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Research Article

The Effect of the Targeted Application of Commercially Available Non-Antibiotic Additives in the Poultry Industry on Antibiotic Usage and Biological Performance under Commercial Field Conditions

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Abstract

Modern poultry production systems often constrain natural poultry behavior and may result in health problems which in turn necessitate the use of antibiotics under veterinary prescription. Within the European Union (EU) there is increased pressure to limit if not prohibit the use of antibiotics for prophylactic as well as metaphylactic purposes in food producing animals.This situation has-encouraged increased attention to be placed on farm biosecurity and stock management improvement as well as the appraisal, development and in-field use of non-antibiotic alternatives (NAA) such as organic acids, exogenous feed enzymes, prebiotics and probiotics, as well as a variety of phytogenic products. The selection and usage of most NAAs commercially available as feed and/or water additives is often not precisely targeted to the particular health issues historically encountered on a specific farm or group of farms. Instead, they tend to be added to the feed or water as a matter of routine by feed manufacturers or farmers with very little prior discussion with the farm veterinarian on the best choice for the particular farm circumstances. In this study ten commercial broiler farms, in Cyprus and Greece, with relatively high historic reliance on antibiotic use were selected to be monitored for both antibiotic usage and biological performance, before (pre-additive production cycles) and after (post-additive production cycles) the targeted application of feed and/or water NAAs. Prior to this, the same farms were also involved in biosecurity improvements implemented after audits carried out following the Wageningen BiosEcurity Assessment Tool (BEAT). The post-additive production cycles compared to the pre-additive production cycles indicated that NAA use was accompanied by a 50.3% decrease in the number of antibiotic treatments ($p<0.01$), a non-significant 21.4% reduction in the days of treatment as well as a 5.7% improvement in biological performance as measured by the European Production Efficiency Factor (EPEF) ($p<0.1$). More substantial improvements were also noted when the post-additive production cycles were compared with the pre-additive production cycles before the biosecurity improvements implementation. In this case the antibiotic treatments were shown to have decreased by 58.7% ($p<0.01$), and this was accompanied by a 52% decrease in the days of treatment ($p<0.01$) as well as an improvement of 16.9% ($p<0.01$) in biological performance as measured by EPEF. On the basis of this work, it may be concluded that the targeted use of feed and/or water additives when based on the specific farm health issues historically encountered can improve the biological performance and in parallel reduce the use of antibiotics in broiler farms.

Keywords: Antibiotics; Broilers; Commercial farms; Feed additives; Performance

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Introduction

The use of antibiotics as growth promoters (AGPs) in animal feeds was permitted in the member states of the European Union (EU) for past decades. However, concerns about the development of antimicrobial resistance (AMR) and the spreading and transfer of antibiotic resistance genes from animal to human sectors, led to the withdrawal of the approval for AGPs in the EU since January 1st, 2006 [1]. Available data suggest that although resulting in a reduction of the overall use of antibiotics in animals, the AGP ban in Europe has associated with a substantial increase in the use of therapeutic antibiotics for food animals [2]. In the poultry sector, there is evidence that the initial removal of AGPs has been associated in some cases to poultry performance problems, feed conversion increases and the rise of certain poultry diseases particularly enteric such as (subclinical) necrotic enteritis [3].The increasing sociopolitical concerns regarding the development of AMR as well as at the same time the need to prevent farmer's economic losses has led to the development of alternatives to antibiotics. The primary goal of these alternative methods is disease prevention and reduction in veterinary intervention in commercial livestock farming, in order to improve animal growth performance, while based on the safety, efficacy and cost-effectiveness of such

Natural Antibiotic Alternatives (NAAs) [4,5]. The term NAA includes probiotics, prebiotics, symbiotics, organic acids, essential oils, enzymes, immunostimulants, and phytogenics (phytobiotics) such as botanicals, herbs, essential oils, and oleoresins. These are the most common feed and/or water additives that are currently widely used in the poultry industry following the ban of AGPs. They can be easily mixed with other feed ingredients, have no tissue residues of concern, and are often shown to improve feed intake, weight gain, feed conversion rate and strengthen bird immunity as well as improve digestive processes. Overall, these effects have a potential positive action on animals health and hence have the potential to decrease reliance on antibiotics [6]. Among the commercially available NAAs, the organic acids play an important role in gut health in animals. These acidifiers could be used to favorably impact the intestinal microbial populations and improve the immune response, hence perform an activity similar to antibiotics in food animals in countering pathogenic bacteria [7]. Short-chain organic acids have a specific antimicrobial activity that is pH dependent. Reductions in bacteria are associated with feeding organic acids, which are particularly effective against acid-intolerant species such as *E. coli*, *Salmonella*, and *Campylobacter*. Both antibiotics and organic acids improve protein and energy digestibility by reducing microbial competition with the host for nutrients and endogenous nitrogen losses, by lowering the incidence of subclinical infections and secretion of immune mediators, and by reducing production of ammonia and other growth-depressing microbial metabolites. Organic acids have several additional effects that go beyond those of antibiotics. These effects include reduction in digesta pH, increased pancreatic secretion, and trophic effects on the gastrointestinal mucosa [8].

Another NAA group consists of plant-based mixtures. These are also referred to as phytochemicals, phytobiotics or phytogenics and are natural bioactive compounds that are derived from plants. A wide variety of herbs and spices (e.g., thyme, oregano, rosemary, marjoram, yarrow, garlic, ginger, green tea, black cumin, coriander and cinnamon) have been used in poultry for their potential application as AGP alternatives. In addition to herbs and spices, various essential oils and phytochemicals (thymol, carvacrol, cinnamalde hyde, eugenol, and extracts from coriander, star anise, ginger, garlic, rosemary, turmeric, basil, caraway, lemon and sage) have been used individually or as blends to improve animal health and performance. The beneficial effects of phytochemicals are attributed to their antimicrobial and antioxidant properties. In addition, the inclusion of phytochemicals in the diets alters and stabilizes the intestinal microbiota and reduces microbial toxic metabolites [9]. Exogenous enzymes such as xylanases and glucanases have been shown to improve feed utilization of dietary components such as protein, amino acids, starch, lipids, and energy. Feed enzymes can affect the gastrointestinal tracts' microbial ecosystem by reducing undigested substrates and anti-nutritive factors and producing oligosaccharides *in situ* from dietary non-starch polysaccharides withpotential prebiotic effects [10]. Probiotics are microorganisms which favor the healthy function of the animal's intestinal tract. A healthy intestinal tract has positive effects on the circulatory and immune system. Many different nutrients, such as pectin, cellulose and xylanases, have been shown to promote the development of various favorable intestinal microorganisms and as such have a prebiotic effect. Prebiotics are not extensively metabolized, and have been shown to encourage targeted metabolic processes, which in turn bring health benefits to the animal's ecosystem [11]. It is common commercial practice that feed manufacturers use a holistic approach in the choice of NAAs included in their poultry feed range. Such an approach is therefore not usually targeted on individual farm situations and nor does it take into account historic farm problems and veterinary interventions. It is also associated with few dialogues between the farmer, the feed supplier, or the farm veterinarian, about the choice of the feed and/or water additive best suited to the individual farm situations. The purpose of this field study was to test in commercial broiler farms from two countries, Cyprus and Greece, a set of NAAs which were selected after due consideration and discussion between the farm veterinarian establishing which were best suited to counter the specific problems identified from historical fact-based information that considered biological performance data, health data and veterinary diagnoses and consequent interventions.

Materials and Methods

Characteristics of the farms

Ten commercial broiler farms in two EU countries (Greece and Cyprus) were involved in this study. For the purposes of this study the farms were allocated to five groups AG, BG, AC, BC and CC depending on the historic information provided. All the farms were selected on the basis that they had a consistent and relatively high reliance on antimicrobial usage in their most recent growing cycles. As such, they were not selected to be representative of each country in either biological performance or antimicrobial usage. In Greece, five separate broiler farms with bird populations above 15,000-each, were enrolled. In Cyprus, five broiler farms each also with above 15,000 birds participated. All the farms participated previously in a separate study investigating the effect of health plan improvement implementations, post biosecurity audits carried out using BEAT (Base Editing Analysis Tool). BEAT is a risk analysis methodology developed by the University of Wageningen on the effects on biological performance and antimicrobial usage [12]. It is based on the FAO 3-Zone Biosecurity model, the BIOCheck UGENT [13] and the Dutch Hygiene scan. It has been described in full by Schreuder et al. [12].

The broiler houses were typical of intensive livestock facilities in the two countries, all with automatic feeders and drinkers and all tunnel ventilated. The heating systems were mostly air to air heat exchangers. The light intensity and photoperiodism followed a similar pattern in all cases. Straw or rice hull litter was used. Plant based diets were used throughout. These followed the nutrient recommendations as well as the feeding program as described in the Aviagen Ross 308 guidelines for birds targeted to be slaughtered at live weight 2.5 to 3.0 kg. The feed used was in the form of mash and was farm mixed from the grower stage onward while for the starter (0-10 days of age) commercially available crumbled broiler feed was used in both countries. Feed and water were offered *ad libitum* throughout the whole cycle.

The day-old chicks originated from one hatchery in each country throughout all the recorded periods. In all cases they were vaccinated at hatch, for Marek, Infectious Bronchitis and Newcastle Disease. No detailed information on the parent stock health statuses were made available. All animal care procedures complied with European Directives 2007/43/EC, 2005/1/EC and 2009/1099/EC which set welfare standards for keeping chickens for meat production, for their transport to the slaughterhouse and their protection during slaughter procedure.

Time line of Study

The 4 periods described in Figure 1 are the results of the successive implementations of two distinct procedures, namely the implementation of biosecurity measures (called BioInt) and the implementation of Natural Antibiotic Alternatives (called Add). The 4 periods are as follows:

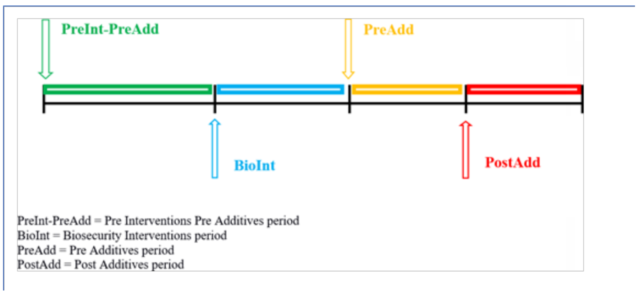

Figure 1: Timeline of Study

a. The historic pre-intervention and pre-additive period (PreInt-PreAdd) corresponding to five consecutive production cycles, where the data collected and ascribed to those cycles was made available to the research team by the farmer and his veterinarian.

b. The biosecurity improvement intervention period (BioInt), posterior to the biosecurity risk analysis (BEAT), covering two production cycles, where improvements were carried out.

c. The pre-additive monitored period (PreAdd) also covering two production cycles, where details of biological performance as well as veterinary interventions were recorded by the research team. This period was then treated as the control.

d. The similarly monitored post-additive production period (PostAdd) of the same duration which was considered as the treatment.

The biosecurity improvements where continuously implemented during the 3 last periods.

Biological performances, health status of the farms and NAAs description and usage by farm

The information based on data recorded during the five production cycles corresponding to the PreInt- PreAdd periods was made available from all the participant farms. Such information included biological performance data covering average slaughter weight, average daily weight gain, feed conversion ratio (FCR), total mortality rate, footpad score (scored from 0 to 2), according to the scoring described by Berg [14] and the European Production Efficiency Factor (EPEF), where EPEF was calculated using the following formula:

EPEF = [[Livability (%) x Live Weight (kg)] / [Age (days) x FCR]] x 100

Antimicrobial usage records for the PreInt-PreAdd period were also made available, as was the veterinary diagnosis attached to each production cycle. These information bases provided the platform upon which discussions involving the farmer, his veterinary consultant and researchers participating in this study took place so as to arrive at an agreed individual farm-based additive regime for the PostAdd period. All such individual farm-based additive regimes made use of commercially available and approved feed and/or water products, at best targeted at a possible reduction of antimicrobial use at each specific site, while also potentially able to maintain similar biological performance as measured by the parameters described above. The seven commercially available feed and/or water additives used in the study are described below in Table 1. All seven were approved for use in poultry within the EU without a veterinary prescription.

Feed/Water Additive	Description
B-act® (Huvepharma®)	Probiotic feed additive containing viable spores of a unique strain of Bacillus licheniformis producing bacteriocins
Avipremium® D (Vetagro®)	Concentrated source of tributyrin in powder form (55% butyric acid).
Biotronic® Top 3 (DSM/ex Biomin product)	Combination of synergistically acting organic acids and flavoring compounds: Formic Acid 20% Acetic Acid 10% Propionic Acid 5%
Digestarom® P.E.P Sol (DSM/ex Biomin product)	Liquid phytogenic blend of natural extracts of aromatic plants containing: Mixture of flavoring compounds E484 Glyceryl polyethylenelglycol ricinoleate Propyleneglycol
Biotronic® Top Lquid (DSM/ex Biomin product)	Combination of synergistically acting organic acids and flavoring compounds
PoultryStar® ME (DSM/ex Biomin product)	Gut Flora Stabilizer Bifidobacterium animalis spp. animalis DSM 16284 Lactobacillus salivarious spp. Salivarious DSM 16351 Enterococcus faecium DSM 21913 Product contains 2x10^8 CFU/g
AdiCox® AP (Adifeed®)	Origin: Source of plant ingredients rich in phytoncides and phytoalexins, based on hot pepper, mustard, soapwort, sweet flag and turmeric. Composition: Capsicum annuum L., var. minimum Miller Heiser , Sinapis alba L., Curcuma longa L., Saponaria officinalis L., Acorus calamus L., Palm oil (hydrogenated), Iron sulphate monohydrate

Table 1: Feed and water additives used in this study.

Table 2 depicts the feed and/or water additives used by farm and/or group of farms, the dosage and the administration route as well as the period of addition. As already mentioned, the 5 groups of farm(s)/additive(s) combinations were the results of the analysis of the PreInt-PreAdd information on both biological performance and veterinary interventions, and more importantly the disease challenges faced during this period. The AG and BG farms faced specific problems identified as omphalitis, necrotic enteritis and colibacillosis. The farms grouped as AC suffered from cases of dysbacteriosis, necrotic enteritis, peritonitis, arthritis and air sacculitis. Group BC suffered from omphalitis, necrotic enteritis, air sacculitis and arthritis while farm group CC suffered from necrotic enteritis, air sacullitis, peritonitis and arthritis. Groups AG and BG where the water source was farm wells also suffered from poor water quality.

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	Number of	Feed / Water	Dosage	Period	Administration
	Broiler	Additive	(per 1000 kg of	(days)	Route
	Houses		feed or 1000 L		
			of water)		
Group AG	two of equal capacity	PoultryStar® ME	500	11 to 40	feed
		Biotronic® Top 3	1000	11 to 40	feed
		Biotronic® Top Liquid	1200	4 to 11	water
		Digestarom® P.E.P Sol	100	15 to 27	water
Group BG	three of equal capacity	AdiCox® AP	60	11 to 40	feed
		B-act®	500	11 to 40	feed
		Biotronic® Top Liquid	1200	4 to 11 and 16 to 28	water
Group AC	two of equal capacity	B-act®	500	10 to slaughter	feed
Group BC	two of equal capacity	Biotronic® Top 3	1000	10 to slaughter	feed
Group CC	one	Avipremium® D	200	10 to slaughter	feed

Table 2: Description of the NAAs used per Group.

Statistical analysis

All the analyses were performed in R 4.1.0 (R Core Team, 2021). To assess the biological performance and antibiotic use during the PreAdd and PostAdd periods, mean scores were determined. To compare the results between the Pre-Add and Post-Add periods, an Analysis of Variance (ANOVA) test was performed. To assess the biological performance and antibiotic use during the PreInt-PreAdd and PostAdd periods, mean scores were also determined. To compare the results between the PreInt-PreAdd and PostAdd periods, Wilcoxon-Rank-Sum tests were performed. The differences were considered statistically significant with $p < 0.05$.

Results

Pre-Add and Post-Add comparison

The key biological performance indices as well as usage of antibiotic treatments are summarised in Table 3. Overall, comparison of the PostAdd and the PreAdd periods showed a significant ($p < 0.05$) reduction of the mortality rate (-37.2%), accompanied by a slight but not statistically significant improvement of EPEF (+5.7%; $p < 0.05$). In addition, a strong reduction (-50.3%) of the average number of antibiotic treatments per production cycle was observed ($p < 0.01$). It was accompanied by a non-significant parallel reduction in the overall days of antibiotic treatment (-21.4%; $p > 0.2$).

	Mortality Rate	EPEF	Number of AB Treatments	Days of AB Treatments
PreAdd	4.22 ± 0.42	333 ± 7	1.91 ± 0.28	4.39 ± 0.58
PostAdd	2.65 ± 0.44	352 ± 8	0.95 ± 0.15	3.45 ± 0.57
p-value*	0.014	0.085	0.006	0.259
	p<0.05	p<0.1	p<0.01	N.S.

Table 3: Average Biological Performance and Antibiotic Use for the PreAdd and PostAdd Periods.

*ANOVA Test

	Mortality Rate	EPEF	Number of AB Treatments	Days of AB Treatments
PreInt-PreAdd	4.04 ± 0.32	301 ± 7	2.30 ± 0.12	7.19 ± 0.52
PostAdd	2.65 ± 0.44	352 ± 8	0.95 ± 0.15	3.45 ± 0.57
p-value*	0.004882	0.000043	0.00000057	0.00012
	p<0.01	p<0.001	p<0.001	p<0.001

Table 4: Average Biological Performance and Antibiotic Use during the PreInt-PreAdd and Post Add periods.

* Wilcoxon Test

PreInt-PreAdd and PostAdd comparison

As the PreAdd period shown in Table 3 was monitored subsequent to the implementation of Biosecurity Improvements (BioInt period) in the farms, this provided the opportunity to perform an additional comparison between the PreInt-PreAdd period - that is before biosecurity improvements and NAA addition -, and the PostAdd period when both biosecurity improvements and NAA addition were present. This comparison is summarised in Table 4, showing that all indicators were significantly improved.In particular, EPEF value showed a highly significant improvement in the PostAdd period (+16.9%; $p<0.001$), emanating from improvements in feed conversion ratio, livability and final live weight (not shown). Similarly, both the number of antibiotic treatments as well as the days of antibiotic treatments per production cycle showed substantial and highly significant reductions: -58.7% ($p< 0.001$) and - 52% ($p< 0.001$), respectively. Mortality rate was also significantly reduced by 34.4% ($p<0.01$).

Discussion

The implementation of farm-tailored Non-Antibiotic Additives (NAAs) was tested in the present study in a context of overall improvement of healthy status of poultry farms. In this context it is recognized that the most beneficial strategy for reducing the need for the use of antibiotic treatment under commercial field conditions is to prevent pathogens from entering and spreading in the farms [13-15]. This can best be done in practice by improving farm biosecurity culminating in the development and implementation of effective flock health and welfare plans. Schreuder et al. [12] discussed in detail how a farm can be divided into three zones which include the area outside the farm (red zone), the area and buildings within the farm except of the poultry houses (orange zone) and finally the poultry houses themselves (green zone). Each zone has its own parameters that need to be assessed on the basis of correct biosecurity. If those parameters don't meet with the proper standards, then they should be changed in order to improve the farms biosecurity. For example, the red zone should be checked for proper pest control as well as personnel, visitor and vehicle access protocols. As far as the orange zone is concerned, cadaver, manure, bedding and feed storages must be tightly sealed and isolated, and cleaning and disinfection of the farm yard as well as the buildings in the farm should be done regularly. Finally, in the green zone cleaning and disinfection of both the poultry house and the entry room and the immediate removal of dead birds are of utmost importance. All the farms participating in this study went through this process before any NAA addition was targeted and used. The NAAs used in each group were chosen according to the groups' specific problems identified from historical fact-based information that covered biological performance data, health data and veterinary diagnoses. For example, certain broiler houses had issues with dysbacteriosis, necrotic enteritis and arthritis. In this case B-act® was the feed additive of choice. Certain probiotics have the ability to suppress the effects of dysbacteriosis in broilers and help inhibit the growth of Clostridium perfringens, the direct causative agent of necrotic enteritis. This leads to a reduction in the flock's mortality, an improved average weight and a decrease in the feed conversion ratio which are findings that coincide with the results of this study. Another benefit of the use of probiotics is the reduction in the incidence of arthritis-induced lameness which is brought about by bacterial translocation from the intestines to the joints [16]. A common characteristic of other grouped broiler houses was the poor quality of water coupled with incidences of necrotic enteritis and arthritis. The feed additive chosen in this case was Biotronic® Top 3. Multiple previous studies have shown that inclusion of organic acids in the feed can lead to a significantly higher final weight, weight gain, and better feed/gain ratio [17, 18]. Organic acids can reduce the number of pathogenic bacteria and their entry into the intestinal mucosa and subsequently the inflammatory processes that will ultimately affect performance [19]. Moreover, the use of organic acids has been shown to significantly increase the height of villi from all segments of the small intestine and to cause a moderate to marked increase of the goblet cell counts, compared to not supplemented controls. Goblet cells are distributed along the villi and the mucin they produce plays a key role in the proper function of the intestinal epithelium [20]. In another group of broiler houses recording similar problems, the targeted NAA regime was based on the addition of Avipremium® D which contained the organic triglyceride tributyrin. There is increasing evidence suggesting that butyrate can act as the major energy source of the colon, reduce pathogen colonization, improve intestinal barrier function, exert anti-inflammatory properties and protect the birds against liver and kidney disfunction. Dietary supplementation with tributyrin has been demonstrated to improve animal performance by increasing the final weight and decreasing the FCR in the entire growth phase. This improvement in performance is brought about by the proliferation and differentiation of intestinal mucosal cells which enhances nutrient absorption and utilization [21]. A different study has shown that dietary sodium butyrate supplementation can improve the growth performance in chickens under stress and that this may be used to moderate the immune response and reduce tissue damage with diseases such as necrotic enteritis, arthritis and peritonitis [22], as it was also the case of certain groups of farms in this study. It is often the case that some commercial farms and/or individual broiler houses within a farm encounter a number of health issues arising out of a complexity of challenges which extend from poor water quality or shortcomings in biosecurity, the latter being not easy to correct in the short term. In this study the targeted choice of additives was extended to both water and/or feed products with a broad range of claimed benefits. Specifically, one group of broiler houses received a combination of PoultryStar® ME which is a symbiotic product blend, together with the organic acid Biotronic® Top 3 in the feed, and Biotronic® Top Liquid and Digestarom® P.E.P Sol in the drinking water. The use of organic acids in both the feed and the water regimes was based on the premise that this combination would provide an enhanced control of Gram-negative pathogens, as well as a direct support to the healthy gut microbiota in the face of a more severe pathogen challenge. Davidson et al. [23] reported that when the bacterial internal pH drops because of the presence of an organic acid, the pathogenic bacteria must use adenosine triphosphate to actively transport excess protons from the interior of the cell, resulting in a depletion of cellular energy and cell death. Another possible reason for the modification of intestinal microbial growth by organic acids can pertains to their prebiotic effects, that result in the production of short-chain fatty acids from bacteria which are also thought to have an antibacterial effect by decreasing luminal pH [24].

The targeted use of the symbiotic mix in this study was also based on the recorded observation that the birds in this group of farms showed frequently increased incidences of lameness attributed to arthritis as well as poor litter quality. According to the study of Stark [25], by combining a pro- with a prebiotic a significant overall reduction in the onset of lameness attributed to bacterial chondronecrosis was observed in comparison with control broilers receiving the non-supplemented diet alone (19.6% vs. 33.2%, respectively). This effect was attributed to the probiotic eliciting beneficial responses to the bird's gastrointestinal microflora and immune system, contributing in reducing or stop-ping bacterial translocation from the gastrointestinal tract to susceptible leg joints. Furthermore, an-other study [26] indicated that these types of symbiotic products were able to prevent clinical signs associated with *Eimeria* challenge in poultry, and alleviate performance losses when included in the diet, especially regarding oocyst shedding. The increase in EPEF as well as the decrease in the FCR observed in the present study agrees with a study carried out by Awad et al. [27] who found that the dietary supplementations of pre- and probiotics resulted in an increase in the villus height and crypt depth ratio of intestinal mucosa of broilers. Subclinical coccidiosis, particularly where poor litter quality is encountered, is often a problem leading to additional enteric stresses such as dysbacteriosis and necrotic enteritis. This is particularly a problem where the system does not follow 'an all-in all-out' practice, and bed collection at depletion is carried out over a period of time. Blends of herbs and spices as well as essential oils and other plant extracts have been used widely in the industry to help coccidiosis control. In this study where such practices and historic problems were encountered, the targeted NAA approach used was based on such products namely Digestarom® P.E.P Sol and AdiCox® AP. Both products are plant-based preparations with reported coccidiostat efficacy. Murugesan et al. [28] reported that phytogenic feed additives support the establishment of a favorable gut microbiota composed of higher numbers of *Lactobacillus* spp. and fewer *Clostridium* spp. Furthermore, the same study found that supplementation of an herb-based mixture to a coccidiostat free diet increased the body weight gain and lowered the FCR.

AdiCox® AP has specifically been shown to act as a natural coccidiostat [29]. This coincides with the results of the present study in which mortality was decreased and the EPEF was increased significantly when using these types of phytogenic products on farms with a history of coccidiosis challenges. The present findings confirm that commercially available NAAs when supported by both an explanation of the mode of action and published efficacy results, can provide a very useful approach in an effort to further reduce the need of veterinary interventions in the form of metaphylaxis and certainly prophylaxis in broiler production. As individual feed and/or water additives often have a different mode of action and application target, the efficacy of such use lies to a large degree on good knowledge of the historic problems and health issues prevailing on the targeted farm. The present study has clearly demonstrated this in the reduction of antibiotic usage after the targeted NAAs addition.

Biosecurity is a major issue facing many commercial broiler farms, particularly those situated in heavily populated poultry areas. Improvements in biosecurity are possible through training and personnel involvement as well as through capital investment, resulting in biological improvements and less reliance on veterinary interventions based on antibiotic use [12]. The present study has shown that when such biosecurity improvements are associated with targeted NAA solutions, even greater improvements in both antibiotic reduction and biological performances can be demonstrated.

Conclusion

Modern poultry production systems often constrain natural poultry behavior and may result in health problems which in turn necessitate the use of antibiotics under veterinary prescription. Within the European Union there is increased pressure to limit if not prohibit the use of antibiotics for prophylactic as well as metaphylactic purposes in food producing animals. Decreased reliance on antibiotics can be achieved by improving farm biosecurity. For this to be effective a detailed and planned biosecurity audit involving both the farmer and the veterinarian across a structured protocol is a prerequisite. Further reduction in antibiotic reliance can be achieved through the targeted selection and use of a non-antibiotic feed and/or water commercially available products best targeted on the specific farm historic health issues.

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Conflicts of Interest

The authors declare no conflicts of interest.

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