Effect of a High or Low Protein Feed Supplement on Severity of a Fungi-Contaminated Diet on Performance of Chicks

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Summary

Four growth trials were conducted on four groups of 15 Arbor Acres chicks (15 d old) to study the effect of dietary protein fortification on the severity of a fungi-contaminated diet.
The chicks of the first group were fed on a common diet contaminated with fungi, while the second group was fed the same diet but with soybean. The third group also received the contaminated diet but with corn starch. The fourth group was fed on a common non-contaminated diet. The experiment lasted for four weeks.
Chicks fed the fungi-contaminated diet were characterised by a considerable reduction in body weight gain and relative growth rate, an increased feed conversion and a mortality rate of 33%. The addition of the protein-rich supplement improved all parameters of growth performance and decreased mortality rate. The protein-poor supplement significantly reduced growth performance and increased mortality rate up to 40%.
In conclusion, fortifying a fungi-contaminated diet with a protein-rich supplement increased the viability of chicks and reduced the negative effects of fungi on performance.

Samenvatting

Het effect van een eiwitrijk of eiwitarm voedingssupplement op de schadelijkheid van een met schimmels besmet voeder voor de prestatie van kuikens
Vier groeiproeven werden uitgevoerd met vier groepen bestaande uit 15 Arbor Acres kuikens (15 d. oud) om het effect te bestuderen van de toevoeging aan het voeder van eiwit op de schadelijkheid van een met schimmels besmet voeder.
De kuikens van de eerste groep werden gevoederd met een gangbaar, maar met schimmels besmet voeder, terwijl de tweede groep hetzelfde besmet voeder kreeg, maar dan met een sojabonensupplement. De derde groep kreeg het besmette voeder met een maïszetmeel supplement. De vierde groep kreeg een gangbaar, niet-gecontamineerd voeder. De proef duurde vier weken.
Kuikens gevoederd met een besmet voeder vertoonden een opmerkelijke daling van het lichaamsgewicht en de groeisnelheid, een verhoogde voederconversie en een sterftecijfer van 33%. De toevoeging van het eiwitrijke supplement verbeterde alle groeiparameters en verlaagde het sterftecijfer. Het eiwitarme supplement veroorzaakte een significante daling van de groeiprestaties en verhoogde het sterftecijfer met 40%.
Er kan besloten worden dat de toevoeging van een eiwitrijk supplement aan een met schimmels besmet voeder de overlevingskansen van kuikens verhoogde en de negatieve effecten van schimmels op de prestaties beperkte.

Introduction

Uncontrolled fermentation is more likely to be harmful (2), because it induces heating, reduced palatability, poor handling characteristics and loss of marketability of feeds. In addition, it contributes to fungal growth. Contamination of poultry diets by fungi represents a considerable percentage of overall contamination problems.
Fungi growth during storage of animal and poultry feeds is well documented and incidence of mycotoxins in such feeds may be widespread (13, 21, 23, 24).
Fungi can reduce the nutritive value of diets due to catabolised nutrients, reduced digestibility or production of toxins. Mycotoxins interact with lipids, proteins and vitamins (13). Fungi and mycotoxins reduce the growth rate and efficiency of feed utilisation of chicks and poults (4,16) and increase mortality rate (6).
The control of fungal activity in animal and poultry feeds or ingredients is a subject which attracted much attention in the last few years as a result of the increasing awareness of hazards presented by mycotoxins (24). There are important tools to reduce the incidence of mycotoxins in order to produce mould-free feedstuffs (21), such as the reduction of the mean contact time with feed-handling system (10), the cleaning and disinfecting of the feed-handling equipment (12), the reduction of the moisture content of the feed (25), the improvement

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of management (12, 25), the use of mould inhibitors (24) and the alternation of dietary ingredients (11, 22).
There is evidence that dietary alterations influence the severity of aflatoxins. A high content of dietary fat decreases the mortality of chickens (22) and turkeys (14), while the effect of vitamin status on aflatoxicosis is less certain (11, 18).
A diet low in protein increases the severity of aflatoxicosis (1, 17, 19, 20). Diets fortified with protein have a protective effect in chickens (5, 9, 15, 22).
The objective of the current study was to elucidate the effect of a protein-rich and a protein-poor supplement on the performance of chicks fed a fungi-contaminated diet in practical subtropical conditions.

Material and methods

Sixty 15 days old Arbor Acres of the poultry farms in El-Minea were randomly divided into four groups of 15 chicks each. The birds were housed in brooders and provided with a source of heat and light. The chicks were vaccinated with a prophylactic dose against Newcastle disease and supplied with doses of furaltone, erythromycine and amprolium as prophylactic treatments against bacterial and parasitic diseases.
Serious health problems appeared with an elevation in morbidity and mortality rates in the birds. The clinical examination, post-mortem examination and the laboratory diagnosis carried on the affected birds showed that the problem was related to the diet and not due to other causes. Samples were taken from the diet for the detection the fungi content. A method for the determination or estimation of the mycotoxins was not available at the time of the current experiment at the Faculty of Veterinary Medicine of the Assiut University.
The result of examination indicated a heavy contamination with fungi, especially Aspergillus species, which are aflatoxin-producing moulds. This diet was used as a reference.
To investigate the effect of the protein level on a fungi-contaminated diet, soybean meal or corn starch were incorporated in the reference diet at a similar percentage to increase or decrease the level of protein by 5%. Mineral-vitamin supplement (premix), common salt and limestone were added in an attempt to balance the diet. Group 1 was fed the reference diet, i.e. the fungi-contaminated diet. Chicks of group 2 received a diet composed of 77.46% control diet, 22.15% soybean meal, 0.26% limestone, 0.07% common salt and 0.06 % premix (high protein diet). Group 3 was offered a diet composed of 77.30% control diet, 22.31% corn starch, 0.26% limestone, 0.07% common salt and 0.06% premix (low protein diet). Group 4 received a common feed, not contaminated with fungi. This feed was obtained from Agriculture Sector, Assiut Province, which is conventionally used in Assiut City.
The diets as well as fresh clean water were available *ad libitum* throughout the experimental period. Body weight increase and feed consumption of chicks in various groups were recorded along the 4 weeks of the experiment. The relative growth rate was calculated according to Crampton and Lloyd (7), while the feed conversion index was calculated using the weekly food consumption in relation to weight gain. Samples of soybean meal, corn starch and diets were chemically analysed according to the AOAC (3) for the determination of moisture, crude protein (CP), ether-extract (EE), crude fiber (CF) and ash. The chemical composition of the experimental feeds and diets are presen-

Table 1
Chemical composition of the experimental feeds and diets.

	Chemical composition, %						
Items	OM	CP	EE	CF	NIFE	Ash	DM
Feeds :							
Soybean meal	94.39	45.54	1.64	5.29	41.92	5.61	90.5
Corn starch	99.69	0.85	0.31	0.40	98.13	0.31	91.6
Diets :							
Diet 1 (control)	90.98	23.10	7.81	5.36	54.71	9.02	89.60
Diet 2 (high protein)	91.32	27.98	6.41	5.32	51.66	8.63	91.45
Diet 3 (low protein)	92.57	18.05	6.11	4.23	64.18	7.43	90.50
Diet 4 (normal diet)	92.45	22.39	8.42	3.21	58.43	7.55	93.80

Diet 1 : fungi-contaminated diet;
Diet 2 : 77.46% diet 1, 22.15% soybean meal and 0.39% mineral-vitamin supplement;
Diet 3 : 77.30% diet 1, 22.31 % starch corn and 0.39% mineral-vitamin supplement;
Diet 4 : non-contaminated diet.

Table 2
Average body weight changes (g) of chicks in the four groups.

Weeks	Group 1	Group 2	Group 3	Group 4
0	100 ± 5^{a}	102 ± 3^{a}	112 ± 8^{a}	105 ± 4^{a}
1	179 ± 9^{a}	193 ± 5^{b}	175 ± 6^{a}	206 ± 6^{c}
2	315 ± 21^{a}	345 ± 4^{b}	302 ± 7^{a}	366 ± 13^{c}
3	484 ± 24^{a}	615 ± 13^{b}	458 ± 10^{a}	664 ± 19^{c}
4	701 ± 26^{a}	984 ± 16^{b}	661 ± 14^{a}	1058 ± 18^{c}

Different indices within a row indicate a significant difference at $p<0.05$.
Group 1: fungi-contaminated diet (five chicks died);
Group 2: fungi-contaminated diet supplemented with soybean meal (two chicks died);
Group 3: fungi-contaminated diet supplemented with corn starch (six chicks died);
Group 4: non-contaminated diet (no chicks died).

ted in Table 1. The obtained data were analysed by Student's t-tests (26).

Results

Body weight changes (Table 2)
The average body weights at the start of the experiment were similar over the four groups. The three fungi-contaminated diets clearly suppressed the body weight gain of the broilers. The effect was already visible after the first week of the experiment and continued consistently to the end of the experiment.
However, due to the protein-rich supplement the broilers from group 2 were able to compensate to a large extent for this negative fungi effect, although the soybean supplemented birds did not fully recover as compared with the non-contaminated diet.
No significant differences were found between group 1 and 3, but there was a consistent tendency for the corn starch supplement to decrease the body weight gain. The protein-rich supplement increased the body weight by 283 g. On the contrary, the protein-poor supplement lead to a decrease in body weight by 40 g.

Weight gain and relative growth rate (Table 3)
From the first week already, the negative effects of the fungi on weight gain and relative growth rate could be noted. Over the whole experiment, weight gain was lower in the non-supplemented fungi-contaminated group (group 1) compared to the non-contaminated diet (group 4). In the first and the last weeks, the effect of the fungi was even more severe with corn starch. The opposite was observed for the soybean supplemented group, although the chicks could not keep up with the non-contaminated group, their average weight gains over the four weeks was considerably higher than the other two fungi-contaminated groups and were closer to the results of the non-contaminated group then they were to the other two groups. The data on the relative growth rate confirmed this information.

Feed intake and feed conversion index (Table 4)
The overall feed intake in the three fungi-contaminated groups was higher than in the non-contaminated group. Both the soybean and the corn starch supplemented groups had even higher feed intakes than the non-supplemented groups.
The feed conversion index for the non-contaminated group was the lowest, while the soybean supplemented group was slightly higher. The non-supplemented contaminated diet was characterized by a poor feed conversion, this result being more pronounced when corn starch was added.
The feed utilization for the three tested diets, as measured by the feed conversion index, varied with each diet. It was, on average, as high as 2.76 for diet 2, but as low as 4.71 for diet 3, while the contaminated diet had an intermediate efficiency of 3.69.

Discussion

The data show clearly that fungi severely affected the performance of broiler chicks, all studied parameters being affected in a negative way. These findings are in agreement with other data (4, 16) showing that fungi and mycotoxins decrease the growth rate and efficiency of feed utilization.
Adding a protein-poor supplement like corn starch to the fungi-contaminated diet did not improve the performance of the chicks. Furthermore, it seemed to induce even worse performance. The present findings

Table 3
Average weight gain (g) and relative growth rate (RGR) in the four groups.

	Group 1		Group2		Group3		Group4	
Weeks	Weight gain (g)	RGR %	Weight gain (g)	RGR %	Weight gain (g)	RGR %	Weight gain (g)	RGR %
0-1	78 ± 4 ^{b}	56	91 ± 3 ^{c}	62	69 ± 2 ^{a}	48	95 ± 3 ^{c}	61
1-2	136 ± 12 ^{ab}	55	151 ± 4 ^{b}	56	127 ± 2 ^{a}	53	165 ± 8 ^{c}	57
2-3	169 ± 6 ^{a}	42	271 ± 5 ^{b}	57	162 ± 5 ^{a}	43	298 ± 7 ^{c}	57
3-4	221 ± 6 ^{b}	37	369 ± 3 ^{c}	46	203 ± 5 ^{a}	36	388 ± 9 ^{d}	39

Different indices within a row indicate a significant difference at $p < 0.05$.
Group 1: fungi-contaminated diet (five chicks died);
Group 2: fungi-contaminated diet supplemented with soybean meal (two chicks died);
Group 3: fungi-contaminated diet supplemented with corn starch (six chicks died);
Group 4: non-contaminated diet (no chicks died).

Table 4
Average feed intake (g) and feed conversion index (FCI) in the four groups.

	Group 1		Group2		Group3		Group4	
Weeks	Feed intake	FCI	Feed intake	FCI	Feed intake	FCI	Feed intake	FCI
0-1	231	2.95	224	2.46	243	3.51	153	1.61
1-2	458	3.36	315	2.08	497	3.90	306	1.85
2-3	616	3.65	692	2.55	737	4.55	778	2.61
3-4	908	4.11	1200	3.25	1108	5.46	1033	2.66
0-4	2216	3.69	2436	2.76	2586	4.36	2096	2.20

Different indices within a row indicate a significant difference at $p < 0.05$.
Group 1: fungi-contaminated diet (five chicks died);
Group 2: fungi-contaminated diet supplemented with soybean meal (two chicks died);
Group 3: fungi-contaminated diet supplemented with corn starch (six chicks died);
Group 4: non-contaminated diet (no chicks died).

agree with other authors (1, 9, 17) who reported that diets low in protein make aflatoxicosis more severe in chickens. Similar conclusions were also drawn for other species (19, 20). It could be hypothesised that the protein content of this ration (18%) was too low in the experimental circumstances to allow normal growth. Moulds have a high protein content and could have accounted for a considerable part of the crude protein in the contaminated diets. By the addition of corn starch, the diet might have been too low in protein for optimal growth. Therefore, the positive action of the protein-rich supplement in this study could have been due to the increase of the actual protein level in the diet.
There is also a possible direct biochemical interaction between mycotoxins and proteins. The positive influence of a protein-rich supplement in fungi-contaminated feed is in accordance with other authors (5, 11, 15, 22). The effect of fungi on performance and the action of a protein-rich supplement appeared early in the experiment. Surprisingly, the birds on the contaminated diets ate more than those on the non-contaminated diet. The negative effect of fungi on growth can thus not be explained by lower feed intakes. It can be seen from the higher feed conversion indexes of the fungi-contaminated diets that the fungi reduced the nutritive value of the feeds. Increasing feed intake could thus be a behavioural response to the inefficient utilization of nutrients in these diets.
This hypothesis could also explain why the birds of the corn starch supplemented group ate even more than the non-supplemented fungi-contaminated group. A slightly decreased protein content in the feed enhances feed intake (8). The reason of the soybean addition causing the highest feed intake, is subject to several hypotheses and could be a topic for further research. The above cited data suggest that protein fortification in diets contaminated with fungi may reduce the toxicity.

Résumé : Effet d'un supplément alimentaire riche ou pauvre en protéines sur la nocivité d'une ration moisie sur la perfomance des poussins
Quatre essais ont été réalisés avec quatre groupes de 15 poussins Arbor Acres (15 jours d'âge) afin d'étudier l'influence d'un supplément alimentaire protéique sur la nocivité d'une ration moisie. Les poussins du premier groupe étaient nourris d'une ration moisie et le second recevait la même ration supplémentée de fèves de soja. Le 3e groupe obtenait aussi la ration moisie avec un supplément d'amidon de maïs tandis que le 4e groupe était nourri d'une ration courante non contaminée. La durée des essais était de 4 semaines. Les poussins alimentés d'une ration moisie ont été caractérisés par une perte du gain du poids corporel et du taux de croissance relative, d'une augmentation de l'indice de consommation ainsi qu'un taux de mortalité de 33%. L'addition d'un supplément protéique a amélioré tous ces paramètres de croissance et a réduit le taux de mortalité. Un supplément pauvre en protéine a occasionné par contre une détérioration de la croissance d'une manière significative ainsi qu'une augmentation du taux de mortalité jusqu'à 40%.
En conclusion, l'addition d'un supplément protéique à une ration moisie améliore la viabilité des poussins et limite les effets négatifs de moisissure sur la performance.

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