# AFLATOXIN PROBLEMS IN POULTRY FEED AND ITS RAW MATERIALS IN INDONESIA[1]

## MASALAH AFLATOKSIN PADA PAKAN DAN BAHAN PAKAN UNGGAS DI INDONESIA

**Sjamsul Bahri**

**Balai Penelitian Veteriner (BALITVET) Departemen Pertanian RI, Jl. R.E. Martadina No. 30, Bogor INDONESIA**

### ABSTRACT

*Media Veteriner. 1998. 5(2): 7-13*

Contamination of aflatoxins in animal feeds is one of a major problem in the development of poultry industry in Indonesia. Aflatoxins may lead to losses in animal productivity, aflatoxicosis and residue in animal products. A series of investigation on aflatoxin contamination in animal feed in poultry had been carried out at Research Institute for Veterinary Science (Balitvet) between 1984 to 1995. It showed that more than 80 % of commercial chicken feeds were contaminated by aflatoxin B1 (AFB1) within a wide range of concentration. Besides AFB1, other aflatoxins such as AFB2, AFG1 and AFG2 were also found. The level of AFB1 more than 200 ppb was found in 13.5 % out of 193 feed samples, whilst 23.3 % and 63.2 % of samples showed concentration 100-200 ppb and <100 ppb respectively. It had approved from the investigation that corn was the most frequent foodstuff contaminated by aflatoxins compared to other animal foodstuff. Most of corn used for chicken feeds appeared to be the major source of aflatoxin contamination, where it could be indicated visually in bad or good kernel appearance. The levels of AFB1 contamination seemed to be higher in the wet season (39.5 ppb) than in the dry season (19.5 ppb) as well as at the lower altitude (39.8 ppb) was higher than at the higher altitude (24.13 ppb). Based on this view, further studies are required to control of the aflatoxins problems in poultry feed in Indonesia.

**Key words**: aflatoxins, animal feeds, poultry

### ABSTRAK

*Media Veteriner. 1998. 5(2): 7-13*

Cemaran Aflatoksin pada pakan unggas merupakan salah satu masalah utama yang dapat menghambat perkembangan industri perunggasan di Indonesia. Hal ini dikarenakan aflatoksin dapat menghambat produktifitas ternak, kesehatan dan meninggalkan residu pada produk-produknya. Serangkaian penelitian terhadap pencemaran aflatoksin pada pakan unggas telah dilakukan di Balai Penelitian Veteriner (Balitvet) Bogor antara tahun 1984 sampai 1995. Hasil-hasil yang diperoleh menunjukkan bahwa lebih dari 80 % pakan unggas komersial terkontaminasi oleh aflatoksin B1 (AFB1) pada berbagai kadar. Selain AFB1, aflatoksin lainnya seperti AFB2, AFG1 dan AFG2 juga diketemukan. Kadar AFB1 lebih dari 200 ppb dijumpai sebanyak 13,5 % dari 193 contoh pakan unggas yang diperiksa, sedangkan 23,3 % dengan kadar 100-200 ppb dan 63,2 % dengan kadar <100 ppb. Pada pengamatan tersebut juga dapat dibuktikan bahwa jagung merupakan bahan pakan yang dominan tercemari aflatoksin daripada bahan pakan lainnya. Jagung-jagung yang tercemar aflatoksin tersebut secara kasat mata dapat dibedakan dari kondisi/keadaan fisik biji jagung tersebut. Kadar pencemaran AFB1 tampaknya lebih tinggi pada keadaan musim hujan (39,5 ppb) dibandingkan pada keadaan musim kering (19,5 ppb). Demikian juga ketinggian tempat yang lebih rendah kadar AFB1 (39,8 ppb) lebih tinggi daripada dataran tinggi (24,13 ppb). Berdasarkan tinjauan ini, penelitian-penelitian lebih lanjut masih diperlukan untuk mengatasi masalah-masalah aflatoksin pada pakan unggas di Indonesia.

**Kata-kata kunci**: aflatoksin, pakan, unggas

### INTRODUCTION

Poultry industry in Indonesia has been developed rapidly in the last decade. The poultry number has been increased year by year. In the year 1993, the poultry population was 17.6 million animal unit, where 65.9 % were

commercial chicken, 29.8 % were indigenous chicken, and 4.7 % were duck (Soehadji, 1994).

The development of the poultry industry in Indonesia is followed by the development of the animal feed industry. It is understood, since 60 % of the poultry production cost is depending on the feed. The most dominant animal feed industry is the poultry feed (layer and broiler).

Animal feedstuff becomes one of the most important factors for increasing animal production. The quality of animal product is not only depending on the feedstuff quantity, but also on its quality. Generally, feedstuff compose by various agriculture-commodities (materials). The feedstuff quality of course depend on the quality of the materials. If the materials have bad quality, it will also produce bad feedstuff. Even the materials are good, but the storage and the production technique are not good, it will produce the feedstuff quality less.

One of the natural factor which affecting the quality of agriculture commodity is the fungal growing on the stuff. This situation is supported by the Indonesian Tropical Climate, where temperature, humidity and the high rainfall are very conducive for fungal growth (*Aspergillus, Penicillium, Eurotium*) on stuffs such as corn, soybean, peanut etc.

Feedstuff or materials which contaminated by fungi, especially *Aspergillus flavus* and *A. parasiticus* will degrade the quality and become hazard for animal health (Diener and Davies, 1969; Dorner *et al.,* 1984), since the fungi produce toxin such as aflatoxin (B1, B2, G1 and G2).

The negative effects of aflatoxin in animal can be acute if the feedstuff highly contaminated by aflatoxin, such as turkey X disease in the UK in 1960 (Blount, 1961). The chronic effects of aflatoxin are more frequent in case of aflatoxin contamination in feedstuff or in lower level of contaminated materials. This situation has not been reported yet, since the chronicle effect could not be observed directly. In Indonesia those problems might be occurred since Ginting (1988) and Widiastuti *et al.,* (1988) reported the aflatoxin contamination cases in chicken feedstuff. In this paper, a review on the aflatoxin situation and its problem in poultry feedstuff industry in Indonesia, and the alternative to control it, is presented.



**Aflatoxin level in Poultry Feedstuff collected from market and farms**

Various research results written by Ginting (1984a, 1984b, 1985) and Widiastuti *et al.,* (1988) show that 61.3 % to 95 % of commercial chicken feedstuff from several places in Indonesia have been contaminated by AFB1, the level content is shown in Table 1. The range is between 10.1 ppb and 54.4 ppb.

As shown in Table 1, the lowest contents of AFB1 level in feedstuff was 61.3 % from broiler starter feedstuff samples from Bogor area collected during dry season. Whereas sample which were taken and analysed in the wet season, the positive samples to AFB1 increased to 92.8 % (Ginting, 1984a). Widiastuti *et al.* (1988) observed the AFB1 level contents in the commercial feedstuff produced by a feed factory for one-year period and showed that 95 % of the feedstuff examined were contaminated by AFB1 (the average level was 52 ppb). This observation showed that most of the Indonesian commercial chicken feedstuff, especially from Jakarta and Bogor had been contaminated by AFB1.

Table 1. AFB1 Contamination in Broiler's Feedstuff in Some Areas in Indonesia

| Sample Source | Samples Number | Sampling seasons | ( %) Positive | Average Levels ppb |
|---|---|---|---|---|
| Bogor (S)[1] | 28 | Wet | 92.8 | 51 |
| Bogor (S)[1] | 31 | Dry | 61.3 | 10.1 |
| Jakarta[2] | 87 | Wet | 85 | 53 |
| Pontianak[2] | 31 | Wet | 64.5 | 26.4 |
| Jakarta[3] | 121 | Wet | 83.5 | 54.4 |
| Bogor[3] | 53 | Wet | 81.1 | 50.8 |
| Bandung[3] | 92 | Wet | 83.7 | 38.8 |
| Bogor[4] | 290 | All through the year | 95 | 52 |

[1]adapted from Ginting (1984a)
[2]adapted from Ginting (1984b)
[3]adapted from Ginting (1985)
[4]adapted from Widiastuti *et al.*, (1988)
S) Broiler's starter feedstuff.

There is a trend that the case of aflatoxin contamination mostly higher in the wet season rather than in the dry season. This trend is supported by Ginting (1988) observation (Table 2). Table 2 shows that the average of AFB1 contents in the wet season (39.5 ppb) is higher than during the dry season (19.5 ppb). It is highly connected to

the increasingly humidity in the wet seasons. This situation is similar to the study done by Haryadi and Setiastuty (1994) which revealed that the prevalence of aflatoxin contamination was more evident during rainy season when the humidity was quite high. From their data on moisture content of groundnut samples, it was clear that the prevalence of aflatoxins was positively correlated with the moisture content of the sample. The increase of humidity factor will accelerate the *A. flavus* and *A. parasiticus* growth, which at last increasing aflatoxin production. According to Thakur and Mandokhot (1976), Blaney *et al.*, (1984) and Bean and Fernando (1986), the rainfall is an important factor for fungal growth to produce aflatoxin in the feedstuff.

Table 2. The Average of AFB1 Level in Broiler Feedstuff Collected form Jakarta, Bogor and Bandung[1]

| Areas altitude | The average level (ppb) of AFB1 in seasons | | Average |
|---|---|---|---|
| | Wet | Dry | |
| Jakarta ( ±7m) | 45.43 | 31.93 | 39.18[c] |
| Bogor (200-400m) | 41.40 | 8.87 | 25.13[d] |
| Bandung (600-1250m) | 30.77 | 17.70 | 24.23[d] |
| Average | 39.5[a] | 19.5[b] | |

[1]Adapted from Ginting, 1988

[a,b,c,d]avaerage within row and column with no common superscipts differ significantly (P<0.05)

Besides the rainfall factor, the altitude of an area is become another important factor for AFB1 contamination level in the foodstuffs. The average of AFB1 level contents in the broiler feedstuff from Jakarta (± 7m above sea level) is 39.18 ppb, compared to 25.13 ppb AFB1 in the feedstuff from Bogor (± 400 m) and 24.23 ppb AFB1 in the feedstuff from Bandung (± 600-1,250 m). Blaney *et al.*, (1984) stated that higher humidity and higher temperature would support fungal growth (*A. flavus* and *A. parasiticus*).

Ginting (1985) reported that during the wet season the AFB1 contents in broiler feedstuff from Jakarta (54.4 ppb) was higher than that from Bandung (38.8 ppb).

**Aflatoxin concentrations on BALITVET routine examination (1988-1994)**

From Balitvet experienced (1988-1994), samples containing of aflatoxins (B1, B2, G1 and G2) from chicken feedstuff were sent to Balitvet for examination. The most frequent finding was AFB1 (98.29 %), followed by AFB2 (78.1 %), AFG1 (47.04 %) and AFG2 (35.59 %). The highest level content of AFG1 was 732 ppb (Table 3 and 4).

From the observation, AFB1 was also the most dominant aflatoxin, compared to the others. This finding was supported by Bainton *et al.*, (1980), that stated from four aflatoxins, AFB1 was the most common aflatoxin found in nature, it was also the most toxic aflatoxin.

Since AFB1 is the most frequent aflatoxin found in the observation, from this point forward we will consider to AFB1 to discuss. One hundred and twenty two out of 193 samples (63.21 %) contained AFB1 level less than 100 ppb, 45 samples (23.32 %) between 100-200 ppb and 26 samples (13.47 %) more than 200 ppb (Table 4).

Table 3. Percentage of Aflatoxin, Which Detected from Poultry Feedstuff Examined in Balitvet

| Year of Samples examined | Number of Samples (N) | % of Aflatoxin Variation Detected | | | |
|---|---|---|---|---|---|
| | | B1 | B2 | G1 | G2 |
| 1988 | 14 | 100 (14/14) | 70 (10/14) | 21(3/14) | 7(1/14) |
| 1989 | 32 | 100 (32/32) | 65 (21/32) | 50 (16/32) | 15(5/32) |
| 1990 | 15 | 100 (15/15) | 93 (14/15) | 27 (4/15) | 27(4/15) |
| 1991 | 25 | 88 (22/25) | 68 (17/25) | 64 (16/25) | 48(12/25) |
| 1992 | 13 | 100 (13/13) | 85 (11/13) | 62 (8/13) | 46(6/13) |
| 1993 | 48 | 100 (48/48) | 85 (41/48) | 69 (33/48) | 62(30/48) |
| 1994 | 46 | 100 (46/46) | 83 (38/46) | 37 (17/46) | 43(20/46) |
| Total Average | 193 | 98.4 (190/193) | 78.7 (152/193) | 50.3 ( 97/193) | 40.4(78/193) |

Source: Bahri *et al.*,(1996)

Table 4. Level of AFB1 (ppb) in Poultry Feedstuff Examined at Balitvet (1988-1994)

| Year of Samples examined | Number of Samples (N) | Range (ppb) | Number and % sample at Level | | |
|---|---|---|---|---|---|
| | | | <100 ppb | 100-200 ppb | >200 ppb |
| 1988 | 14 | 8-120 | 12 (86 %) | 2 (14 %) | 0 (0 %) |
| 1989 | 32 | 16-720 | 16 (50 %) | 10 (31 %) | 6 (19 %) |
| 1990 | 15 | 4-240 | 12 (80 %) | 2 (13 %) | 1 (7 %) |
| 1991 | 25 | 0-732 | 10 (40 %) | 7 (28 %) | 8 (32 %) |
| 1992 | 13 | 24-326 | 7 (54 %) | 5 (38 %) | 1 (8 %) |
| 1993 | 48 | 5.3-640 | 27 (56 %) | 15 (31 %) | 6 (13 %) |
| 1994 | 46 | 1.7-560 | 38 (82 %) | 4 (9 %) | 4 (9 %) |
| Total/Average | 193 | 1.7-732 | 122 (63.2 %) | 45 (23.3 %) | 26 (13.5 %) |

Source: Bahri *et al.*, (1996)

According to Giambrone *et al.* (1985), the AFB1 level around 100 ppb or more is able to produce sub-clinical intoxication in broiler. From Table 4, we could observe that 71 (45+26) samples (36.79 %) were contaminated by AFB1 more than 100 ppb. It also showed that poultry feedstuff samples sent to Balitvet, was mostly heavily contaminated by aflatoxin, compared to the direct samples collected from field. It can be understood, since most of the samples sent to Balitvet has already been suspected with aflatoxin contamination because of the expensive cost for aflatoxin analysis.

**Aflatoxin in Duck Feedstuff**

Aflatoxin contamination in Alabio duck feedstuff from South Kalimantan are presented in Table 5 (Zahari and Tarmudji, 1995). Table 5 shows that 19 samples of duck feedstuff collected from South Kalimantan farmers are positive to AFB1, with range between 4 and 160 ppb, the average level is 60.21 ± 43.35 ppb. The 73.7 % of 19 samples have level above 30 ppb. According to Culvenor (1974), the AFB1 level in duck feedstuff should have concentration less than 30 ppb. Study on the histopathology of duck livers showed aflatoxicosis alteration that might have correlation with the aflatoxin presence in the feedstuff. Aflatoxin contamination was also found in the fine rice bran and other materials, even in level between 8-20 ppb.

Table 5. AFB1 Level in Alabio Duck Feedstuff Collected from South Kalimantan[1]

| Samples | Samples Number | Range (ppb) | Number and Percentage Samples | | |
|---|---|---|---|---|---|
| | | | <30 ppb | 30-100 ppb | >100 ppb |
| Feedstuff | 19 | 4-160 | 5 (26.3 %) | 11 (57.9 %) | 3 (15.8 %) |
| Fine Rice bran | 8 | 0-20 | 6 (75 %) | 0 | 0 |
| Mixed materials | 8 | 0-8 | 1 (12.5 %) | 0 | 0 |

[1] Adapted from Zahari and Tarmudji (1995).

## AFLATOXIN IN RAW MATERIALS

**Aflatoxin in Agriculture Products and By-product of Agroindustries**

Aflatoxin contamination (B1, B2, G1 and G2) in the feed raw materials and the waste products which composed the animal feedstuff are shown in Table 6. From various materials, it seems that corn is the most common material contaminated by aflatoxin. Besides corn, the other raw materials which contaminated such as pollard, slip mill, soy bean cake, while the waste products which were contaminated such as chocolate seed skin and rice bran. The concentration of aflatoxin were varied. Dharmaputra *et al.* (1997) also reported their study, that five out of 14 samples (soybean cake from feedmills) were contaminated by aflatoxin between 7.9-34 ppb. The highest aflatoxin concentration was 34 ppb. (samples taken from Surabaya feed mill). Since the aflatoxin concentration in the agriculture and by-products are low, it shows that feedstuff seems suspiciously to be contaminated by aflatoxin.

Table 6. Level of Aflatoxin in Various Agriculture Products and By-products

| Samples of Agriculture Products and Agriculture By-products (N) | Samples source | The Average Level of Aflatoxin (ppb) | | | |
|---|---|---|---|---|---|
| | | B1 | B2 | G1 | G2 |
| Corn (6) | Bogor[1] | 78.1 | ND | ND | ND |
| Rice Bran (4) | Bogor[1] | UD | ND | ND | ND |
| Coconut Cake (2) | Bogor[1] | 10.9 | ND | ND | ND |
| Peanut Cake (3) | Bogor[1] | UD | ND | ND | ND |
| Meat Mill (1) | Bogor[1] | 50 | ND | ND | ND |
| Kapok Cake (1) | Bogor[1] | UD | ND | ND | ND |
| Peanut Cake (1) | Lampung[2] | 25 | 2.31 | 12 | 1.57 |
| Dried Coconut Cake (4) | Lampung[2] | UD | UD | UD | UD |
| Coconut Cake (1) | Lampung[2] | UD | UD | UD | UD |
| Soy bean Cake (1) | Lampung[2] | UD | UD | UD | UD |
| Rice Bran (5) | Lampung[2] | 18.1 | 4.6 | 7.33 | 6.14 |
| Pineapple Skin + Rice Bran (1) | Lampung[2] | 7.23 | UD | UD | 26.48 |
| Cassava Cake (1) | Lampung[2] | 9.63 | 48 | 108.9 | UD |
| Chocolate Skin (1) | Lampung[2] | 38.55 | 14.54 | 8.55 | UD |
| Chocolate Seed Skin (1) | Lampung[2] | 39 | UD | 9.39 | UD |
| Corn Leaves (1) | Lampung[2] | 24.1 | 111.5 | 18.77 | UD |
| Corn stalk (1) | Lampung[2] | 38.5 | 16.97 | 7.71 | UD |
| Soy Bean Cake (2) | Bogor[2] | 7.12 | 5.23 | 3.23 | 12.22 |
| Cocco Cake (4) | Bogor[2] | 23.57 | UD | 0.67 | 3.14 |
| Dried Cocco Cake (4) | Bogor[2] | UD | UD | UD | UD |
| Slip Mill (4) | Bogor[2] | 30.1 | 7.0 | 5.55 | 12.1 |
| Pollard (3) | Bogor[2] | 18.93 | UD | 21.4 | 5.14 |
| Tegal Corn (30) | Bogor[3] | 21.3 | ND | ND | ND |
| Thailand Corn (30) | Bogor[3] | 46.0 | ND | ND | ND |
| Lampung Corn (30) | Bogor[3] | 194.6 | ND | ND | ND |
| Corn/maize (20) | Bogor[4] | 39.14 | ND | ND | ND |

[1]Adapted from Ginting (1984a) ND = Not Done UD = Not Detected
[2]Adapted from Maryam and Sastrawihana (1994)
[3]Adapted from Ginting (1986)
[4]Adapted from Bahri *et al.* (1995)

**The role of Corn as the main source of Aflatoxin contamination in Animal Feedstuff**

Buckle (1983) and Dutton and Westlake (1985) revealed that poultry feedstuffs were very common contaminated by aflatoxin or the other mycotoxins. Ginting (1984a, 1984b, 1985 and 1988) reported the aflatoxin contamination in commercial poultry feedstuff in Indonesia. Whilst Widiastuti *et al.* (1988), have proofed, that the AFB1 concentration in corn and commercial poultry feedstuff in a feed factory showed high correlation. In this case, if the AFB1 level was high, the AFB1 level of the feedstuff was also high (Table 7). In contrast, if the AFB1 level in corn was low, the AFB1 level in the feedstuff was also relatively low. Since corn is the main material in the feedstuff, Widiastuti *et al.* (1988) took an inference that corn was as a major source of aflatoxin contamination in the commercial poultry feedstuff.

Table 7. The Average Level of AFB1 in Corn Kernel and Chicken Feedstuff Taken from A Feed Factory from August 1985 to August 1986[1]

| Month of Sampling | Level of AFB1 (ppm) in | |
|---|---|---|
| | Corn Kernel[2] | Chicken Feedstuff |
| August 1985 | 0.056 | No sample |
| September 1985 | 0.008 | 0.005 |
| October 1985 | 0.007 | 0.005 |
| November 1985 | 0.010 | 0.002 |
| December 1985 | 0.130 | 0.054 |
| January 1986 | 0.053 | 0.040 |
| February 1986 | 0.064 | 0.052 |
| March 1986 | 0.369 | 0.095 |
| April 1986 | 0.243 | 0.220 |
| May 1986 | 0.105 | 0.080 |
| June 1986 | 0.152 | 0.035 |
| July 1986 | 0.095 | 0.030 |
| August 1986 | 0.013 | 0.011 |

[1]Adapted from Widiastuti *et al.*(1988)
[2]Corn kernel is the main material for Chicken Feedstuff from the same Feed Factory.

A further direct observation to corn, done by Widiastuti *et al.* (1988), showed that the visual examination method was able to distinguish which corn was relatively low contaminated by AFB1 and which one was heavily contaminated by AFB1 (Table 8). From five groups of corn, visually could be distinguished that corn which color was yellow fluorescent to bright green, had highest AFB1 level contents, that was 1.93 ppm, followed by fungal corn (0.742 ppm) etc. as shown in Table 8.

Table 8. The AFB1 level in various quality of corn observed visually[1]

| Corn quality Observed Visually | AFB1 (ppm) Levels | |
|---|---|---|
| | Range | Average |
| Purple | 0.001-2.0 | 0.213 |
| Insects Damage | 0.001-1.5 | 0.221 |
| Yellowish fluorescence – Bright Green (365 nm/UV) | 0.010-20.0 | 1.193 |
| Moldy | 0.016-5.0 | 0.742 |
| Good | 0.001-1.0 | 0.061 |

[1]Adapted from Widiastuti *et al.* (1988)

## CONCLUSION

The frequency of aflatoxin contamination in the raw materials as well as in the feedstuff in Indonesia are very high (more than 80 %) and also happening all through the year. AFB1 is the most common toxin found than the other three (AFB2, AFG1 and AFG2). As the main source of contaminated material compared to the other materials, corn is the most common raw material contaminated by aflatoxin.

## REFERENCES


Bahri, S., Yuningsih, R. Maryam dan P.Zahari. 1994. Cemaran Aflatoksin pada Pakan Ayam yang Diperiksa di Laboratorium Toksikologi Balitvet tahun 1988-1991. *Penyakit Hewan.*, (47): 39-42.

Bahri, S., P. Zahari, and R. Maryam. 1995. Aflatoxin Contents in Feedstuffs: A Preliminary Study. Paper was presented in the World Veterinary Congress XXV in Yokohama, Japan, 3-9 September 1995.

Bahri, S., R. Maryam, R. Widiastuti, dan P. Zahari. 1996. Aflatoksikosis dan Cemaran Aflatoksin pada Pakan serta Produk Ternak. *Prosiding seminar nasional peternakan dan veteriner*, Bogor 7-8. November 1995, p: 95-107.

Bainton, S.J., R.D. Coler., B.D.Jones., E.M.Morley., M.J. Nagler and R.L. Turner. 1980. Mycotoxin Training Manual. Tropical Products Institute, London. p: 20-65.

Bean, G. and T. Fernando. 1986. Winged Bean (*Psophocarpus tetragonolobus* (L). DC) as a Substrate for Growth and Aflatoxin Production by Aflatoxigenic Strains of *Aspergillus* spp. *Mycopath.*, 93: 3-7.

Blaney, B.J., C.J. Moore and A.L. Tyler. 1984. Mycotoxins and Fungal Damage in Maized Harvested during 1982 in Far North Queensland. *Aust.J. Agric. Res.*, 35: 463-471.

Blount,W.P. 1961. Turkey "X" Disease. *J. Brit. Turkey Fed.*, 9: 52-77.

Buckle, A.E. 1983. The Occurrence of Mycotoxins in Cereals and Animal Feedstuff. *Vet. Res. Commun.*, 7: 171-186.

Culvenor, C.C.J. 1974. The Hazard from Toxic Fungi in Australia. *Aust. Vet. J.*, 50: 69-78.

Dharmaputra, O.S., H. Susilo, and M. Sidik. 1997. Populasi Cendawan Pascapanen dan Kandungan Aflatoksin pada Bungkil Kedelai. *Prosiding Kongres Nasional XIV dan Seminar Ilmiah Perhimpunan Fitopatologi Indonesia.* Palembang, 27-29 Oktober 1997. Vol. II: 240-249.

Diener, U.L. and N. Davis. 1969. Aflatoxin Formation by *Aspergillus flavus*. *In* Goldblatt L.A. (ed). Aflatoxins. Academic Press, New York. USA. p:77-105.

Dorner, J.W., R.J. Cole and U.L. Diener. 1984. The Relationship of *Aspergillus flavus* and *Aspegillus parasiticus* with Reference to Production of Aflatoxins and Cylopiazonic acid. *Mycopathologia.*, 87: 13-15.

Dutton, M.F. and K. Westlake. 1985. Occurrence of Mycotoxins in Cereals and Animal Feedstuff in Natal, South Africa. *J. Assoc off Anal.*, Chem. 68: 839-842.

Giambrone, J.J., U.L. Diener, N.D. Davis, V.S. Panangala, and F.J. Hoerr. 1985. Effects of Aflatoxin on Young Turkeys and Broiler Chikens. *Poultry Sci.*, 64: 1678-1684.

Ginting, Ng. 1984a. Aflatoksin di Dalam Bahan Baku Pakan dan Pakan Ayam Pedaging: I. di daerah Bogor. *Penyakit Hewan.*, 27: 152-155.

----------. 1984b. Aflatoksin pada Pakan Ayam Pedaging di Daerah Khusus Ibukota Jakarta Raya dan Kotamadya Pontianak. *Penyakit Hewan.*, 28: 212-214.

---------- 1985. Aflatoxin in Broiler Diets in Indonesia. *Proceedings 3rd AAAP Animal Science Congress.* May 6-10. 1985. Seoul. Korea. p: 528-530.

----------. 1986. Variasi Kejadian dan Kandungan Aflatoksin pada Jagung yang Bersumber dari Tegal, Thailand dan Lampung pada Suatu Pabrik Makanan Ternak di Bogor. *Penyakit Hewan.*, 31: 79-81.

----------. 1988. Sumber dan Pengaruh Aflatoksin Terhadap Pertumbuhan dan Performa Lain Broiler. Disertasi. Universitas Padjadjaran Bandung.

Haryadi, Y. and E. Setiastuty. 1994. Characterization of Aflatoxins B1, B2, G1 and G2 in Groundnuts and Groundnut Products. *Proceedings of the 6th International Working Conference on Stored-product Protection.* 2: 996-998.

Maryam, R, dan T.B. Sastrawihana. 1994. Laporan Hasil Penelitian Mikotoksin pada Pakan Ternak Asal Limbah Pertanian dan Agroindustri. Laporan Intern, Balitvet.

Soehadji. 1994. Membangun Peternakan Tangguh. Orasi Ilmiah Penganugerahan Gelar Doctor Honoris Causa Bidang Ilmu Peternakan. Universitas Padjadjaran. 15 September 1994.

Thakur, R.S. and V.M. Mandokhot. 1976. More about Aflatoxin in Poultry Feeds. *Poult. Advis.*, p: 31-32.

Widiastuti, R., R. Maryam, B.J. Blaney, Salfina and D.R. Stoltz 1988. Corn as a Source of Mycotoxins in Indonesian Poultry Feeds and the Effectiveness of Visual Examination Methods for Detecting Contamination. *Mycopath.*, 102: 45-49.

Zahari, P. dan Tarmudji. 1995. Aflatoksikosis Pada Ternak Itik Alabio di Kalimantan Selatan. *Prosiding Seminar Nasional Teknologi Veteriner untuk Meningkatkan Kesehatan Hewan dan Pengamanan Bahan Pangan Asal ternak*. Cisarua, Bogor, 22-24 Maret 1994. Balai Penelitian Veteriner. p: 408-441.