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Passage of *Salmonella* through the crop and gizzard of broiler chickens fed with fermented liquid feed

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*In vivo* experiments were conducted in order to investigate the passage and bacterial reduction of *Salmonella* in the crop and gizzard of chickens when fed two different feeds. The chickens were fed dry conventional feed and fermented liquid feed. The fermented feed contains a relatively high concentration of lactic and acetic acid and lactobacilli. One and three week old broiler chickens were necropsied at short intervals after inoculation with *Salmonella Enteritidis*. Counts of *Salmonella* from the crop, gizzard, duodenum, caecum and colon/rectum were obtained. This revealed a sharper decrease of *Salmonella* in the anterior parts of the gastro-intestinal tract in chickens fed with fermented feed than in chickens fed dry feed. It is therefore concluded that fermented feed improves the barrier formed by the crop and gizzard. The reduction of *Salmonella* is fully realised in the crop and gizzard. The lower intestinal compartment did not show a substantial effect on the reduction of *Salmonella*. The performed *in vivo* method appeared to be an appropriate way to study intervention strategies that aim to control *Salmonella* by improving the barrier function of the upper gastro-intestinal tract.

**Introduction**

Salmonella bacteria are a major problem to the poultry industry. This is largely the result of entry of these bacteria into the human food chain. Human infections take the form of a gastroenteritis, which in highly susceptible individuals can result in death. Means of increasing the resistance of poultry to infection are therefore being sought (Barrow, 2000). The objective of the present study was to investigate whether fermented liquid feed (FLF) further strengthens the acidic barrier formed by the crop and gizzard, and whether it thereby decreases the susceptibility of chickens for *Salmonella*.

The acidic environment of the stomach in mammals is a natural barrier against ingested pathogens (Giannella *et al*., 1973). The crop, proventriculus and gizzard form the anterior parts of the gastro-intestinal (GI) tract of chickens where the pH is low. The crop wall is colonised by Lactobacilli (Fuller, 1973; Fuller and Brooker, 1974; Barnes *et al*., 1980; Schneitz *et al*., 1993), which causes a decrease in pH by production of volatile fatty acids (Fuller, 1973). In the proventriculus hydrochloric acid and pepsine are secreted. In the gizzard, where feed is mixed and ground, the pH is about 2 to 3.

The inactivation of pathogens in the gizzard and crop needs to go quickly, because the passage of feed in young broiler chickens is fast (Shires *et al*., 1987; Buyse *et al*., 1993). The mean retention time of feed in the crop and gizzard is about 8 and 50
minutes respectively, and the mean retention time for the whole intestinal tract is about 6 hours in near 800 gram weighing broilers (Shires et al., 1987). In vitro studies showed that the environment in the upper intestinal tract of chickens, but especially the gizzard, effectively inactivate food pathogens. Cox et al. (1972) showed in vitro a total reduction of 6 log_{10} CFU Salmonella in the modelled gizzard (pH 2.6) and the modelled total intestine. In the crop and proventriculus only a 1 log_{10} CFU reduction was achieved. During in vitro studies with Campylobacter (Chang and Chen, 2000) a near complete reduction, with 5 log_{10} CFU at the start, was obtained in the simulated gizzard. In the crop and proventriculus the Campylobacter reduction was limited to 1.2 log_{10} CFU.

Despite the presence of this upper intestinal barrier, chickens can become infected with food pathogens under natural circumstances. This illustrates that Salmonella and other bacteria have the ability to survive the passage of the barrier part of the upper GI tract. This can be explained by the fact that in vivo passage of ingested fluid or particles from one intestinal compartment to another is not an all-at-once event but a dynamic process, which is in contrast to static in vitro circumstances. Thus some bacteria will pass quite directly to the duodenum and others stay longer in the crop or gizzard, fairly accidental. Besides this, it takes time before the crop or gizzard content is mixed and comes into contact with produced acids and remaining acid content. Consequently, some bacteria are shortly in contact with bacteriostatic or bacteriocidal substances in the first part of the intestine, whereas other have a longer contact. The passage of the anterior part of the intestine is therefore a stochastic process. Accordingly, it was chosen to assess the effect of Fermented Liquid Feed on the reduction rate of inoculated Salmonella Enteritidis (SE) in comparison with dry feed (control) fed chickens in vivo and not in vitro.

The hypothesis underlying this study was that Fermented Liquid Feed (FLF) improves the acidic barrier that is formed by the crop and gizzard, as it is rich in lactic acid and acetic acid, and it has a low pH. From pig husbandry it is known that farms that feed fermented by-products have a lower prevalence of Salmonella (Wolf et al., 2001). We have shown previously that broiler chickens that are fed fermented liquid feed are less susceptible for a single oral inoculation with Salmonella and Campylobacter than chickens on a normal diet (Heres et al., unpublished). When a low pH, high concentrations of lactobacilli and organic acids improve the barrier function of the crop and gizzard of FLF fed chickens, a faster reduction of Salmonella will occur in FLF fed broilers and less Salmonella will be observed in the duodenum and lower parts of the GI-track.

Materials and Methods

Bacterial strain

The Salmonella strain used for inoculation was a naladixic acid resistant Salmonella Enteritidis PF4 (SE-nalIR) originally isolated from processed poultry meat in a naladixic acid sensitive form. An overnight SE-nalIR culture in Buffered Pepton Water (BPW, Oxoid CM099) was used for inoculation. The overnight culture contained 5 × 10^7 CFU/ml in experiment A and 9.9 × 10^7 CFU/ml in experiment B. The culture suspension was kept on ice before and after inoculation. Of these suspensions 0.25 ml was applied orally, by dripping it at the pharyngeal site with a blunt needle. After applying of the inoculum no waste of the inoculum was observed.

Experimental design

The experiments were split into A and B. In experiment A, the chickens were 1 week old. This age was chosen because young chickens are extremely susceptible for Salmonella (Milner and Shafter, 1952). In experiment B the chickens were three weeks old. At this age chickens have larger intestines. It is therefore easier to sample content from these chickens than from young chickens.

In experiment A, 64 one-day old broilers were reared in two groups on litter. One group was fed a control feed, the other group was fed with FLF. At day 8 of the experiment 48 chickens were inoculated with Salmonella Enteritidis (SE). The inoculation-sampling intervals in experiment A were 10, 20, 30, 45, 60, 90, 120, and 360 minutes. Three chickens per interval per feed group were used.

In experiment B, 60 one-day old broiler chickens were reared in two groups on litter. During the whole study period one group was fed a control feed, the other group was fed FLF. At the 8th day of the study period the chickens were housed individually. At day 22 the chickens were inoculated and their organs were sampled. The time between inoculation and sampling was 20, 40, 60, 90, 120 or 360 minutes. For each inoculation-sampling interval 5 chickens per treatment group were used.

Sampling of the intestinal content was performed in the compartment where the chickens were housed. The temperature in the department was lowered from 27°C to 21°C at sampling. Chickens were euthanized with T61 (euthanaticum, Hoechst Roussel Vet BV, Amsterdam, The Netherlands), intracerebrally. The gastro-intestinal tract was removed from the chicken and was disinfected at the serosal surface with 70% alcohol. With disinfected instruments content of rectum/colon (not in experiment B), caecum, duodenum, gizzard and crop content was collected and suspended in 9 ml BPW. The weight of the content (approximately 1 gram) was noted so that the actual dilution per sample could be calculated afterwards.

Animals

Ross 508 broilers, originating from a flock with no history of previous Salmonella infection, were used. Eggs were hatched in the institute’s hatching cabin. Paper pads from the hatching cabin, from transport boxes and from fresh faecal droppings at day 8 were cultured to examine for the presence of Salmonella. As no Salmonellae could be detected in these samples and because the parent flock was free of Salmonella, it was concluded that the chickens were reared free of Salmonella. Faecal swabs of individually housed chickens were taken daily from day 8 to 21 in experiment B. No swab tested positive for Salmonella. The experiments were conducted according to the national ethical and animal welfare regulations and approved by an independent ethical committee.

Housing

In both experiments, A and B, the chickens were reared in two groups in separate compartments on litter. The pen in these compartments was 2.5 square meters in size. Individual housing pens measured 0.5 by 0.5 meter. Each pen had closed walls and ceiling, without the possibility of contact between animals housed in different pens. In experiment A the individual pens had a wired floor, in experiment B they had a solid floor with sawdust. The compartments were lighted 24h per day.
Feed and water
The dry control feed was a commercial broiler feed (Arkervaart-Twente, Leusden, The Netherlands). This antibiotic-free, growth promoter-free and pelleted feed was gamma sterilised with 0.9 Mrad. To prepare the fermented feed, 1.4 kg water was added to 1 kg of this dry feed. Five hundred grams of this liquid feed was inoculated with 1 ml of an overnight culture of Lactobacillus plantarum (Urrings et al., 1993) in De Man Rogosa-Sharpe-broth (MRS, Oxoid CM359). This mixture was incubated in sterile glass jars at 30°C for 24–48 hours (starter batch). Batches of 12.4 kg liquid feed were inoculated with 3 of these fresh starter batches and mixed thoroughly. Subsequently, the feed was incubated for 2 days at 30°C. A pH of 4 was reached after this fermentation. The number of lactobacilli in these batches was \(10^7\)–\(10^{10}\) CFU/g. The fermented feed was stored at 4°C until use. Feed was administered in small troughs with a wired cover. Feed was refreshed daily. Drinking water was acidified with fumaric acid, acetic acid, and propionic acid (7.5, 14.3, and 21.2 mmol/l respectively). Water was administered in 1 litre round drinkers. The chickens were fed ad lib throughout the experiment until necropsy.

Bacteriology
To determine the Salmonella free status of the chickens the paper pads and faecal samples were enriched in BPW (37°C, 18-24 hours). The enrichment culture was inoculated on Modified Semi-solid Rappaport Vassiliadis broth (MRS, Oxoid CM910, 42°C, 18-24 h). In order to determine the number of colony forming units of SE-nalIR, Brilliant Green Agar, (BGA, Oxoid, CM329) +100ppm naladixic acid plates (BGA +) were used. The BGA + plates were incubated at 37°C for 18 hours.

Intestinal content was sampled in 9 ml BPW (first dilution). Before serial dilutions (1:10) were made in BPW, samples were resuscitated during 1.5 hours at room temperature (20°C).

In experiment A, 100 µl from the first and second dilution of rectal/colonic, caecal and duodenal content were spread on BGA + plates. From the gizzard and crop 100µl of the first to fourth dilution were plated.

In experiment B, 1 ml of the first 1:10 dilution of caecal content was spread on spread 50 ml BGA + plates to enumerate SE in the caecal samples with 20, 40, 60, 90 and 120 minutes inoculation-necropsy intervals. Quantitative enumeration of SE in the caecal samples with the 360 minutes inoculation-necropsy interval was performed by track dilution(Jett et al., 1997). Therefore 10 µl of the first to sixth dilutions were put on a squared 50 ml BGA + plates. From duodenum and gizzard samples 100 µl of the first and second dilution were spread on BGA + plates. From the crop samples 100 µl of the first to fourth dilution were plated.

In both experiments approximately 0.1 gram of duodenal and gizzard content was directly spread on BGA + plates at the time of sampling. The first dilution in BPW of all samples was enriched at 37°C for 24 hours and thereafter plated on BGA +

Statistical analysis
Colonies on count plates were transformed to log₁₀ CFU/g according to standard procedures. If one or more Salmonella colonies were found on the direct plating of intestinal content and after enrichment but not on any of the count plates the colonisation level was set at 1.0 log₁₀ CFU/g. If Salmonella was exclusively found after enrichment the number was set at 5 CFU/g (\(≈ 0.7\) log₁₀ CFU/g). If in a sample no Salmonella was detected the number was set at 1 CFU/g (\(≈ 0.0\) log₁₀ CFU/g). Per time point, per intestinal organ a Students' T-test was performed in MS-excel for statistical testing of differences between counts obtained from chickens fed control feed and FLF.

Results
The log₁₀ number of colony forming units per gram intestinal content (CFU/g) at the different intervals after inoculation are shown (Figure 1) per sampled part of the gastro-intestinal (GI) tract. Statistical differences are indicated with asterisks. In Tables 1 and 2 the number of SE positives samples is shown to provide more details about the prevalence of SE in the different organs. It was intended to gather 1 gram of content. In experiment A the average weights of sampled content of the crop, gizzard, duodenum and caecum were respectively 0.7, 1.0, 0.2, 0.5 and 0.4 gram. There was no significant difference between the sample weights of the FLF and the dry feed group. In experiment B the average weights were 1 gram, except for the duodenum. Here the average sample weights were significantly different (\(\times < 0.05\)) with 0.7±0.2 for the FLF and 0.9±0.2 for the dry feed group.

Crop
In both experiments a fast decrease of SE is seen in the FLF group, but not in the group of dry feed chickens. In experiment A there is hardly any reduction of Salmonella in the crop of dry feed chickens, whereas the number of Salmonella is reduced with 3 log₁₀ in the FLF chickens. SE counts were significantly different (\(\times < 0.01\) and \(\times < 0.05\)) at the 90 and 120 minutes intervals. In experiment A, in contrast to experiment B, SE was detected in the crop in FLF fed chickens until 6 hours following the inoculation. In experiment B with 3 week old chickens no SE was detected in the crop of chickens fed FLF 2 and 6 hours p.i.. In the dry feed group of experiment B the SE number in the crop was only slightly decreased after 6 hours and still present in all samples. SE counts were significantly different from 60 minutes p.i. onwards.

Gizzard
In experiment A, SE could not be detected in the directly plated samples of the gizzard of FLF fed chickens, and the last positive sample was found at 30 minutes p.i. after enrichment. In the dry feed groups the CFU of SE could be estimated on the directly plated samples during the first 1.5 hours and Salmonella was even detected at 6 hours after inoculation in two out of 3 samples. The SE counts were not significantly different. In experiment B the decrease in CFU was comparable with that obtained from the crop in both feed groups although the levels were lower. After 1 hour, Salmonella was detected in 1 out of 20 samples of the FLF group, whereas in the dry feed group, 15 of 20 samples were SE positive in experiment B. SE counts were significantly different (\(\times < 0.05\) and \(\times < 0.01\)) at 60 and 120 minutes p.i.
Figure 1. Comparison of Salmonella Enteritidis counts in the crop, gizzard, duodenum, caecum and colon/rectum of broiler chickens fed with dry feed and fermented liquid feed at different intervals after inoculation in two experiments A and B.
<table>
<thead>
<tr>
<th>Feed group:</th>
<th>10</th>
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<th>30</th>
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<th>60</th>
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<td>0</td>
<td>2</td>
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<td>0</td>
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**time after inoculation (minutes)**

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</table>

*DF = dry feed group, FLF = Fermented Liquid Feed group.*

*between brackets are the number of samples that were only positive after overnight enrichment.*
Table 2. Number of Salmonella enteritidis positive samples from the crop, gizzard, duodenum, and caecum of chickens fed Fermented Liquid Feed and Dry feed at different time intervals after inoculation (experiment B, n = 5)

<table>
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<th>Feed group:</th>
<th>20</th>
<th>40</th>
<th>60</th>
<th>90</th>
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<tr>
<td>Crop</td>
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<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>2</td>
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<tr>
<td>Gizzard</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Duodenum</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Caecum</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
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</tr>
</tbody>
</table>

*DF = dry feed group, FLF = Fermented Liquid Feed group.
*between brackets are the number of samples that were only positive after overnight enrichment.

**Duodenum**

As in the crop and gizzard, the counts of SE in the duodenum declined after inoculation in both groups. In the FLF group the levels were lower than in the dry feed group. Two hours after infection no Salmonella could be detected in the FLF group of chickens, whereas 2 out of 3 chickens (exp. A) and 3 out of 5 chickens (exp. B) were SE positive in the dry feed group. In experiment B SE counts were significantly different at the 60 and 120 minutes interval \( P < 0.01 \)

**Caecum**

In both experiments the counts of SE in the caeca were higher in the FLF group at 2 hours following infection. At the end, the average number was larger in the control groups. Unexpectedly, in the caecum of dry feed fed chickens of experiment A, 1 respectively 2 caecal samples were already positive at 20 and 30 minutes after inoculation. Also in experiment B there was one positive sample at 40 minutes p.i. already in the dry feed group. Only at 90 minutes p.i. in experiment B, SE counts were significantly different \( P < 0.05 \).

**Colon/rectum**

The sampling results of the colon/rectum in experiment A were comparable with the sampling results of the caecum. No significant differences were observed.

Both experiments showed the same trend and differences between feed groups. The results of experiment B are more sensitive and precise. This is a result of a larger number of samples and the larger amount of sample available in the 3-week-old chickens, than in the 1 week old chickens of experiment A. In experiment A, counts were only significantly different in the crop. In experiment B significant differences were also observed in gizzard, duodenum and caecum.

**Discussion**

The present study confirms that fermented liquid feed (FLF) improves the upper intestinal barrier against the food born pathogen Salmonella. The results clearly show that the CFU’s of *Salmonella* Enteritidis decrease faster in the crop and gizzard of FLF fed chickens, than in chickens fed a normal diet. It therefore appears that less Salmonella will pass the crop and gizzard of FLF fed chickens.

In chickens fed dry feed the decrease of viable SE in the crop was limited to 0 or 1 log_{10} cfu in 2 hours in experiment A and B respectively. This small decrease corresponds with the reduction found *in vitro* by others (Cox et al., 1972). But this small decrease in the crop can also be assigned to clearance by passive passage with feed. Even in the gizzard of chickens fed dry feed the reduction of Salmonella was limited. Whereas especially in the gizzard a reduction would be expected, as the pH in the gizzard is low, i.e. about 2 (Ford, 1974).

Fermented feed may improve the acid barrier because it contains high concentrations of lactic acid and acetic acid. The concentration of lactic acid and acetic acid in FLF were 24.4 ± 6.0 mg/g and 4.80 ± 0.84 mg/g respectively (Heres et al., unpublished). The acids are bactericidal at a low pH, for instance in the crop (pH between 4 and 5) and gizzard (pH between 2 and 3). At a pH close to the pKa of the organic acid molecules, these molecules will appear in higher concentrations in the non-dissociated form. In that state, the organic acid molecules pass the membrane of the bacterial cell by diffusion. After intracellular dissociation it causes the intracellular pH to decrease and causes the organic acid to accumulate in the cell. Enzymes that are pH dependent become inactive and
organic acids have toxic effects on their own. Both effects cause cell death (Russell and Diez Gonzalez, 1998). Lactic acid also functions as a permeabiliser of the gram-negative bacterial outer membrane and may act as a potentiator of the effects of other antimicrobial substances (Alakomi et al., 2000). Winsen et al. (2000) showed a reduction of Salmonella in fermented feed.

An alternative explanation for the faster decrease of Salmonella in the crop and gizzard of FLF fed chickens, namely a faster clearance due to a higher passage rate of fermented feed, was rejected. The reduction of 2 to 6 log CFU is too high to support this. Moreover, if the observed differences were an effect of faster passage, higher levels of Salmonella would have been found in the anterior parts of the intestine, i.e. duodenum, and Salmonella would have been detected there earlier, which is not in accordance with the results.

In vivo passage experiments, as described here, have, as far as we know, not been performed previously. In vitro experiments taking into account the mean passage time for the different parts of the intestines showed a major reduction in the first parts (the crop and proventriculus, but especially the gizzard) of the GI-tract (Cox et al., 1972; Chang and Chen, 2000). The present results indicate that these previously described in vitro models of bacterial reduction in the anterior part of the GI-tract, provide a too simplified representation of reality. A total reduction in counts from the gizzard was not observed in chickens fed dry feed in contrast to the large reduction observed in previous in vitro experiments. The passage of intestinal content is a dynamic and not a static process as mimicked in in vitro models. In real live some bacteria are only shortly, whereas others have a longer contact period with bacteriostatic or bacteriocidal substances in the first part of the GI tract. By gathering intestinal contents at different inoculation-sampling intervals, at different locations in the GI tract, the effect of this dynamic process is accounted for.

A high inoculation dose of SE was chosen to be able to compare the levels of colony forming units in the different parts of the gastro-intestinal tract. It was a priori known that in both feed groups Salmonella would reach the caecum, because in previous experiments 10^7 CFU SE finally colonised all chickens fed dry feed and all FLF fed groups (Heres et al. unpublished). It was unexpected however, that already at 20 to 40 minutes p.i. Salmonella positive samples could be observed in the caeca of chickens fed with dry feed. In studies where feed markers have been included the first markers are detected in the faeces after 1 hour and the markers are totally recovered within 24 hours (Sturkie, 1986). The Mean Retention Time (MRT) of feed markers in the intestines is 338 ± 10.8 min. The MRT in the crop, gizzard, duodenum, caecum and colon are 7.4, 50.2, 7.2, 78.7 and 44.4 minutes respectively in a near 800 gram broiler (Shires et al., 1987). The observation that Salmonella was already prevalent in the caecum and colon/rectum at 20, 30 and 40 minutes after inoculation of dry feed chickens is therefore unexpectedly fast. This observation is even more complicated as at the following 1 hour interval no Salmonella was detected in these parts. The early presence of Salmonella in the caeca and colon/rectum may nevertheless indicate that infections of Salmonella can spread very rapidly through a poultry population. This could result in contamination of chickens during transport to the slaughterhouse, because contaminated transport vehicles may result in Salmonella infected chickens, which are shedding bacteria within 1 hour after start of the transport.

Chicken crops are far more likely to rupture than caeca during the slaughter process. They therefore increase the risk of carcass contamination with Salmonella derived from the crop contents (Hargis et al., 1995). If Salmonella decreases faster in the crop of FLF fed chickens the risk of carcass contamination may be reduced. This last implication must be interpreted with care, because the velocity of Salmonella reduction in the crop and gizzard content was not tested in chickens under feed withdrawal as normally done in chickens going to slaughter. Feed withdrawal goes hand in hand with increased risk for Salmonella in the crop (Hinton et al., 2000).

High amounts of lactic acid bacteria were fed with FLF. In the caeca of chickens fed with FLF, lactobacilli are present at high levels (Heres et al. unpublished). However, these lactobacilli did not prevent the multiplication of the Salmonellas that reached the caecum. It is therefore questionable whether probiotics could prevent colonisation of Salmonella in the caeca, unless there are specific lactobacilli that have specific negative interactions with Salmonella.

If chickens fed with FLF are exposed to low numbers of Salmonella, in contrast to the high levels applied in the present experiments, there is an increased possibility that no Salmonella passes the crop and gizzard of these chickens. Therefore, there might be a reduced probability for chickens fed with FLF to become colonised after low-level exposure.

It is concluded that fermented liquid feed has a substantial effect on the improvement of the upper intestinal barrier against Salmonella in broiler chickens. Moreover, the applied in vitro study appeared to be a suitable method to evaluate the effect of intervention strategies that aim to improve the acidic barrier in the upper GI-tract by causing bacterial reduction.
Acknowledgements

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References


Résumé

Passage de Salmonella au travers du jabot et du gésier de poulets nourris avec un aliment liquide fermenté

Des expérimentations in vivo ont été réalisées pour étudier le passage et la réduction bactérienne de Salmonella dans le jabot et le gésier de poulets nourris avec deux aliments différents. Les poulets ont été nourris avec un aliment conventionnel sec et un aliment liquide fermenté. L'aliment fermenté contenait une concentration relativement forte d'acides aérobies et lactiques ainsi que des lactobacilles. Les poulets de chair âgés d'une et trois semaines ont été autopsiés à des intervalles courts après l'inoculation de Salmonella Enteritidis. Des comptages de Salmonelle ont été réalisés à partir du jabot, gésier, duodénum, caecum et colónrectum. Les résultats ont montré une diminution plus nette de Salmonella au niveau des parties antérieures du tractus gastro-intestinal chez les poulets nourris avec l'aliment fermenté que chez ceux nourris avec l'aliment sec. Il a donc été conclu que l'aliment fermenté améliore la barrière formée par le jabot et le gésier. La réduction de Salmonella est totalement réalisée dans le jabot et le gésier. La partie inférieure du tractus digestif n'a pas montré d'effet substantiel sur la réduction de Salmonella. La méthode expérimentale réalisée in vivo semble être un moyen approprié pour étudier les stratégies du contrôle des Salmonelles en améliorant la fonction de barrière jouée par le tractus gastro-intestinal supérieur.

Zusammenfassung

Passage von Salmonellen durch den Kropf und Muskelnagen von mit fermentiertem Flüssigfutter ernährten Broilern


Resumen

Pase de Salmonella a través del buey y molleja de pollos de engorde alimentados con alimento líquido fermentado

Se realizaron algunos experimentos in vivo para investigar el pase y la
reducción de Salmonella en el buche y molleja de pollos al ser alimentados con dos tipos de alimento diferentes. Los pollos fueron alimentados con alimento convencional y alimento líquido fermentado. El alimento fermentado contiene una concentración relativamente alta de ácido láctico y acético, y lactobacilos. Se necropsiaron pollos de una y tres semanas de edad en cortos intervalos de tiempo tras la inoculación con Salmonella enteritidis. Se obtuvieron contajes de Salmonella del buche, molleja, duodeno, ciego y colon/recto. Estos contajes revelaron una marcada disminución de Salmonella en las partes anteriores del tracto gastrointestinal en pollos alimentados con un alimento fermentado en comparación con los alimentados con el alimento seco. Por lo tanto se concluye que el alimento fermentado mejora la barrera formada por el buche y molleja. La reducción de Salmonella es evidente en la molleja y buche. El compartimento intestinal posterior no mostró un efecto sustancial en la reducción de Salmonella. El método in vivo realizado parece apropiado para estudiar las estrategias de intervención que tienen como objetivo controlar la Salmonella mediante la mejora de la función de barrera de la parte anterior del tracto gastrointestinal.