AN ABSTRACT OF THE THESIS OF

Mark Bland for the degree of Master of Science

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Title: Effect of Mount St. Helens' Volcanic Ash on Broiler Chicken Respiratory and Digestive Tracts, Growth, Feed Efficiency and Poultry House Environment

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Abstract Approved: Dr. H. S. Nakaue

I. DURATION OF EXPOSURE--HISTOLOGICAL EFFECTS ON BROILER LUNGS, PERFORMANCE, AND HOUSE ENVIRONMENT WITH MT. ST. HELENS' VOLCANIC ASH DUST

Fourteen hundred broilers were exposed to Mt. St. Helens' volcanic ash (A) dust (D) from 28 to 49 days of age to correlate the duration of exposure time to histological effect on lungs, and to determine the effects on broiler performance and house environment.

Histological examinations of the lungs from birds exposed for four days to either AD for 60 min (AD 60) in the morning and afternoon, daily (3276 g ash/day) or AD after one direct (Di) application (Ap) (20 kg/m^2) on wood shaving litter revealed mild lymphoid hyperplasia and granuloma formation accompanied by phagocytized crystalline material seen in some alveolar macrophages; however, no effect was observed in lung tissues from broilers exposed for four days to AD for 15 min

(AD 15) in the morning and afternoon, daily (82 g ash/day). Birds exposed to all AD treatments and examined after seven days had similar histological changes in the lungs as those seen at four days including giant cell granuloma formation. No significant histopathological changes were found in the turbinates and air sacs with any AD treatments.

Mean body weight, ammonia concentration, mortality and respiratory dust (particles ranging in size from 0.5 to 10 μm) levels were not significantly different among the treatments. Significantly poorer mean feed conversion was observed with broilers exposed to AD 60 than the A Di Ap exposure. No difference in feed conversion was observed between the control and either AD 15 or AD 60 treatments. From this experiment, the observed histological changes in the lungs occurred four days of exposure or less at AD 60 (3276 g/day).

II. THE EFFECTS OF MOUNT ST. HELENS' VOLCANIC ASH ON THE DIGESTIVE TRACTS OF BROILERS

Six hundred and eighty broilers were fed 15% and 30% of either sand (S) or Mt. St. Helens' volcanic (V) ash (A) in a corn-soybean diet for seven weeks to determine the histological effects and mineral levels of selected tissues and to determine the broiler performance.

Histological examinations of the crop, proventriculus, gizzard, duodenum, ceca, and colon from broilers fed either 30% S or 30% VA for seven weeks revealed no significant abnormal tissues. Broilers fed either 30% S or 30% VA to seven weeks of age had significantly lower zinc and aluminum levels in the lungs than in the lungs of the control

birds. No significant differences in the levels of iron, calcium, lead, silicon, and mercury were observed in the tibia, liver, and lungs among the dietary treatments.

Mean body weights for broilers fed 30% VA were significantly lower than the control, 15% S and 15% VA treatments. No significant differences were found between the 30% S and 30% VA. Birds fed the two highest levels of S or VA had significantly poorer feed conversion than the control group.

Broilers fed either 30% S or VA had significantly wetter litter at seven weeks of age than did either the 15% S or 15% VA treatments. No significant differences in mortality were observed between the treatments. VA fed birds showed a decrease in body weights and displayed no detrimental effects on the digestive tracts.

EFFECTS OF MOUNT ST. HELENS' ASH ON BROILER CHICKEN RESPIRATORY AND DIGESTIVE TRACTS, GROWTH, FEED EFFICIENCY AND POULTRY HOUSE ENVIRONMENT

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EFFECT OF MOUNT ST. HELENS' VOLCANIC ASH ON BROILER CHICKEN RESPIRATORY AND DIGESTIVE TRACTS, GROWTH, FEED EFFICIENCY AND POULTRY HOUSE ENVIRONMENT

INTRODUCTION

On May 18, 1980 Mount St. Helens erupted, spreading volcanic ash an estimated 1.5 to 2.0 cubic kilometers on farms, range, and forest land reaching eastward almost to the Dakotas and northward into Canada (Cook, et al., 1981). Large numbers of farm animals, wildlife, insects, plants, and humans were exposed to volcanic ash from this and subsequent eruptions.

Up to this time the majority of publications dealing with volcanic ash were concerned with its effects on plant and insect life (Smathers, 1974; Kratky, et al., 1974; Philogene, 1972; Khomentovskii, 1979) reported from various eruptions throughout the world. No information was available on the effects of volcanic ash on commercial or wild avian populations. However, since the initial eruption of Mount St. Helens, several reports have dealt with ash exposure to mammals (Huber, 1980; Akematsu, 1982; Castranda, et al., 1982; Sanders, 1982) with two of these dealing with birds (Smith 1980; Nakaue, et al., 1982). Obviously wild birds may be more severely effected by the exposure to volcanic ash, more so than the commercial birds since they are outdoors. However, commercial birds can serve as excellent test models for volcanic ash studies in avian species since they are anatomically and physiologically quite

similar. Information on both types is desirable but not readily obtainable with wild birds.

When wild or commercial birds are exposed to volcanic ash, there are two major routes that volcanic ash may enter the bird, through ingestion and inhalation. The two studies reported here deal with the effects of volcanic ash on the digestive and respiratory tracts, bird performance and house environment. In the first experiment, broilers were exposed to volcanic ash dust through aerosol exposure. The respiratory tracts were examined microscopically and histologically. The rate at which any histological changes occurred in the respiratory tracts was determined. In the second experiment, broilers were fed 15 and 30 percent volcanic ash in the feed and the histological effects of the intestinal tracts determined. Broiler performance was monitored in both experiments.

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CHAPTER II

DURATION OF EXPOSURE--HISTOLOGICAL EFFECTS ON BROILER LUNGS, PERFORMANCE, AND HOUSE ENVIRONMENT WITH MT. ST. HELENS' VOLCANIC ASH DUST[1]

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ABSTRACT

Fourteen hundred broilers were exposed to Mt. St. Helens' volcanic ash (A) dust (D) from 28 to 49 days of age to correlate the duration of exposure time to histological effect on lungs, and to determine the effects on broiler performance and house environment.

Histological examinations of the lungs from birds exposed for four days to either AD for 60 min (AD 60) in the morning and afternoon, daily (3276 g ash/day) or AD after one direct (Di) application (Ap) (20 kg/m^2) on wood shaving litter revealed mild lymphoid hyperplasia and granuloma formation accompanied by phagocytized crystalline material seen in some alveolar macrophages; however, no effect was observed in lung tissues from broilers exposed for four days to AD for 15 min (AD 15) in the morning and afternoon, daily (82 g ash/day). Birds exposed to all AD treatments and examined after seven days had similar histological changes in the lungs as those seen at four days including giant cell granuloma formation. No significant histopathological changes were found in the turbinates and air sacs with any AD treatments.

Mean body weight, ammonia concentration, mortality and respiratory dust (particles ranging in size from 0.5 to 10 μm) levels were not significantly different among the treatments. Significantly poorer mean feed conversion was observed with broilers exposed to AD 60 than the A Di Ap exposure. No difference in feed conversion was observed between the control and either AD 15 or AD 60 treatments. From this experiment, the observed histological changes in the lungs occurred four days or less exposure to AD 60 (3276 g/day).

INTRODUCTION

On May 18, 1980, a cataclysmic explosion of Mt. St. Helens, a mountain in Southwestern Washington, resulted in 59 people dead or missing, leveled 240 square kilometers of forest and deposited a cloud of ash into the atmosphere that circled the Earth. The threat of more ash-like eruptions from Mt. St. Helens and the potential volcanic activity of other volcanoes in the Western United States and Mexico, suggest that the effect of volcanic ash influence on poultry is an issue to be addressed.

To date, the immediate effect of volcanic ash on poultry health is not known but has been related more to power outages, the plugging of various filters, and the loss of transportation facilities for poultry, feed and eggs.

Research data (Castranova, et al., 1982) have concluded that volcanic ash has some toxic effects on the alveolar macrophages within the lung tissue of animals; however, additional studies by Smith (1980), Huber (1980), and Nakaue, et al. (1982) have shown that volcanic ash is not toxic to the overall health and performance of chicks and rats. Smith (1980) reported that Dr. J. McGinnis of Washington State University found no adverse effects on growth and health of chicks when fed diets, ad libitum, containing volcanic ash levels of 10, 20 and 30 percent. In a preliminary toxicological study with volcanic ash, Huber, et al. (1980) noted that laboratory rats were very tolerant to ingested and saturated solutions of volcanic ash. Castranova, et al. (1982) monitored the toxicity of

volcanic ash on alveolar type II epithelial cells, lung microsomes, and alveolar macrophages from rabbits and rats. The results from this investigation showed little effect on oxygen consumption of rabbit type II cells, oxygen consumption or superoxide released of resting rat alveloar macrophages, and membrane integrity of rat alveolar macrophages. However, stimulated rat alveolar macrophages showed that volcanic ash does inhibit antibacterial potency of these macrophages (Castranova, et al., 1982). Sanders (1982) reported that 40 mg of volcanic ash intratrachially instilled into rats caused an ill-defined inflammatory reaction. Some of the rats showed granuloma formation, a limited linear fibrosis, and a moderate lipoproteinosis. Lymph nodes were enlarged with numerous microgranulomas but without reticulum and collagen formation. Nakaue, et al. (1982) reported that broilers exposed to no volcanic ash and to aerosol inductions of volcanic ash at 21 days of age for four weeks showed no significant differences for mean body weights, feed conversion, atmospheric ammonia levels, mortality, and carcass quality. Broilers exposed to volcanic (V) ash (A) dust (D), by direct application (10 kg/m^2) on the litter and VA for six hours showed phagocytized crystalline material within alveolar macrophages, and moderate lymphoid hyperplasia in lung tissue after a four week exposure period. Microscopic examination of nasal turbinates for all treatments revealed no significant changes.

The purpose of this experiment was to focus attention on the correlation of the dosage rate to time exposure effects on the histological changes in the lungs of broilers, broiler performance, and house environment with volcanic ash.

MATERIALS AND METHODS

Approximately 1400 day-old commercial broiler chicks of mixed sexes were housed in a windowless, uninsulated, mechanically ventilated house. There were four treatments with two pens per treatment. Each pen (3.1 m x 4.3 m) contained 178 chicks. The birds in the control treatment group had no exposure to VA. The second treatment, one direct application (Di Ap) of VAD, was applied on the wood shaving litter at a rate of 20 kg/m^2 of floor space at 28 days of age. The third and fourth treatments involved aerosol induction of ash into the pens to create a dusty environment simulating conditions following an eruption. The periods of daily aerosol exposures for treatment three were from 0830 to 0845 hr and 1530 to 1545 hr, daily (AD 15) and from 0830 to 0930 and 1530 to 1630 hr, daily (AD 60) for treatment four. These birds were subjected to the treatments from 28 to 49 days of age.

The pens were negatively ventilated with an exhaust fan in each of the eight pens. The fans were controlled by a time clock operating 15 min on, 45 min off from 17-42 days of age. These fans were adjusted to 30 min on, 30 min off from 43 to 49 days of age. The fans operated daily from 2000 hr to 0800 hr except during the fifth week when a heat wave with temperatures exceeding 38C was experienced. For this reason, the fans were also operated from 1100 to 1500 hr, on and half hr during this time. The ventilating fans in each pen were not operated during the periods when ash was blown.

Brooding and management procedures were followed according to the procedure of Dorminey and Nakaue (1977). Bird density was 0.08 m^2/bird. Litter consisted of wood shavings at a depth of 8 cm. Feed and water were provided ad libitum throughout the test. The feeding program consisted of a 23% crude protein starter mash from one to 24 days of age. A 21% crude protein finisher mash was fed from 25 days of age to the termination of the study.

The volcanic ash used in this experiment was collected in Western Oregon following the June 12, 1980 eruption. Mineral content of the ash from the eruption was similar to the May 18, 1980 eruption (Schneidegger and Federman, 1982). The ash was sun dried and screened to remove coarser material prior to use.

The apparatus used to blow the ash into the pens consisted of an air blower, above which an extended conic plastic funnel (20.2 cm) was fitted. Within this plastic funnel an inverted metal funnel was placed with a specific number of holes to enable the ash to flow without obstruction. Measured amounts of ash were placed in the plastic funnel daily and vibrated into the blower tube by an agitator. The flow rate was regulated manually with a valve. Ash was blown into the pens through a large plastic tube (10.2 cm diameter).

Mean body weights, incidence of mortality, and feed consumption were measured during the 28 to 49 day production period.

A LaMotte[2] air sampling pump was used to measure the atmospheric ammonia levels in each of the eight pens on 0, 10, 15, and 20 days of ash exposure. Air was collected in a dilute sulfuric acid solution for ten minutes at a rate of two liters/minute. To these

solutions one ml of Nessler's Reagent was added to create an orange-brown color with the intensity read on a spectrophotometer at 240 nm against a dilute sulfuric acid blank. Atmospheric pressure, temperature and air flow rate were considered in the final calculation. A Royco particle counter[3], model 218, was used to measure respiratory dust particle levels varying from 0.5 to 10 μm in diameter and total settled dust was measured on the 0 and 20 day of ash exposure. The total settled dust was sampled by placing three petri dishes (9.0 cm diameter) 1.22 m above the litter floor from 0815 to 1645 hr (8.5 hr) and another three petri dishes from 1645 to 0815 hr (15.5 hr) per pen. The dust samples were weighed and oven dried at 100C for 48 hours and weighed after equilibration to room temperature in dessicators.

Litter moisture levels were determined at the end of the ash exposure. Four litter samples of approximately 500 grams each were taken from different areas in each pen. Approximately five grams of the mixed pooled samples from each pen were oven dried at 100C for 48 hr and equilibrated to room temperature. The cooled samples were reweighed and percent moisture calculated.

All mortalities after seven days of age were necropsied.

USDA inspectors from a commercial processing plant determined carcass condemnation for each treatment at processing time.

From one male and one female per pen at 0, 4, 7, 10, 14, 17, and 21 days of ash exposure, lung and turbinate tissues were sampled and preserved in 10% neutral duffered formalin solution. Tissues from birds following 4, 7, 14, and 21 days of ash exposure were

prepared by embedding in paraffin from which six μm sections were made and stained with hematoxylin eosin for light microscopic examination.

The data were analyzed by one-way analysis of variance and significant treatment means separated by the least significant difference test (Snedecor and Cochran, 1980).

RESULTS AND DISCUSSION

Microscopic examination of the lung tissue from birds exposed to volcanic ash showed varying degrees of lymphoid hyperplasia and granuloma formation with phagocytized crystalline material seen in some macrophages following four days of exposure to volcanic ash in A Di Ap and AD 60 treated pens. Normal lung tissue from a control bird with no ash exposure is shown in Fig. 1. Mild lymphoid hyperplasia and presence of lymphoid follicles were observed in lung tissue from a broiler exposed to AD 60 twice daily, for four days of ash exposure (Fig. 2). Crystalline material was evident in the macrophages from birds exposed to AD 60 (Fig. 3). The ash crystals, being an irritant, caused an accumulation of alveolar macrophages forming granulomas in the lung tissue. Giant cell formations were seen around granulomas at seven days of ash exposure to AD 60 (Fig. 4). The presence of giant cells are usually seen several days after the formation of granulomas. Lung tissues from birds exposed for four days to A Di Ap also showed mild lymphoid hyperplasia and granuloma formation with phagocytized crystalline material seen in macrophages. No histological effects were observed in lung tissues from broilers exposed four days to AD 15, twice daily. This could be due to the significantly lower total dust levels seen in pens treated with AD 15 (Table 3). There were no significant histopathological changes found in the turbinates and air sacs with any of the ash treatments.

There were no significant differences observed among the treatments for mean body weight and mortality (Table 1). This finding

concurs with Nakaue, et al. (1982). Feed conversion was significantly better for broilers exposed to A Di Ap than the broilers grown in the control pens or in pens with ash blown in.

Data for mean ammonia level and litter moisture are presented in Table 2. No significant differences in mean ammonia concentrations were observed before and at 10 and 20 days of exposure. On the 15th day, pens with A Di Ap had significantly lower ($P \leq 0.05$) mean ammonia levels than the pens with ash blown in. Mean litter moisture in A Di Ap and AD 60 treated pens were significantly lower ($P \leq 0.05$) than the control and AD 15 treated pens (Table 2).

Mean respiratory dust and total dust data after volcanic ash treatments are presented in Table 3. No significant differences in respiratory dust levels were noted at the conclusion of the experiment. Total settled dust levels between the periods from 0815 to 1645 hr and from 1645 to 0815 hr at 21 days of ash exposure in control and AD 15 treated pens showed no significant differences (Table 3). During the period from 0815 to 1645 hr, AD 60 treated pens were significantly dustier than the control and AD 15 treated pens. A Di Ap treated pens were significantly dustier than the control, AD 15, and AD 60 at the conclusion of the experiment. During the 1645 to 0815 period, no significant differences were observed between the A Di Ap and AD 60 treated pens. Carcass condemnation data (Table 3) indicated no adverse effect on carcass quality of market broilers with VA exposure at processing time, which is in agreement with Nakaue, et al. (1982).

Earlier reports showed that volcanic ash crystals had no potential for cytotoxicity and fibrogenic capabilities to alveolar macrophages. This was shown by its lack of an effect in trypan blue exclusion assay (Fruchter, et al., 1980). Although trypan blue exclusion has been shown to be less sensitive assay for toxicity to alveloar macrophages, Castranova, et al. (1982) concluded that in vivo ash exposure in rats is moderately toxic (intratracheal injection of 9 mg ash/int.) to the lung due to the fact that it does inhibit the antibacterial potency of alveolar macrophages as monitored by superoxide release.

In general, overall broiler performance and carcass quality were not significantly affected by the short-term exposure to volcanic ash. It appears that the relationship of volcanic ash to respiratory diseases in commercial poultry seems to be minimal.

This study showed that volcanic ash exposure following either directly applied or AD 60 initiated an inflammatory reaction in the lungs of broilers as early as four days.

Volcanic ash can apparently inhibit the secretion of antibacterial substances from alveolar macrophages; therefore, may decrease the ability of the macrophage to protect the lung from secondary respiratory infections over a period of time. However with short time ash exposure, no respiratory infection was noticed in this experiment.

Figure 1. Normal lung tissue 10x

Figure 1.

Figure 2. Mild lymphoid hyperplasia (LH) and lymphoid follicles (LF) in lung following inhalation of volcanic ash 25x

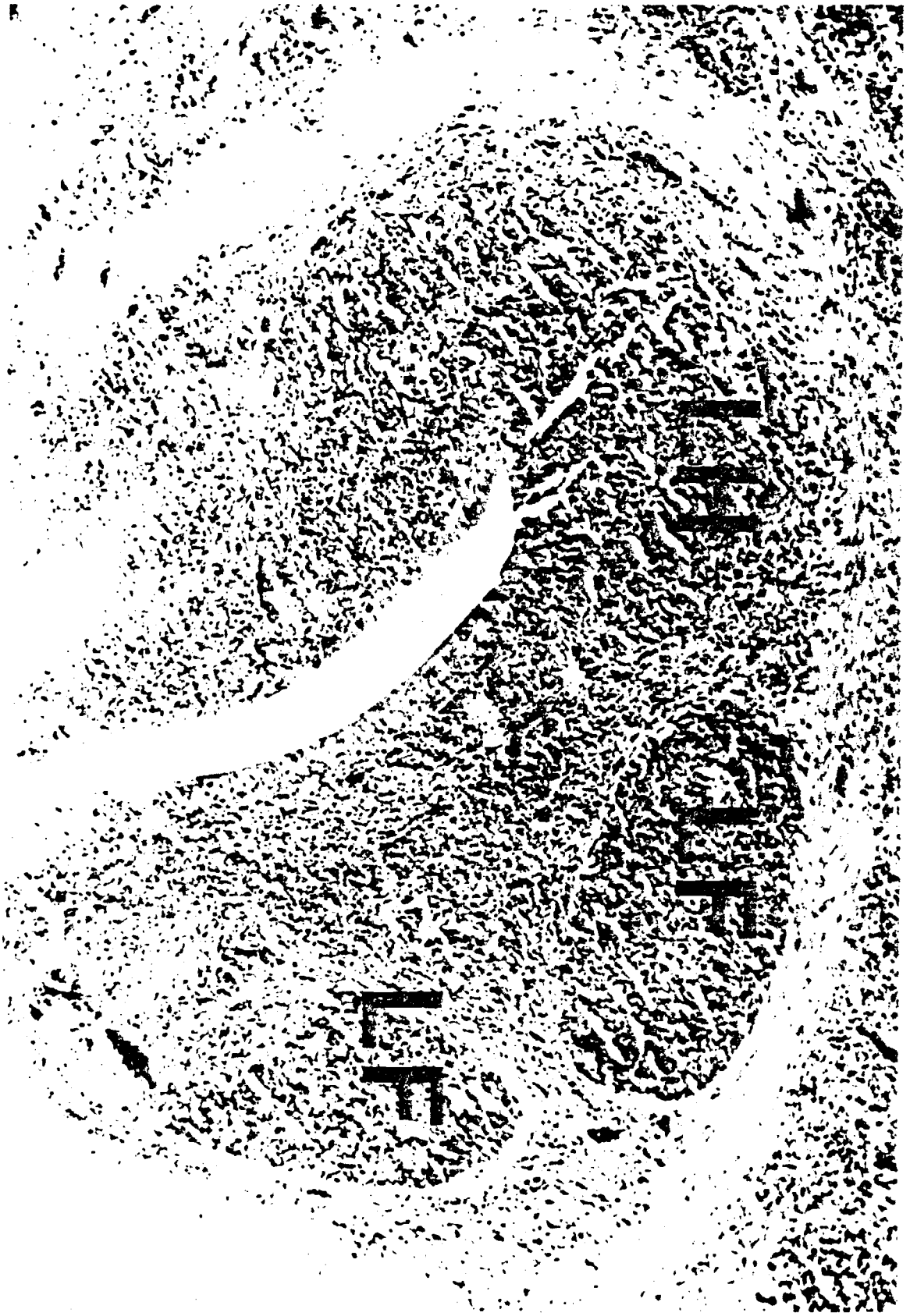

Figure 2.

Figure 3. Increased magnification of Figure 2 showing volcanic ash crystals (arrow) within macrophages of the lung 64x

Figure 3.

Figure 4. Giant cell (arrow) formation around a granuloma at 7 days of ash exposure 64x

Figure 4.

TABLE II.1 Effects of Mount St. Helens' volcanic ash on broiler performance and mortality during 28-49 days of age

Volcanic ash treatments*		Mean body weight gain[1]	Feed conv.[1]	Mean mortality[1]
Method of Application	Quantity			
		g	feed/gain	%
None	None	995[a]	2.51[b]	2.9[a]
Applied on litter	20.0 kg/m^2	994[a]	2.38[a]	3.7[a]
Blown in pens	15 min period 2x daily (27.4 g/min)	1016[a]	2.44[ab]	3.8[a]
Blown in pens	60 min period 2x daily (27.3 g/min)	988[a]	2.61[bc]	1.8[a]

[1]Mean values in each column with different superscripts are significantly different ($P \leq 0.05$).

*Volcanic ash was applied or blown into the pens from 28-49 days of age (21 day exposure).

TABLE II.2 Effects of Mount St. Helens' volcanic ash on atmospheric ammonia and litter moisture levels in broiler pens during 28-49 days of age

Volcanic ash treatments*		Mean NH_3[1] Level				Mean[1]
Method of application	Quantity	days on test				Litter moisture days on test
		0[2]	10[2]	15[2]	20[2]	21
		ppm				%
None	None	13[a]	50[a]	64[a]	32[a]	32.8[a]
Applied on litter	20.0 kg/m^2	12[a]	46[a]	50[a]	28[a]	20.5[b]
Blown in pens	15 min period 2x daily (27.4 g/min)*	18[b]	46[a]	68[b]	42[a]	33.6[a]
Blown in pens	60 min period 2x daily (27.3 g/min)	11[a]	64[a]	75[b]	32[a]	22.8[b]

[1]Mean values in each column with different superscripts are significantly different ($P \leq 0.05$).

[2]Mean temperature values for the eight pens at 9am; Day 0 78F, Day 10 85F, Day 15 84F, Day 20 73F.

*Volcanic ash was applied or blown into the pens from 28-49 days of age (21 day exposure).

TABLE II.3 Effects of Mount St. Helens' volcanic ash on total dust, respiratory dust levels in broiler pens and carcass condemnation

Volcanic ash treatments*		Total dust[1]		Mean[1,2]	Carcass Condemnation
Method of Application	Quantity	0815 to 1645 hr Days on test	1645 to 0815 hr Days on test	Resp. dust Days on test	No. condemned
		21	21	21	No. examined
		$ng/mm^2/min$		$x10^{10}/ft^3$	
None	None	4.6[a]	2.9[a]	43.0[a]	1/304
Applied on litter	20.0 kg/m^2	27.2[c]	9.5[b]	43.7[a]	0/310
Blown in pens	15 min period 2x daily (27.4 g/min)	5.5[a]	3.6[a]	44.3[a]	3/282
Blown in pens	60 min period 2x daily (27.3 g/min)	12.2[b]	7.1[b]	42.9[a]	6/296

[1]Mean values in each column with different superscripts are significantly different ($P \leq 0.05$).

[2]Total respiratory dust for particles ranging in size from 0.5 to 10 μm diameter.

*Volcanic ash was applied or blown into pens from 28-49 days of age (21 day exposure).

LIST OF ENDNOTES

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CHAPTER III

THE EFFECTS OF MOUNT ST. HELENS' ASH ON THE DIGESTIVE TRACTS OF BROILERS[1]

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ABSTRACT

Six hundred and eighty broilers were fed 15% and 30% of either sand (S) or Mt. St. Helens' volcanic (V) ash (A) in a corn-soybean diet for seven weeks to determine the histological effects and mineral levels of selected tissues and to determine the broiler performance.

Histological examinations of the crop, proventriculus, gizzard, duodenum, ceca, and colon from broilers fed either 30% S or 30% VA for seven weeks revealed no significant abnormal tissues. Broilers fed either 30% S or 30% VA to seven weeks of age had significantly lower zinc and aluminum levels in the lungs than in the lungs of the control birds. No significant differences in the levels of iron, calcium, lead, silicon, and mercury were observed in the tibia, liver, and lungs among the dietary treatments.

Mean body weights for broilers fed 30% VA were significantly lower than the control, 15% S and 15% VA treatments. No significant differences were found between the 30% S and 30% VA. Birds fed the two highest levels of S or VA had significantly poorer feed conversion than the control group.

Broilers fed either 30% S or VA had significantly wetter litter at seven weeks of age than did either the 15% S or 15% VA treatments. No significant differences in mortality were observed between the treatments. VA fed birds showed a decrease in body weights and displayed no detrimental effects on the digestive tracts.

INTRODUCTION

The voilent eruption of Mount St. Helens on May 18, 1980 resulted in the loss of 400 m from the top of the mountain and thrusted an enormous volcanic ash cloud that rose 18,600 m into the atmosphere. This and subsequent eruptions deposited volcanic ash on large areas of Washington and neighboring states.

Applied research and practical observations have demonstrated that volcanic ash from Mount St. Helens is non-toxic and apparently not harmful when fed to chickens, dairy calves, and rats, although it might affect the rate of weight gain in the animals.

Research by Dr. J. McGinnis at Washington State University (Smith, 1980), found no adverse effects on the health of chicks. However, when fed diets, ad libitum, containing volcanic ash levels of 10, 20, and 30 percent there was a six percent decrease in growth rate for each ten percent increase in the ash content of the diet, compared to four percent decrease for the same amount of sand in the diet. Up to 30 percent of ash in the diet had no affect on mortality, (Cook, 1980).

Huber, et al. (1980) noted that laboratory rats were very tolerant to ingested and saturated solutions of volcanic ash. Dairy calves, three to four months in age, were fed rations containing ten percent volcanic ash for a four week period, showed no abnormal internal symptoms or accumulation of volcanic ash in the intestinal tract (Cook, 1981).

Sand, which has similar physical characteristic and chemical composition as ash, (Chaplin, 1980), along with other silicates, have

been used in animal feeds as fillers for years (Day, et al., 1970).

Rowland and Hooge (1980) reported that 6, 8, 10 percent sand in the diet reduced feed efficiency in broilers, while Sellers (1980) found no effect on feed efficiency in broilers fed 2.5 or 5 percent sand in the diet. They found that at levels of three percent or greater in the diet either reduced or failed to improve growth rates in young broilers and layers.

The purposes of this experiment were to determine the cytopathological changes and mineral levels of selected tissues and to determine the broiler performance when Mt. St. Helens' volcanic ash were fed from day-old to seven weeks of age at 15 and 30 percent of the ration.

MATERIALS AND METHODS

Six hundred eighty day-old commercial feather sexed broiler chicks were housed in a windowless, positive pressure ventilated room. There were five dietary treatments with four replicates per treatment. Each replicate or pen (1.23 m x 2.46 m) included 13 male and 12 female chicks for a total of 100 chicks per treatment. Five additional pens were used for sacrificing purposes, each pen contained 36 chicks of equal sex representing each treatment.

The five dietary treatments were formulated to be isonitrogenous (Table 1) for the starter and finisher mash feeds. Corn and soybean meal were used to equalize the protein levels. The diet in treatment one consisted of a 23 percent crude protein starter mash and fed from one to 21 days of age and a 21 percent crude protein finisher mash was fed from 22 days of age to the termination of the study (seven weeks of age). Treatments two and three consisted of diets containing 15 and 30 percent sand (S) and treatments four and five consisted of diets containing 15 and 30 percent volcanic (V) ash (A) by weight in the 23 and the 21 percent crude protein starter and finisher feeds, respectively.

Bird density was approximately 0.121 square m per chick. The chicks were brooded under a 250 watt infrared heat lamp per pen. The heat lamps were thermostatically controlled using room temperature starting at 85F (29.4C) and manually lowered by five degrees F each week through the fifth week, then set at 56F (13.3C) thereafter. A little giant-cup watering system were utilized with each pen

containing a stove pipe hanging feeder. Incandescent lighting was provided continuously with 60 watt bulbs suspended 2.4 m above the floor. Clean wood shavings approximately five cm deep covered each pen.

The volcanic ash used in this experiment was collected in Western Oregon following the June 12, 1980 eruption of Mount St. Helens. The ash was sun dried and screened to remove coarser material prior to use. The mineral content of the ash (Table 2) from the June 12 eruption was similar to the May 18, 1980 eruption (Scheidegger and Federman, 1982).

Mean body weights, incidence of mortality, and feed consumption were measured during the one to 49 day production period. All mortalities after seven days of age were necropsied by Oregon State University Veterinary Diagnostic Laboratory.

Litter conditions were determined by giving each pen a score of zero through five, at the termination of the experiment. The litter scores were rated as zero being excellent non-caking and 5 being soggy and severely caked.

Two females and two males per treatment were sacrificed at 0, 3, 7, 14, 21, 28, 35, 42, and 49 days of age and the liver, kidney, breast muscle, spleen, proventriculus, gizzard, crop, duodenum, ceca, and colon tissue were sampled from each bird. Tissue samples were preserved in ten percent neutral buffered formalin solution. Tissue samples of the crop, proventriculus, gizzard, duodenum, ceca and colon from birds following 49 days of age were prepared for histological examinations. The tissues were prepared by embedding in paraffin

from which six micrometer sections were made and stained with hematoxylin eosin for light microscopic examination.

Three samples each of tibia bone, liver, and lung tissues from broilers fed either 30 percent ash or 30 percent sand and control diets following 49 days of feeding, were analyzed for differences in the levels of iron, calcium, lead, silicon, aluminum, zinc, and mercury. Approximately one gram from each tissue sample was weighed and placed in tightly sealed screwcap tubes with four mls of concentrated nitric acid. The tubes were heated at 90C for one hour and cooled to room temperature. The digests were filtered through glass wool into volumetric flasks and diluted to ten mls with water.

Mercury was measured by flameless atomic absorption using a Coleman 50 Analyzer. The bubbler contained five mls of water, five ml of 10 N potassium hydrochloride, one ml of stannous chloride in 2.4 N hydrochloric acid, and a drop of octanol. Two standards and two duplicate samples were measured before fresh reagents were used.

Aluminum and silicon were analyzed in a Perkin Elmer Atomic Absorption Spectrometer Model 403 equipped with an HGA 2000 graphite furnace.

The remaining elements were measured with the same instrument using air acetylene flame.

Carcass quality of the marketed birds for each treatment was determined in a commercial processing plant by United States Department of Agriculture Inspectors.

The data were anlyzed by one way analysis of variance and significant treatment means separated by the least significant difference test (Snedecor and Cochran, 1980).

RESULTS AND DISCUSSION

Microscopic examinations of tissues of the digestive tracts in broilers fed 30 percent of either VA or S for seven weeks, revealed no significant differences compared with the controls. Broilers fed 30 percent or either VA or S to seven weeks of age had significantly lower zinc and aluminum levels in the lungs than in the lungs of the control birds. No significant differences were observed in the tibia, liver, and lungs for iron, calcium, lead, silicon, and mercury among the dietary treatments, (Table 3).

Feeding VA or S to broilers for seven weeks showed no ill effects or significant differences in mortality (Table 4) which is in agreement with McKinny (Smith, 1980).

Mean body weights for broilers fed 30 percent A at seven weeks of age were significantly lower than either the control or 15 percent of VA or S (Table 4). Broilers fed 30 percent of either S or VA had significantly poorer feed conversions than the control group, while broilers fed 15 percent of either S or VA had a significantly poorer feed conversion than the control. Feed conversion for broilers fed 15 percent of either S or VA had significantly better feed conversion than the 30 percent of either S or VA (Table 4). These results concur with Sellers et al. (1980), and Rowland and Hooge (1980), who reported that various silicates in the diet either reduced or failed to improve feed efficiency or growth rates in broilers and layers.

Broilers fed 30 percent of either S or VA had significantly wetter litter at 7 weeks of age than the control group (Table 4).

Broiler producers need not be concerned if their feeds have been contaminated with VA since no detrimental effects were observed in the digestive tracts of broilers when fed VA for seven weeks. Volcanic ash does seem to depress growth weights and feed efficiency at the 30 percent level. This could be due to a decrease in the dietary caloric levels in the feed, causing the birds to consume more feed.

TABLE III.1 Composition of experimental diets

Ingredient	Starter					Finisher				
	Control	15% sand	30% sand	15% ash	30% ash	Control	15% sand	30% sand	15% ash	30% ash
Corn, yellow	58.35	39.87	21.40	39.87	21.40	63.52	45.03	26.57	45.03	26.57
Soybean meal, 47%	32.25	35.72	39.17	35.72	39.17	27.50	30.98	34.42	30.98	34.42
Sand	-	15.00	30.00	-	-	-	15.00	30.00	-	-
Ash	-	-	-	15.00	30.00	-	-	-	15.00	30.00
Meat meal w/bone ml	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Fat, animal	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Alfalfa meal, 17%	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Deflou. Phos.	.42	.42	.42	.42	.42	.25	.25	.25	.25	.25
Limestone flour	.35	.35	.35	.35	.35	.13	.13	.13	.13	.13
Salt, iodized	.25	.25	.25	.25	.25	.25	.25	.25	.25	.25
Trace min. mix[1]	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05
Vitamin premix[2]	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20
D L methionine, 98%	.13	.14	.16	.14	.16	.10	.12	.13	.12	.13
Zoamix, 25%	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05
Baciferm	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05
Calculated Analysis										
Protein, %	23.2	23.2	23.2	23.2	23.2	21.37	21.37	21.37	21.37	21.37
Met. energy, kcal/kg	3022	2503	1955.89	2503	1955.89	3085	2562	2014	2562	2014
Calcium, %	.97	.97	.98	.97	.98	.82	.82	.83	.82	.83
Avail. phos., %	.48	.47	.46	.47	.46	.44	.43	.42	.43	.42
Meth. + cyst., %	.88	.88	.88	.88	.88	.80	.79	.79	.80	.79

[1]Supplies per kg of feed: calcium, 97.5 mg; manganese, 60 mg; iron, 20 mg; iodine, 1.2 mg; zinc, 27.5 mg; cobalt, 0.2 mg.

[2]Supplies per kg of feed: vitamin A, 3300 I.U.; vitamin D_3, 1100 I.C.U.; riboflavin, 3.3 mg; d-pantothenic acid, 5.5 mg; niacin, 22 mg; choline, 191 mg; vitamin B_{12}, 5.5 mcg; vitamin E, 1.1 I.U.; manadione bisulfite complex, 0.55 mg; folacin, 0.22 mg.

TABLE III.2 Major chemical (%) composition of two ash samples from Mt. St. Helens' eruptions

Chemical Compounds	Date of Eruptions	
	May 18, 1980	June 12, 1980
	%	
SiO_2	72.50	75.43
Al_2O_3	13.63	12.68
FeO	1.36	1.63
MgO	0.21	0.13
CaO	1.59	1.13
K_2O	2.45	1.87
TiO_2	0.25	0.28
Na_2O	5.17	4.35
Total	97.18	97.50

TABLE III.3 Mineral levels in femur, lungs, and liver in broilers fed 30 percent sand or volcanic ash for 49 days[1]

Treatment	Tissue	Mineral levels (µg/g)						
		Fe	Zn	Ca	Pb	Al	Si	Hg
Control	femur	59.4	88.4	60,500	1.13	19.0	13.7	.01
30% ash	femur	90.1	110.5	69,600	1.4	18.2	25.2	.02
30% sand	femur	71.76	98.6	61.633	1.14	16.0	9.7	.09
Control	lungs	102.4	10.7[b]	155.0	-[2]	15.8	5.12	.04
30% ash	lungs	166	6.7[a]	116.3	-	3.34	17.2	.03
30% sand	lungs	150	6.8[a]	124.17	-	2.77	10.0	.07
Control	liver	78	18.3	162.7	-	6.3	3.79	.06
30% ash	liver	87.6	9.8	205	-	3.6	10.0	.05
30% sand	liver	88.5	11.6	245.3	-	13.1	10.0	.03

[1]Mean values in each column with different superscripts are significantly different ($P \leq 0.05$).

[2](-) Below detectable levels

TABLE III.4 Influence of two sand and two volcanic ash diets on performance of broiler chicks to 7 weeks of age[1]

Dietary treatments	Weeks on test: 4 wks Mean body wts	4 wks Mean feed conv.	7 wks Mean body wts	7 wks Mean feed conv.	Mean mort. after treat.	Mean litter score[2]
	g	feed/gain	g	feed/gain	%	
Control	909[a]	1.72[a]	1936[a]	2.27[a]	5[a]	2.9[a]
15% sand	886[a]	2.01[b]	1850[a]	2.6[b]	4[a]	4.1[ab]
30% sand	832[a]	2.54[c]	1777[ab]	3.17[c]	6[a]	4.5[b]
15% ash	936[a]	1.91[ab]	1905[a]	2.61[b]	7[a]	4.0[ab]
30% ash	823[a]	2.45[c]	1623[b]	3.45[d]	5[a]	4.8[b]

[1]Mean values in each column with different superscripts are significantly different ($P \leq 0.05$).

[2]Litter score: 0 = excellent, non-caking; 5 = severely caked

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CHAPTER IV

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