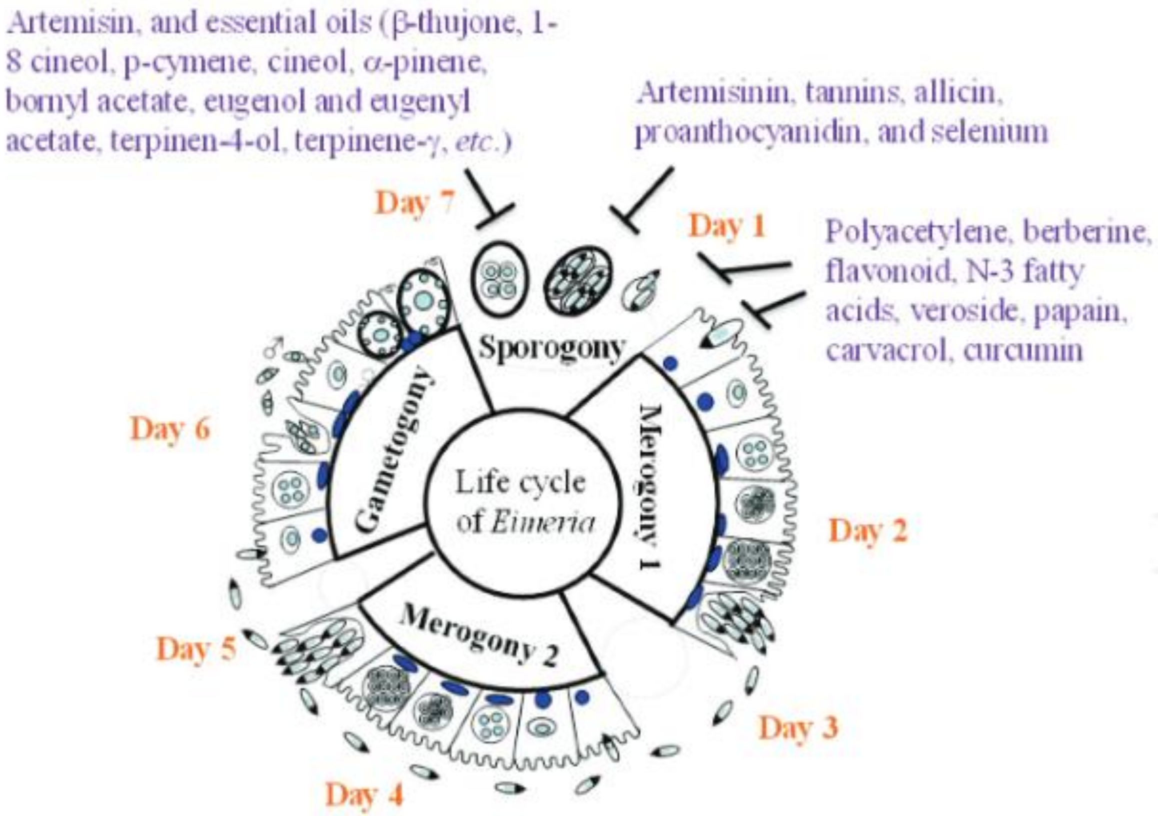


Figure 6. Plant compounds target different stages of life cycle of *Eimeria* species. Different phytocompounds inhibit the sporogony and merogony stages. Figure reproduced with permission from [32].

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Herbal derivatives

Fabaceae: *Sophora flavescens*, Gleditzia japonica
Menispermaceae: *Sinomenium acutum*;
Combretaceae: *Quisqualis indica, Ranunculaceae, Pulsatilla koreana*
Ulmaceae: *Ulmus macrocarpa*;
Asteraceae: *Artemisia asiatica*; *Artemisia sieberi; Artemisia afra*
Meliaceae: *Melia azedarach*;
Piperaceae: *Piper nigrum*;
Urticaceae: *Urtica dioica*,
Brassicaceae: *Lepidium sativum*;
Apiaceae: *Foeniculum vulgare*;
Rubiaceae: Morinda lucida;

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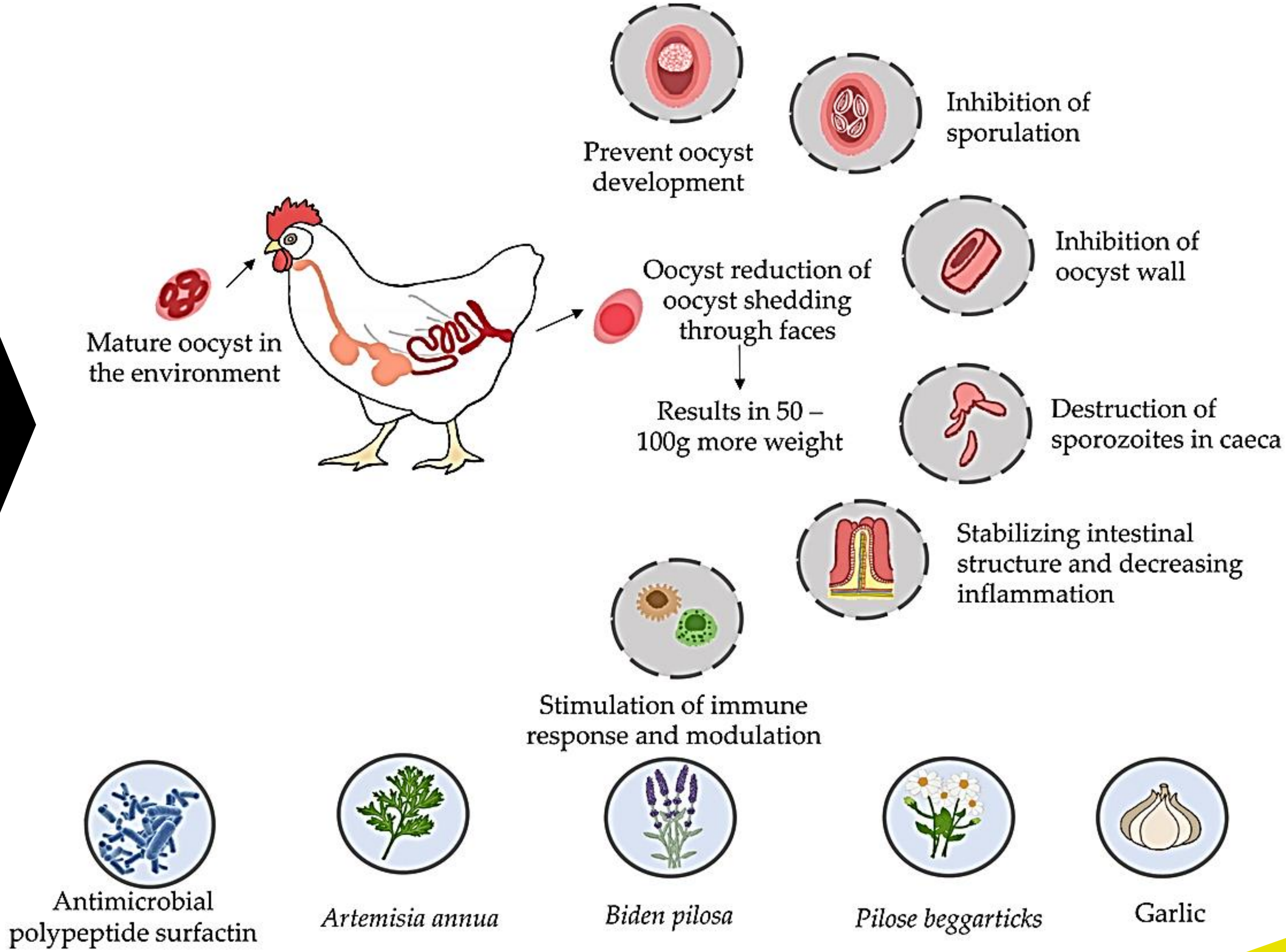
Herbal derivatives

Burseraceae: *Commiphora swynnertonii*,
Moringaceae: *Moringa oleifera, Moringa indica, Moringa stenopetala*;
Lamiaceae: *Origanum spp., Lavandula stoechas; Mentha arvensis*;
Lauraceae: *Laurus nobilis*;
Musaceae: *Musa paradisiaca*;
Solanaceae: *Solanum nigrum*;
Meliaceae: *Melia azadirachta*;
Amaryllidaceae: *Tulbaghia violacea*,
Vitaceae: *Vitis vinifera*;
Fagaceae: *Quercus infectoria*;
Anacardiaceae: *Rhus chinensis*;
Combretaceae: *Terminalia chebula*

Use of natural coccidiostats

The life cycle of Eimeria, alongside an exploration of the intellectual prospects for employing natural coccidiostats.



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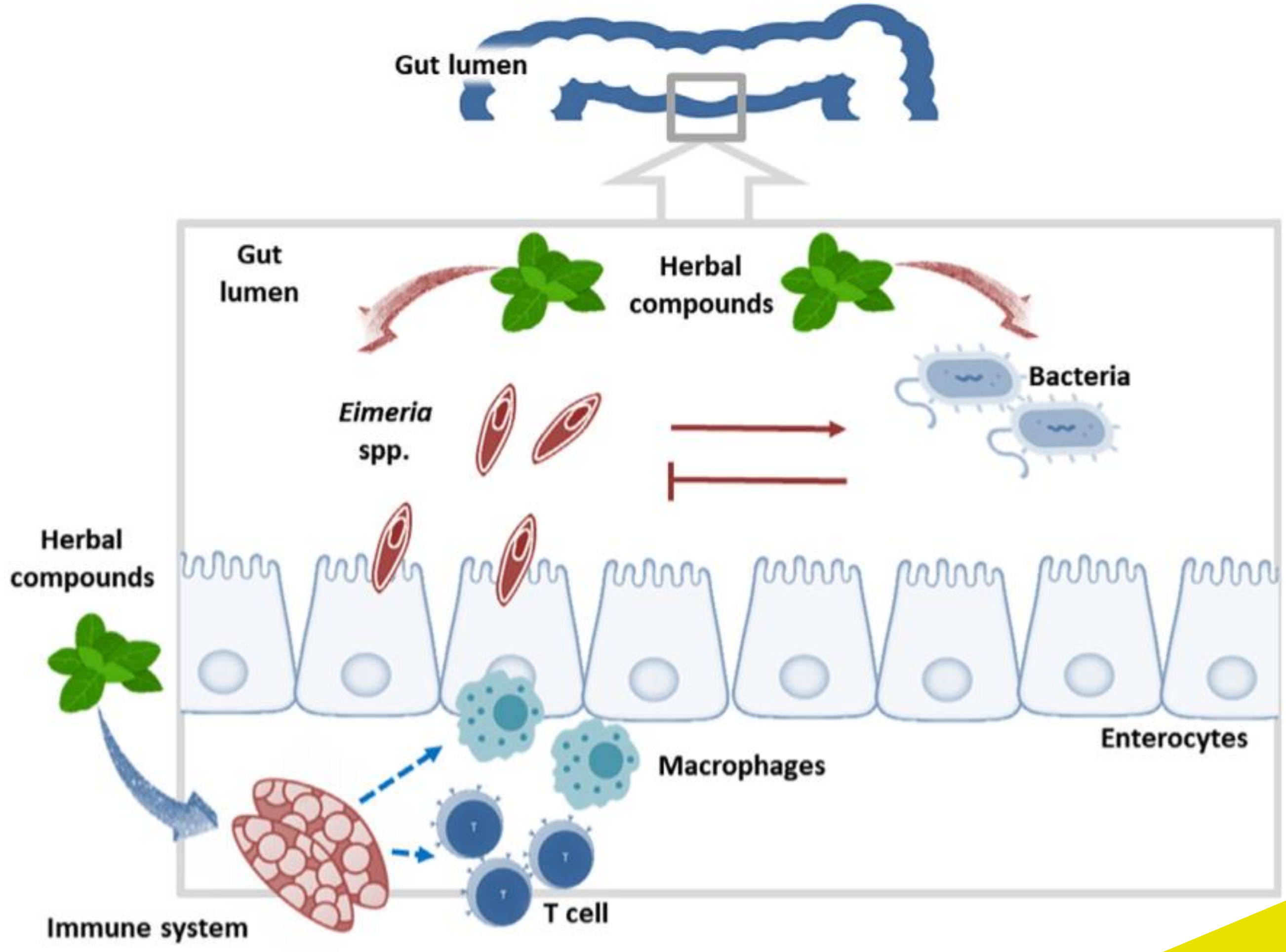
Herbal anticoccidian compounds

Gut-associated T cells, macrophages, and the schematic process of immune response of chickens to herbal anticoccidian compounds.



Herbs

Action	Compound (Plant/fungi)	Function
Inhibition of *Eimeria* life cycle	Artemisin (*Artemisia annua*)	Induce reactive oxygen species (ROS) that inhibit oocyst wall formation and sporulation
	Tannins, Pine (*Pinus radiata*)	Inhibition of life cycle and decreased sporulation of the oocyst
	Allicin and sulfur compounds, Garlic (*Allium sativum*)	Antimicrobial activity and inhibition of sporulation of *E. tenella*.
	Selenium, Phenolics and Green tea (*Camellia sinensis)*	Inhibition of sporulation of coccidian oocysts.
	Papain (*Carica papaya)*	Inhibition of coccidiosis probably by proteolytic degradation of *Eimeria*
	Saponins (*Cyamopsis tetragonoloba)*	Suppression of coccidiosis
	Essential oils from thyme, tea tree and clove	Destruction of *Eimeria* oocysts
	Ethyl acetate extract (*Meyerozyma guilliermondii*)	Destruction of *Eimeria* spp. oocysts
Immune response modulators	Probiotics (*Pediococcus acidilactici* and *Saccharomyces boulardii*)	Enhanced humoral immunity, changes in body weight gain and fecal oocyst shedding rates.
	Arabinoxylans (*Triticum aestivum*)	Immunostimulatory and protective effects against coccidiosis in broiler chickens
	Sugar cane (*Saccharum officinarum*)	
	Polysaccharides (*Astragalus membranaceus Radix, Carthamus tinctorius, Lentinula edodes, Tremella fuciformis)*	Enhancement of anticoccidial antibodies and antigen-specific cell proliferation in splenocytes via cellular and humoral immunity to *E. tenella*
	Phytonutrients mixtures: VAC (carvacrol, cinnamaldehyde, *Capsicum* oleoresin).	Protection against *E. tenella* infection. Increase in NK cells, macrophages, CD4+ T cells, CD8 + T cells and cytokines IFN γ and IL6.
	MC (*Capsicum* oleoresin and turmeric oleoresin)	
	Lectins (*Fomitella fraxinea*)	Enhancement of both cellular and humoral immune response

Table 3. Natural compounds identified with potential to inhibit *Eimeria* life cycle and acting as immune system modulators.

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Artemisia annua

microorganisms

MDPI

Article

Efficacy of *Artemisia annua* against Coccidiosis in Broiler Chickens: A Field Trial

Mircea Coroian [1,*,†], Loredana Maria Pop [1,†], Virgilia Popa [2,†], Zsuzsa Friss [3,†], Ovidiu Oprea [4], Zsuzsa Kalmár [1,5,6], Adela Pintea [7], Silvia-Diana Borșan [1], Viorica Mircean [1], Iustina Lobonțiu [3], Dumitru Militaru [2,8,9], Rodica Vârban [10] and Adriana Györke [1,*]

frontiers | Frontiers in Physiology

TYPE Original Research
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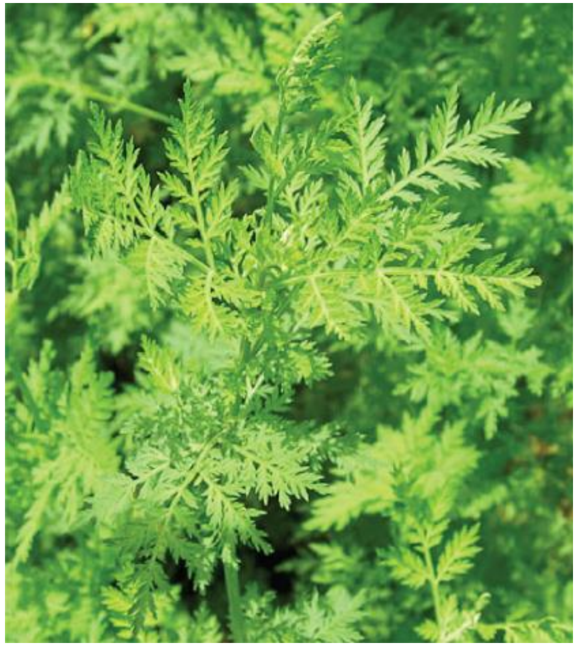
EDITED BY
Katarzyna B. Miska,
Agricultural Research Service (USDA),
United States

REVIEWED BY
Sara Cloft,
Purdue University, United States
Matt Tucker,
Agricultural Research Service (USDA),
United States
Gino Lorenzoni,
The Pennsylvania State University (PSU),
United States

*CORRESPONDENCE
Woo Kyun Kim,

Effects of *Artemisia annua* supplementation on the performance and gut health of laying hens challenged with mixed *Eimeria* species

Milan Kumar Sharma[1], Guanchen Liu[1], Venkata Sesha Reddy Choppa[1], Hamid Reza Rafieian-Naeini[1], Fatemeh Sadat Mahdavi[1], Brett Marshall[1], Robert M. Gogal Jr[2] and Woo Kyun Kim[1*]



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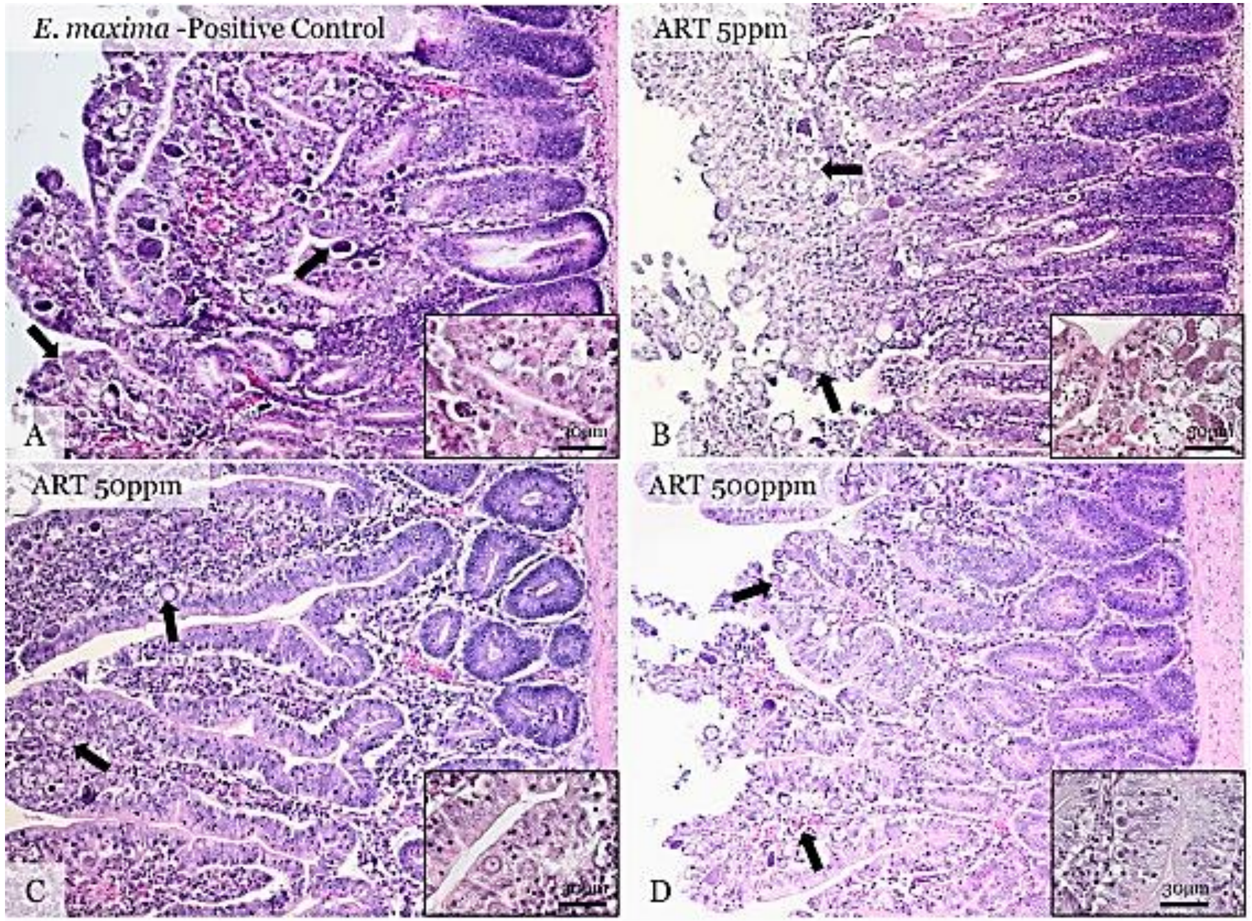
Artemisia annua



Group	I	II	III
NC	–	–	–
PC	87.3 ± 0.76[a]	82.7 ± 2.02[a]	95.42 ± 0.74[a]
ART5	87.8 ± 1.28[a]	78.1 ± 1.17[a]	87.83 ± 1.19[b]
ART50	87.8 ± 1.16[a]	78.5 ± 1.11[a]	92.17 ± 0.67[a]
ART500	79.7 ± 0.68[c]	72.7 ± 0.97[b]	93.8 ± 0.57[a]
MON	84.0 ± 1.01[b]	81.4 ± 1.24[a]	87.3 ± 0.86[b]

Values with no common superscript in a column were significantly different ($p < 0.05$); results are expressed in percentages as means ± SEM;
I: sporulation rate at 6 days p.i.
II: sporulation rate at 7 days p.i.
III: sporulation rate at 8 days p.i.

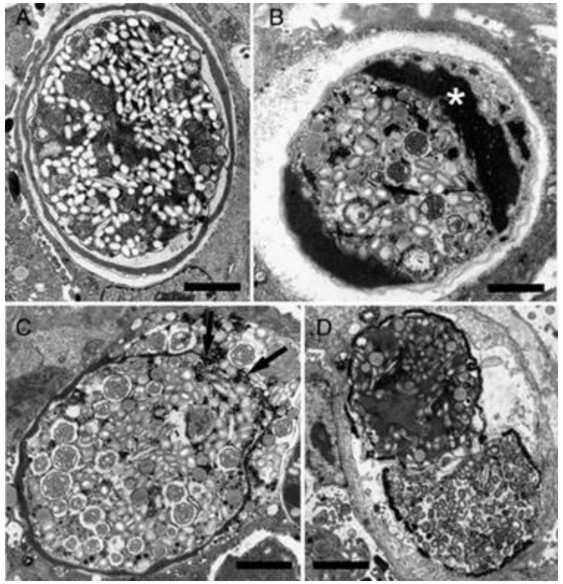


Table: The effect of artemisinin on oocysts sporulation rate in experimental groups of chickens challenged with E. acervulina (experiment I), E. maxima (experiment II), E. tenella (experiment III), compared with control groups

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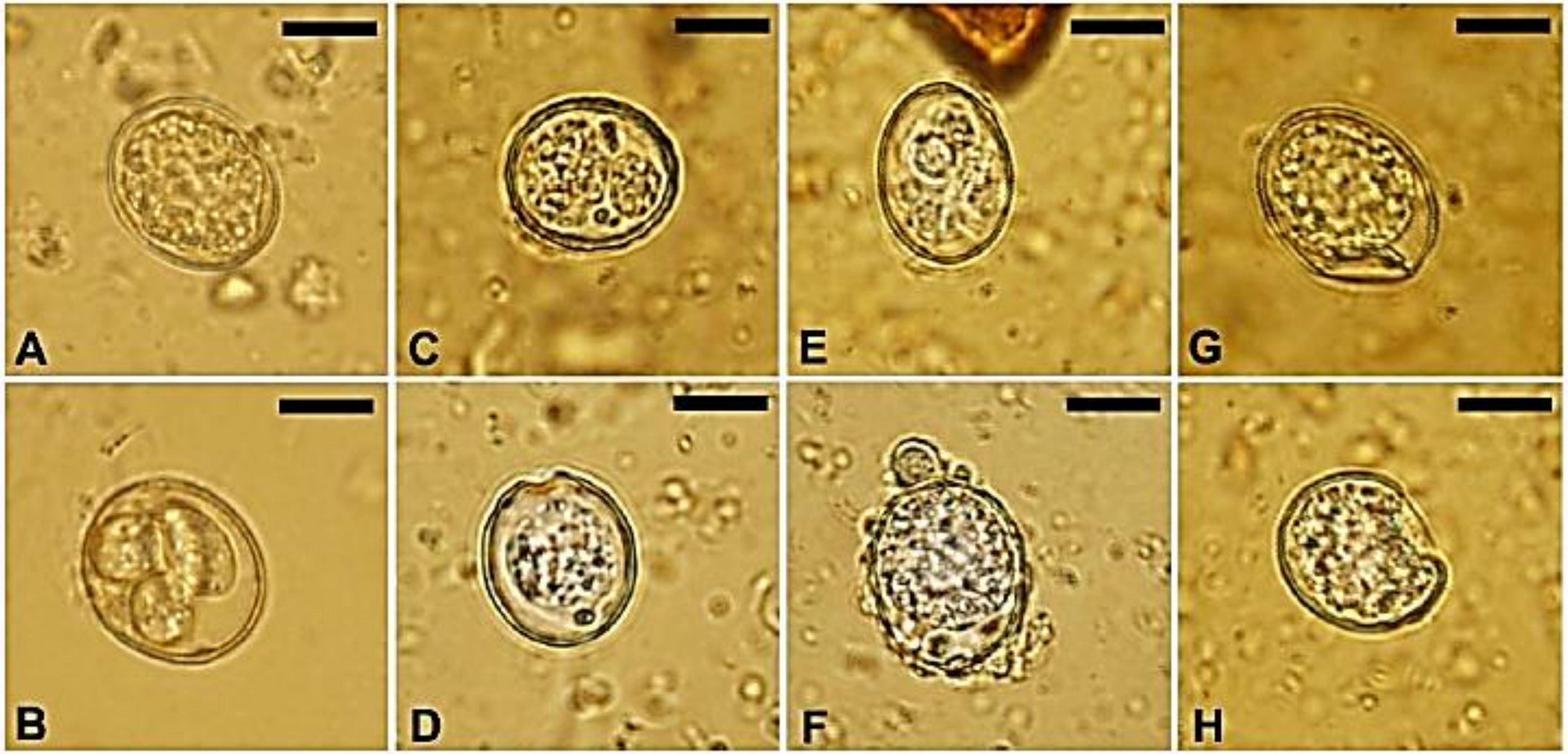
Artemisia sieberi



Changes observed after exposure of E. papillata oocytes to different treatment.
(a) normal nonpopulated oocysts in H_2O;
(b) normal sporulated oocysts in $K_2Cr_2O_7$;
(c-h) abnormal oocytes in the ASLE (300 mg/mL). Scale bar = 12.5µm.

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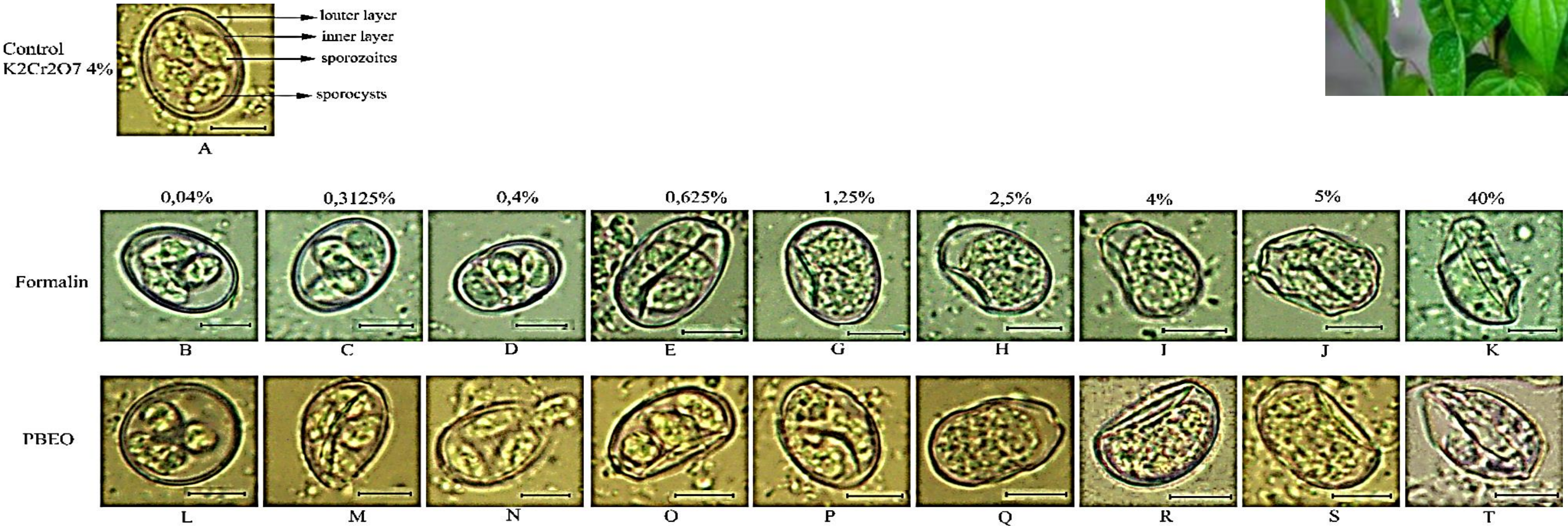
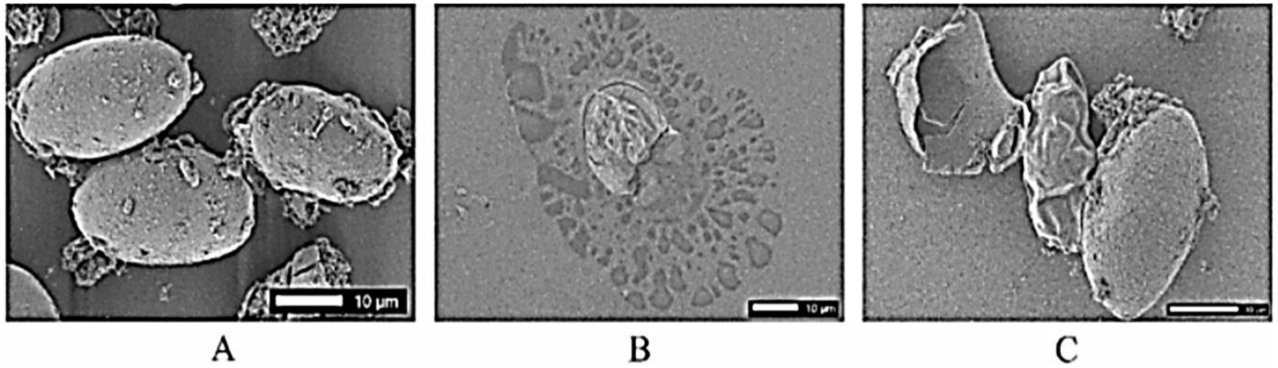
Piper bettle L.

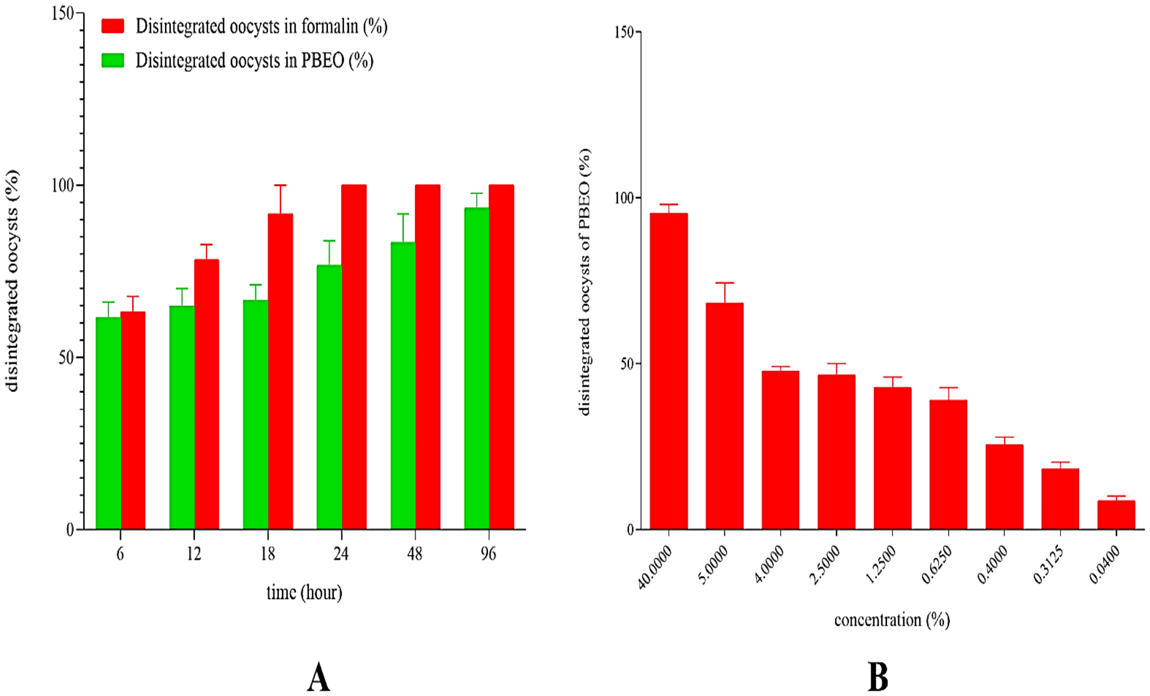


Morphology of Eimeria tenella oocysts treated with various concentrations of Piper bettle L essential oil (PBEO) and formalin after incubations for 72 h.
(A) 4% $K_2Cr_2O_7$ control in 72 h of incubation time.
(B-K) Oocysts in 0.04%, 0.3125%, 0.4%, 0.625%, 1.25%, 2.5%, 4%, 5%, and 40% formalin.
(L-T) Oocysts in 0.04%, 0.3125%, 0.4%, 0.625%, 1.25%, 2.5%, 4%, 5%, and 40% PBEO.
Scale bars represented 10 µm.

Piper bettle L.



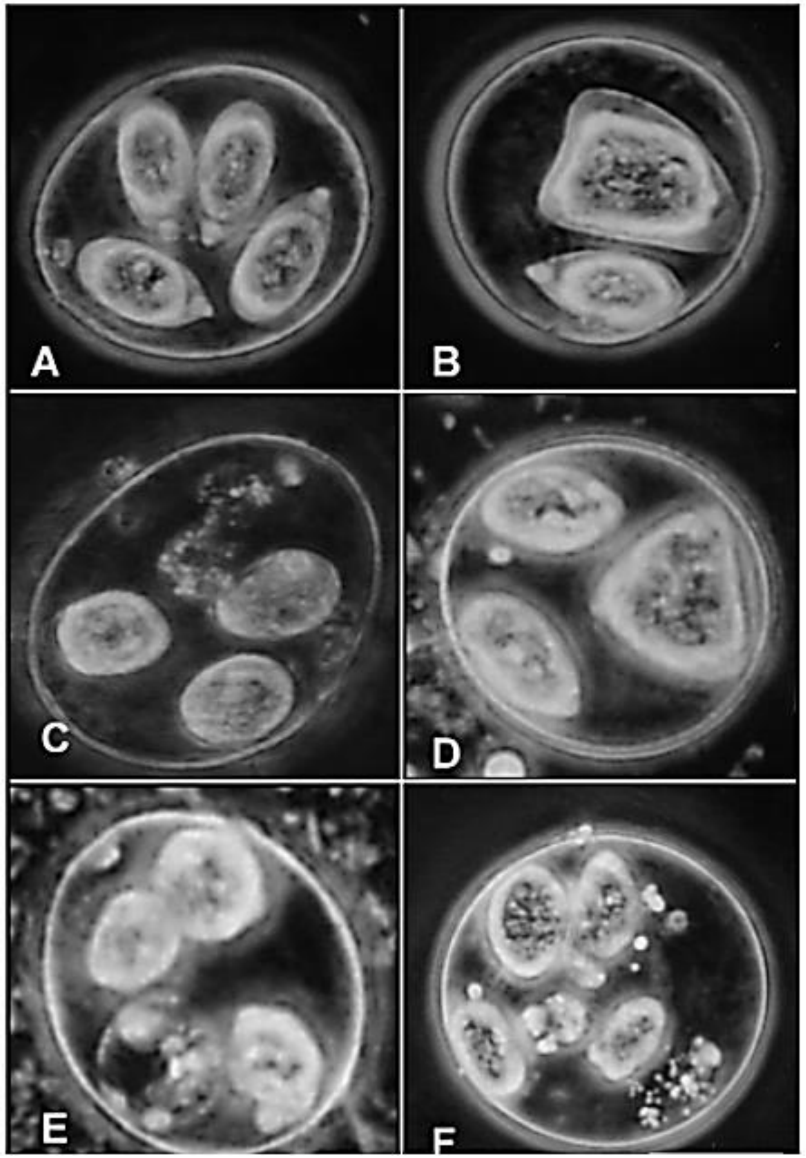
(A) Eimeria tenella oocysts from the control group showed an ovoid shape with intact walls and smooth surfaces.
(B) Oocyst in 40% formalin showed total wall disintegration after 72 h incubation.
(C) Oocyst-wall treated with Piper bettle L essential oil (PBEO) 40% was remarkably ruptured after incubation for 72 h.



Oocysticidal activities of formalin and Piper bettle L essential oil (PBEO) to *Eimeria tenella* oocysts

(A) Disintegrated *E. tenella* oocysts treated with 20% PBEO and 20% formalin in different incubation times.
(B) Number of disintegrated oocysts (%) incubated in different concentration ranges.

Pine bark (*Pinus radiata*)



Photomicrographs of oocysts of Eimeria maxima
A – a typical sporulated oocyst from control incubation containing water only;
B–F – abnormal oocysts from incubations containing 500 and 1000 µg pine bark extract (PBE)/ml. Oocysts were incubated for 48 h in the presence or absence of PBE and were viewed under bright field microscopy. Exposure to PBE caused changes in sporocyst numbers, size and morphology.
(Note: Oocysts are slightly flattened to better illustrate morphology.)
Scale bar (A–F) = 20 µm

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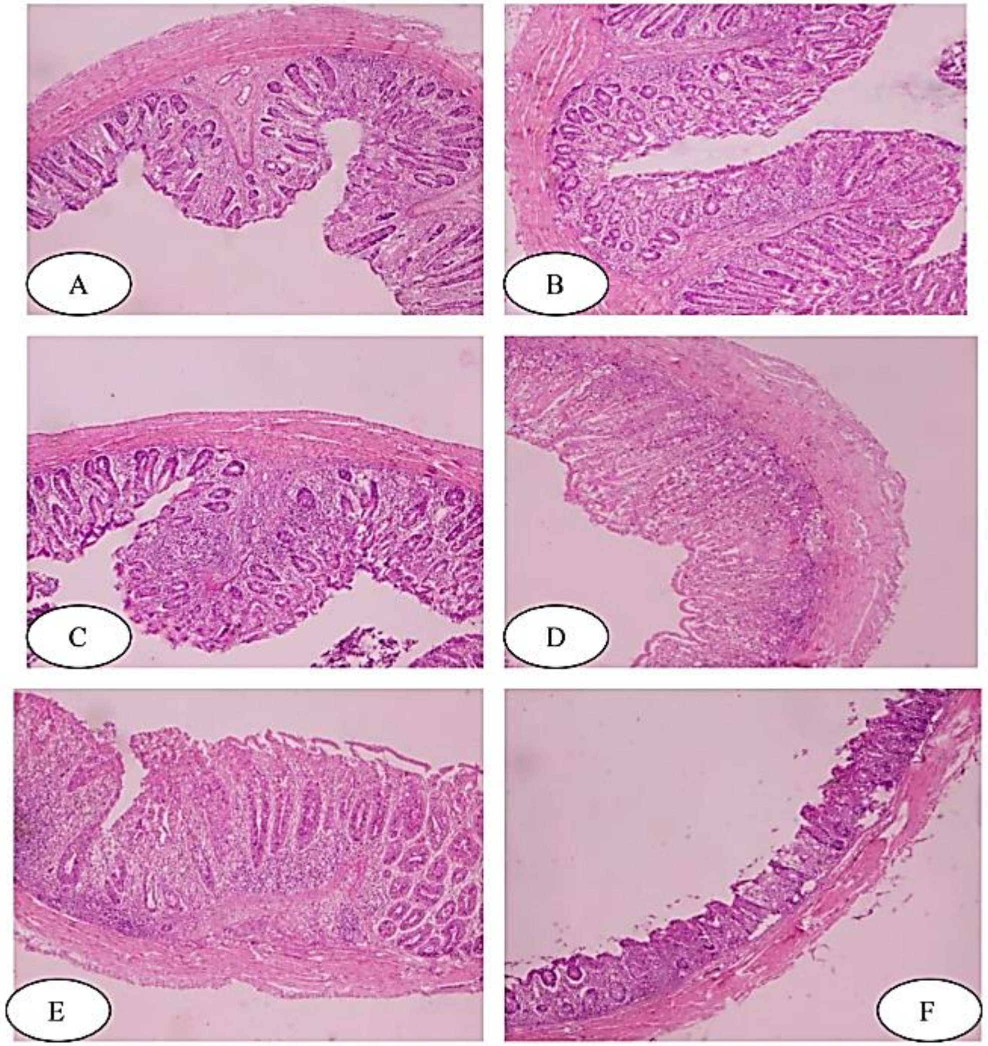
Garlic and Ginger



(A) Negative control
(B) Amprolium treated
(C) Garlic treated
(D) Ginger treated
(E) Ginger and garlic treated
(F) positive control
H & E stain (40 X) n = 100 µm.

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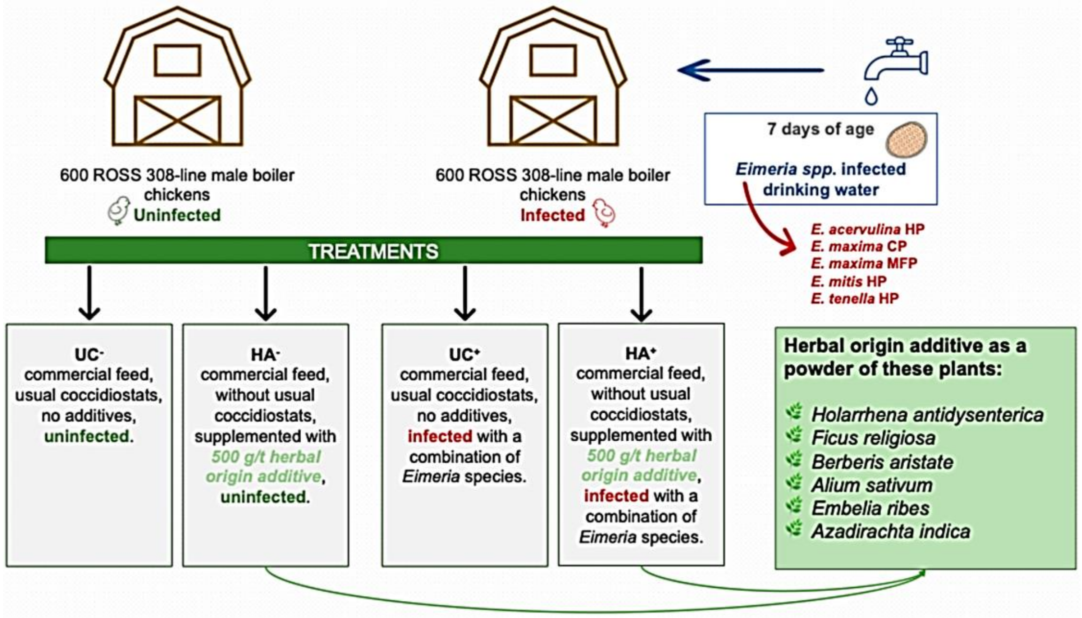
Mixed herbs

Table 5. The impact of herbal origin additives on the DM content and oocyst count in the broiler chicken litter.

Item [1]	Age [2]	Treatments [3,4]				SEM [5]	*p*-Value
		UC⁻	UC⁺	HA⁻	HA⁺		
DM of litter (%)	14 d	76.91	82.92	86.85	86.20	1.77	0.172
	21 d	75.81	78.62	76.64	76.49	0.62	0.451
	35 d	68.71 [a]	76.84 [b]	66.97 [a]	77.10 [b]	1.15	0.001
Oocyst (g/l)	14 d	0.00 [a]	120.80 [b]	173.00 [c]	245.60 [d]	21.76	0.000
	21 d	0.00 [a]	90.00 [b]	82.20 [b]	107.60 [c]	9.71	0.000
	28 d	2.80 [a]	12.40 [b]	7.20 [c]	8.80 [d]	0.82	0.000

Note: [1] DM, dry matter; [2] d, day; [3] UC⁻, control without infection with usual coccidiostat; UC⁺, control experimentally infected with usual coccidiostat; HA⁻, experimental without infection with herbal origin additive; HA⁺, experimentally infected with herbal origin additive. [4] The means with different superscript letters (a–d) in a row differ significantly ($p < 0.05$). [5] SEM, standard error of the means.



Evaluation of Herbal Anticoccidials on Growth Performance in Experimentally Infected Broiler Chickens

by Vilma Vilienė [1], Asta Racevičiūtė-Stupelienė [1], Daria Murawska [2], Michał Gesek [3], Paulius Matusevičius [4], Zoja Miknienė [5] and Monika Nutautaitė [1,*]

Mixed herbs

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Institute of Genetics and Animal Biotechnology
of the Polish Academy of Sciences, Jastrzębiec, Poland

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Evaluation of the effectiveness of alternative methods for controlling coccidiosis in broiler chickens: a field trial

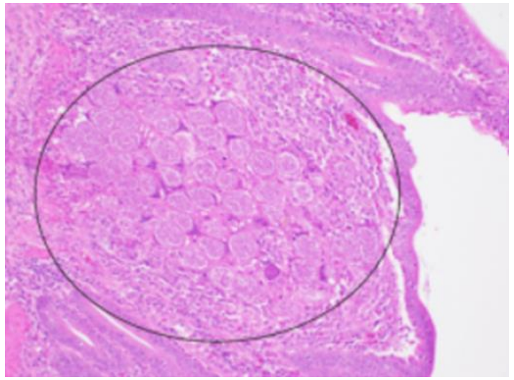
Sebastian Nowaczewski[1]*, Sebastian Janiszewski[2], Sebastian Kaczmarek[3], Natalia Kaczor[2], Przemysław Racewicz[1], Łukasz Jarosz[4], Artur Ciszewski[4], Piotr Ślósarz[1], Marcin Hejdysz[1]

[1] Department of Animal Breeding and Product Quality Assessment, Poznań University of Life Sciences, Złotniki, Słoneczna 1, 62-002 Suchy Las, Poland
[2] AVICARE – support for poultry production - limited liability company, Piekarska 4, 62-820 Stawiszyn, Poland
[3] Department of Animal Nutrition, Poznań University of Life Sciences, Wołyńska 33, 60-637 Poznań, Poland
[4] Department of Epizootiology and Clinic of Infectious Diseases, University of Life Sciences in Lublin, Głęboka 30, 20-612 Lublin, Poland

Table 6. Number (×10³) of *Eimeria* sp. oocysts in 1 gram of feces

Age (day)	Coccidiostat		Vaccine		Herbs		*P* value
	mean	SEM	mean	SEM	mean	SEM	
7	0.00	0.00	0.00	0.00	0.00	0.00	-
14	0.00^b	0.00	0.98^a	0.05	0.00^b	0.00	<.0001
21	30.76^b	0.74	71.96^a	2.71	74.56^a	2.67	<.0001
28	85.76^a	2.11	49.70^c	0.89	74.78^b	5.60	<.0001
35	11.97^a	0.59	5.01^c	0.17	9.13^b	0.97	<.0001

^{abc}In rows means bearing different superscripts differ significantly at P≤0.05.

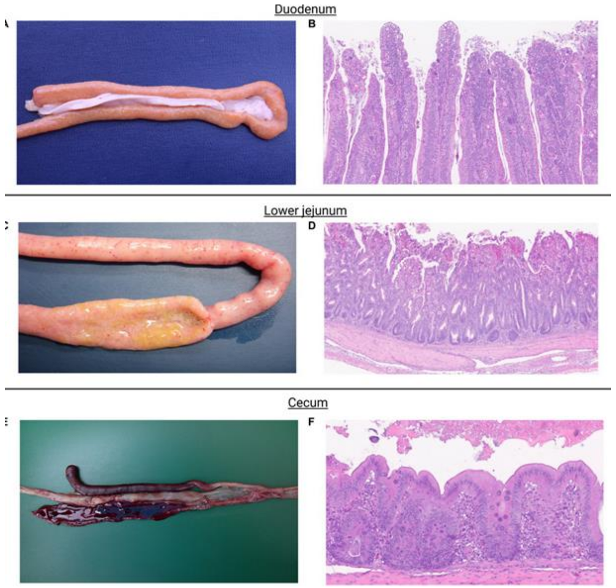


Mixed herbs

▸ Vet Med Sci. 2022 Oct 17;9(2):829–836. doi: 10.1002/vms3.971

Evaluation of therapeutic effects of an herbal mixture (*Echinacea purpurea* and *Glycyrrhiza glabra*) for treatment of clinical coccidiosis in broilers

Seyed Ali Ghafouri [1], Abolfazl Ghaniei [2,✉], Amir Ebrahim Tavanaee Tamannaei [3], Soheil Sadr [3], Ali Charbgoo [3], Shakila Ghiassi [3], Morteza Abuali [4]



Mean ± SEM weight of birds in four groups of study during the 42 days

Group	First day	Day 7	Day 14	Day 21	Day 28	Day 35	Day 42
Herbal mixture (Group A)	48 ± 0.9	171 ± 6	408 ± 16	645 ± 50^{a}	867 ± 42^{a}	1430 ± 46^{a}	1910 ± 124^{a}
Toltrazuril (Group B)	48 ± 0.9	171 ± 6	408 ± 16	650 ± 50^{a}	865 ± 34^{a}	1310 ± 77^{a}	1833 ± 82^{a}
Challenged and not treated (Group C)	48 ± 0.9	171 ± 6	408 ± 16	550 ± 33^{a}	751 ± 42^{a}	1259 ± 44^{a}	1655 ± 118^{a}
No challenge	48 ± 0.9	171 ± 6	408 ± 16	670 ± 50^{a}	955 ± 82^{a}	1431 ± 103^{a}	1881 ± 151^{a}
No treatment (Group D)							

Note: Means denoted by different superscript letters show significant differences between groups in each column ($p < 0.05$).

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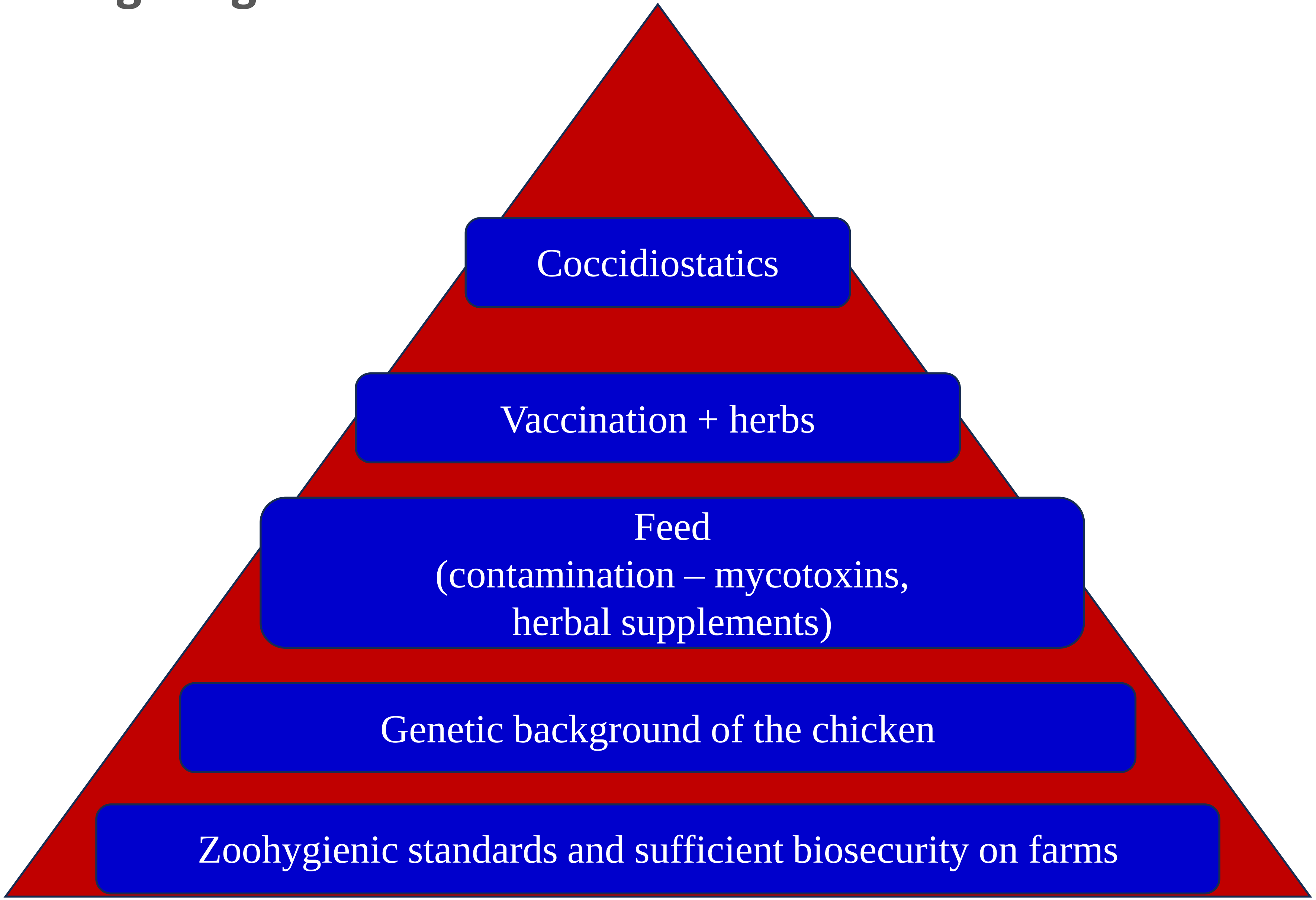
Fight against coccidiosis



Questions & Answers

THANK YOU!

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