Effect of addition of propionic acid and fumigation with aluminum phosphide on the nutritive value of grain corn stored in silos six month

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Abstract

The use of corn for poultry feed is on average 50-60% of its portion. Corn has many advantages compared to other feed materials. Corn storage in silos is aimed at maintaining the quality of the stored grains by avoiding, reducing or eliminating various factors that can reduce their quality and quantity. A longer storage tends to reduces the nutritional value of corn. Corn without treatment (control) was found to reduce crude protein from 8.41 to 6.95%, crude fat from 4.28 to 3.69%, gross energy from 3390 to 3282 kcal after 6 months of storage. Total aflatoxin increased from 5.19 to 38.40 pbb and crude fiber increased from 1.32 to 2.67%. But the addition of propionic acid as preservative and fumigation material using anti-weevil (aluminum phosphide) could slow the damage process of corn.

Keywords: Corn storage, nutritional, propionic acid, aluminum phosphide

Introduction

Corn was originally used as staple food in several countries as a source of carbohydrates. But along with the development of the poultry industry in the early 1970s, then corn began to be used as an energy source for modern poultry feed. According to BPS (2015) data, with a land area of 3.8 million hectares, in 2014 corn production in Indonesia in the form of dry shelled grains reached 19.03 million tons or increased by 2.81% compared to 2013 (18.51 million tons). Corn production in North Sumatra Indonesia until June 2018 was approximately 400,000 tons (North Sumatra Food and Horticulture Plant Service, 2018). The prediction for 2019 North Sumatra could produce approximately 800,000 tons of corn.

Corn storage in silos can last for 4-6 months. This is aimed at maintaining the availability of corn throughout the year for animal feed production. Feed storage in silo is designed to restore the quality of stored grains by avoiding, reducing or eliminating various factors that can reduce the quality and quantity of the commodity. The maximum limit of total aflatoxin in corn is 50 ppb as raw material for poultry feed while the maximum storage moisture content is 14% (SNI, 1998).

Storage of grains with high moisture content will support the growth of fungi, especially *Aspergillus flavus* and *A. parasiticus* which could produce secondary metabolites in the form of aflatoxin that accelerate the process of damage to the feed ingredients (Syarief *et al*., 2003). If this problem is not addressed immediately it will cause a decrease in the physical and chemical quality of corn. This decline often causes a big loss to the feed industry and farmers because corn could not be used safely and its sale value would decrease, further affecting the profitability of livestock enterprises.

The use of corn in animal feed, especially poultry, ranges from 50-60% of the ration. This is because corn has many advantages compared to other raw materials, among them are its energy content which can reach 3350 kcal/kg (NRC, 1994) and xanthophyll level which is quite high.

In terms of amino acids, corn is seen as an ingredient that is quite rich in methionine so that the combination of corn with lysine sources such as soybean meal is considered adequate in the preparation of livestock rations. However, the energy content, xanthophyll and amino acids of corn are actually influenced by many factors. One example is the moisture content, the higher the moisture content of corn, the lower the energy content in it. The length of storage of corn also affects the quality of corn including energy content and aflatoxin.

Alternatives applied to maintain the quality of shelled corn, in particular total aflatoxin, is through the drying and fermentation process before storage. Provision of propionic acid is effective against fungi and inhibits growth of bacteria and yeast and could reduce the increase in pH, inhibit seed respiration when used as preservative in seed storage and reduce damage as a result of silo management (Mills and Kung, 2002; Kung et al., 2003). A study was then conducted to determine the extent of the influence of the duration of corn storage in silos on changes in the quality of corn with the addition of propionic acid.

Materials and Methods

Corn used for the experiment was of good quality according to SNI (Standar Nasional Indonesia, 1998) standards with moisture content around 14.0 - 14.5%. The corn was obtained from PT Charoen Pokphand Indonesia after undergoing the drying process. Propionic acid was used as an additive and aluminum phosphide as a fumigation agent.

NIRS machine was used to carry out the proximate analysis of corn. Modified mini silos made of barrels or buckets were used to depict the condition of the original silos.

Design and treatments

The study was conducted using a complete randomized design with 3 treatments:

P0: Corn Control
P1: Corn + 1.5% propionic acid
P2: Corn + 1.5% propionic acid + aluminum phosphide (fumigation)

Application dosages:

1. Propionic acid 1.5% (liquid): spray 50 g/100 kg feed.
2. Aluminum phosphide: 15 g/wk/silo.

The experiment was repeated thrice.

Making mini silos

Mini silos were made according to the concept of silo (2.5-ton capacity) using iron barrels of 100 kg capacity.

Sampling method

Samples ware be taken evenly using a sampling tool. The purpose of sampling using a tool (manual instrument) is to avoid damage to the corn and to ensure that the samples obtained were more uniform or representative.

Samples of 1 kg in weight were taken from 15 different points in the silos. The samples were obtained at the end of the month for every treatment. All samples were kept in a corn divider, so that the results were more uniform.

Fumigation

Fumigation was carried out every week on P2 treatment using aluminum phosphide.

Five 3-g tablets of aluminum phosphide were placed inside the silos and this was repeated every week.

Data analysis

Data were taken every month based on storage time: 1 to 6 months. The data obtained were analyzed using ANOVA of SAS and Duncan Statistical Test for mean comparison was continued following ANOVA. The study variables consisted of gross energy, moisture content, crude protein, crude fat, crude fiber, ash, total aflatoxin and T-2 toxin.

Results and Discussion

Chemical composition

Moisture content

The addition of propionic acid and aluminum phosphide did not show significant effect (P>0.05) on changes in corn moisture content at different storage stages (Table 1). This was caused by the stability of temperature and humidity during storage of corn in the silos.

Table 1. Effect of addition of propionic acid and aluminum phosphide at different storage times on moisture content of stored corn

Storage time (mo)	Treatment			Mean moisture content (%)
	PO	P1	P2	
0	14.01	14.01	14.01	14.01±0.01
1	14.25	14.06	14.26	14.19±0.11
2	14.26	14.08	14.11	14.15±0.10
3	14.22	14.10	14.14	14.15±0.06
4	14.13	14.00	14.15	14.10±0.08
5	14.19	14.10	14.11	14.14±0.05
6	14.19	14.10	14.11	14.13±0.05
Mean	14.18±0.09	14.07±0.04	14.13±0.07	

P0: Corn control
P1: Corn + 1.5% propionic acid
P2: Corn + 1.5% propionic acid + aluminum phosphide (fumigation)

Storage of corn in the mini silos with moisture content of 14% is considered safe because at this level of moisture there is no evaporation process caused by high moisture content in the silos, and this agrees with Magan and Aldred (2007). This prevents the absorption of moisture due to high humidity from outside the silo as mentioned by Winarto et al. (1988) that the moisture content on the surface of the stored material is influenced by the humidity, if the moisture content of the material is low while the relative humidity around is high then absorption of moisture from the air will occur so that the material becomes moist or moisture content will increase. It can then be seen that there is no significant effect of addition of propionic acid and aluminum phosphide and storage time on corn moisture content.

Crude protein

The results showed that the addition of propionic acid and aluminum phosphide at different storage time showed significant ($P<0.05$) effects on crude protein content (Table 2). The addition of propionic acid and aluminum phosphide (P2) showed a lower level of crude protein reduction compared to the other treatments. This was due to the physical condition of the corn which was still intact and not damaged by the infestation of weevils due to fumigation using aluminum phosphide. Addition of propionic acid also suppressed fungal growth in corn.

Table 2. Effect of addition of propionic acid and aluminum phosphide at different storage times on crude protein of stored corn

Storage time (mo)	Treatment			Mean crude protein (%)
	PO	P1	P2	
0	8.41	8.41	8.41	$8.41^{d}\pm0.00$
1	8.37	8.40	8.41	$8.40^{d}\pm0.02$
2	8.32	8.28	8.40	$8.33^{d}\pm0.02$
3	8.13	8.07	8.32	$8.17^{c}\pm0.13$
4	7.88	7.98	8.27	$8.05^{c}\pm0.20$
5	7.53	7.66	8.05	$7.75^{b}\pm0.27$
6	6.95	6.97	7.84	$7.25^{a}\pm0.51$
Mean	$7.94^{a}\pm0.54$	$7.97^{a}\pm0.51$	$8.24^{b}\pm0.22$	

P0: Corn control
P1: Corn + 1.5% propionic acid
P2: Corn + 1.5% propionic acid + aluminum phosphide (fumigation)

Aside from being a source of carbohydrate, corn is also an important source of protein in the formulation of rations. Corn protein content (8-11%) consists of five fractions, namely: albumin, globulin, prolamin, glutelin, and nonprotein nitrogen.

In contrast to corn without any treatment (P0) and the addition of propionic acid (P1), a greater decrease in the level of crude protein was detected in P2 treatment. This was inseparable from the increased damage to corn due to the infestation of weevils, where the weevils physically damaged the corn and reduced the nutritional value of the corn. This is in accordance with Mangundiharjo (1978) that the damage of stored material could be in the form of quantitative damage such as decreased weight of the material which could result in qualitative damage such as discoloration, dirt contamination, unpleasant odor and decreased nutrient content. Tefera at al. (2011) also added that *S. zeamais* infestation was found to reduce the nutrient content, germination and market value of the stored corn.

Increasing the amount of corn damage due to weevils would also increase the level of aflatoxin due to the presence of fungi. It can be seen that the increase in the number of fungi in corn can also reduce the nutritional value of corn, as according to Syarief et al. (2003) that the growth of *Aspergillus flavus* and *A. parasiticus* produced secondary metabolites in the form of aflatoxin which could accelerate the process of damage to the feed ingredients.

There was an interaction between the addition of preservatives (proponic acid and aluminum phosphide) and the length of storage time of corn to decrease the crude protein of corn as shown by P0 and P1 treatments, while in the P2 treatment the decrease was less (Figure 1). The factor of adding aluminum phosphide in P2 treatment was considered to be able to maintain the quality of corn, especially from pest infestation.

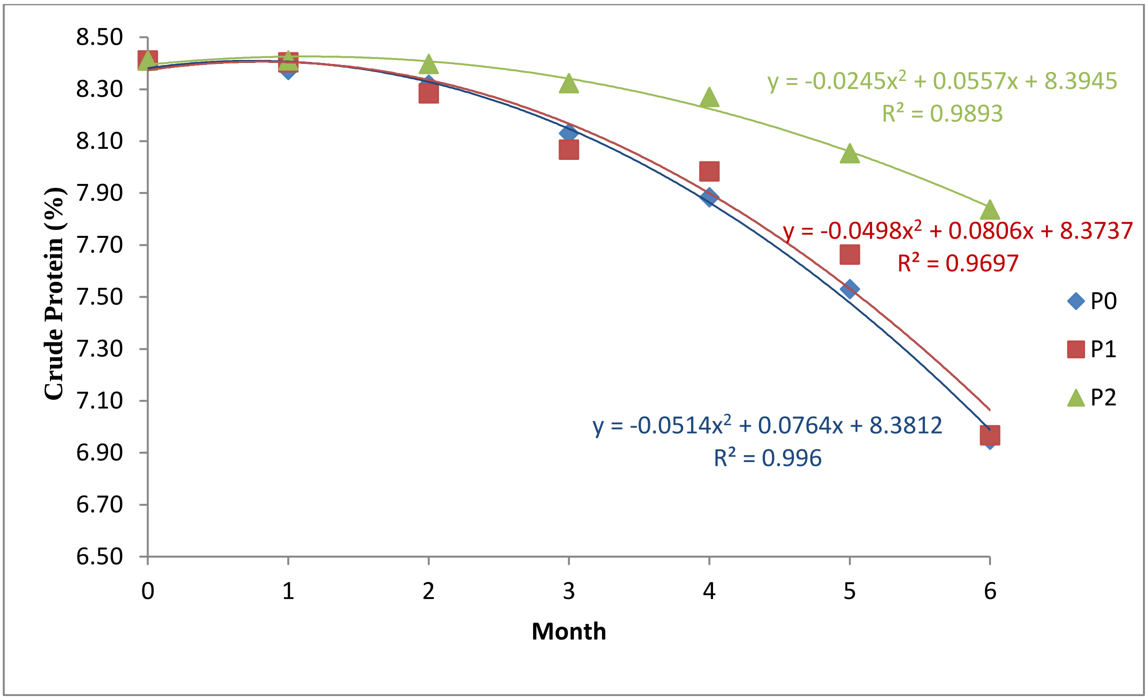

Figure 1. Effect of addition of propionic acid and aluminum phosphide on crude protein of corn stored for different storage durations

Crude fat

The addition of propionic acid and aluminum phosphide in P2 treatment showed lower levels of crude fat reduction compared to the other treatments (Table 3). This was due to the physical condition of the corn that was still intact and not damaged by the infestation of weevils due to fumigation using aluminum phosphide and the growth of fungi which slowed due to the effects of propionic acid.

Table 3. Effect of addition of propionic acid and aluminum phosphide at different storage times on crude fat of stored corn

Storage time (mo)	Treatment			Mean crude fat (%)
	PO	P1	P2	
0	4.28	4.28	4.28	4.28^{d}±0.00
1	4.23	4.25	4.27	4.25^{d}±0.02
2	4.11	4.23	4.27	4.20^{cd}±0.08
3	3.99	4.14	4.25	4.13^{bcd}±0.13
4	3.89	4.09	4.22	4.07^{bc}±0.17
5	3.86	4.01	4.20	4.02^{b}±0.17
6	3.69	3.80	4.17	3.89^{a}±0.25
Mean	4.01^{a}±0.21	4.11^{b}±0.17	4.24^{c}±0.04	

P0: Corn control
P1: Corn + 1.5% propionic acid
P2: Corn + 1.5% propionic acid + aluminum phosphide (fumigation)

Fat is an important nutrient in preparing rations for livestock. Besides fat can also contribute energy to livestock. The results of the study suggested that the addition of propionic acid and aluminum phosphide and storage time had significant (P<0.05) effect on crude fat content of stored corn.

In contrast to P0 treatment, the addition of propionic acid (P1) showed a greater level of decrease in crude fat than P2 treatment. This was inseparable as the increased damage of corn was due to the infestation of weevils which physically damaged the corn and reduced its nutritional value. This is consistent with Nonci et al. (2006) that the weevil, *Sitophilus zeamais,* laid eggs in corn seeds before the harvesting stage or while in storage. A few days later, the eggs hatched into larvae and ate the inside of the corn kernels. Pabbagge et al. (1997) added that larvae completed their life cycle in the seeds so that the seeds were damaged.

There was significant interaction between the addition of preservative ingredients (proponic acid and aluminum phosphide) and the length of storage of corn in decreasing the crude fat of corn (Figure 2). The level of crude corn fat in treatments P0, P1 and P2 showed a pattern that was negative for the duration of corn storage. Thus, it can be concluded that the length of corn storage has a negative pattern on the crude fat content of corn depending on the added preservative.

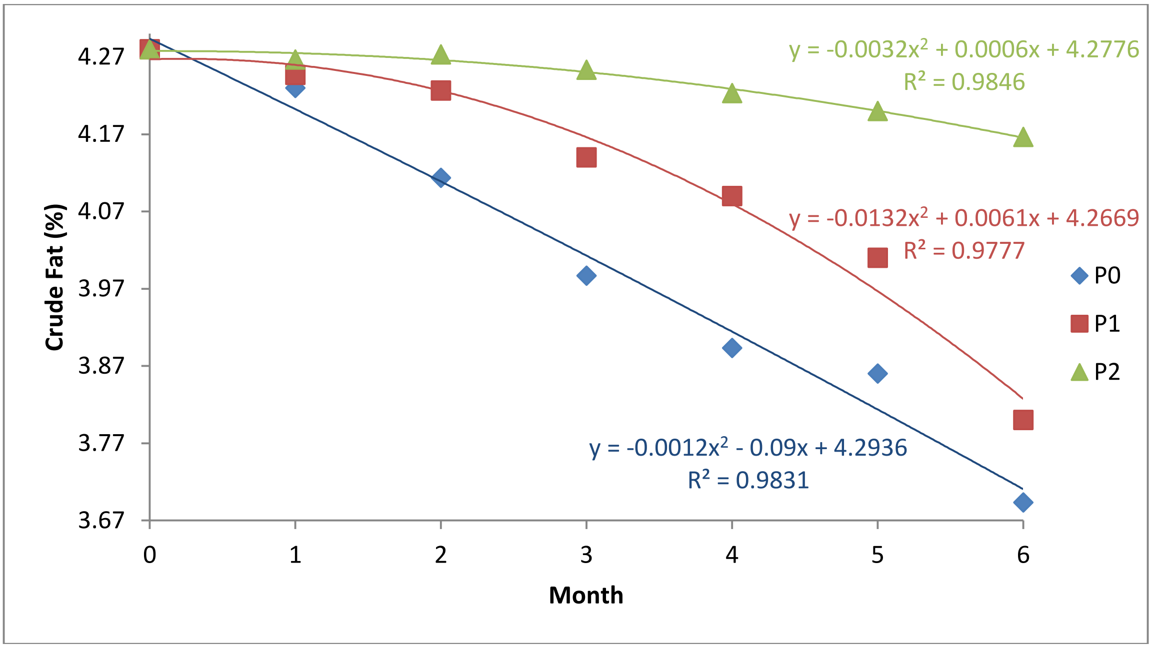

Figure 2. Effect of addition of propionic acid and aluminum phosphide and storage time on crude fat of stored corn

The addition of propionic acid and aluminum phosphate in P2 treatment was considered to be able to maintain the quality of corn, especially from weevil infestation and fungal growth which could reduce the quality of corn. This agrees with Mangundiharjo (1978) and Tefera et al. (2011) that weevils could reduce the nutritional value of corn.

Syarief et al, (2003) stated that the growth of *Aspergillus flavus* and *A. parasiticus* produced secondary metabolites in the form of aflatoxin which could accelerate the process of damage to feed ingredients. Decreased crude corn fat was also included in the category of damage to feed ingredients.

Crude fiber

The results showed that the addition of propionic acid and aluminum phosphide and storage time significant effects ($P<0.05$) on crude fiber content of the stored corn (Table 4). Corn is one of the feed ingredients that is always present in chicken feed and is a good source of energy because its crude fiber is low around 2%, so corn can be used at a higher level. Addition of aluminum phosphide (fumigation) to P2 treatment did not show a large increase in crude fiber compared to treatments P0 and P1. Aluminum phosphide acts as a fumigant that prevents weevils from physically damaging the corn. Larvae damage the endosperm of corn, depleting the essence of corn nutrition and leaving the crude fiber as mentioned by Trematera et al. (2007) that *S. zeamais* damaged cereals causing heavy shrinkage, decreased quality through increased free fatty acids, thus destroying stored cereals.

Table 4. Effect of addition of propionic acid and aluminum phosphide and storage time on crude fiber of stored corn

Storage time (mo)	Treatment			Mean crude fiber (%)
	PO	P1	P2	
0	1.32	1.32	1.32	1.32^{a}±0.00
1	1.33	1.32	1.32	1.32^{a}±0.01
2	1.34	1.33	1.33	1.33^{a}±0.01
3	1.40	1.36	1.32	1.36^{a}±0.04
4	1.59	1.45	1.33	1.46^{a}±0.13
5	1.97	1.79	1.35	1.70^{b}±0.32
6	2.67	2.35	1.35	2.12^{c}±0.69
Mean	1.66^{b}±0.50	1.56^{b}±0.39	1.33^{a}±0.01	

P0: Corn control
P1: Corn + 1.5% propionic acid
P2: Corn + 1.5% propionic acid + aluminum phosphide (fumigation)

Corn stored without adding aluminum phosphide (P0 and P1) showed the highest level of damage as seen from the physical shape of the hole made in the corn. Weevils can reduce the nutritional value of corn, one of which is the increase of crude corn fiber, which according to Nonci et al. (2006) that if the damage was heavy, in one seed there could be more than one hole. Tefera at al. (2011) also added that *S. zeamais* infestation could reduce nutrient content, germination and reduce market value.

There was an interaction between the addition of propionic acid and storage time on crude fiber of corn (Figure 3), while the addition of aluminum phosphide with long storage time did not show significant effect on the crude fiber of corn. The level of corn crude fiber in treatments P0 and P1 showed a positive pattern for the duration of corn storage. Thus, it can be concluded that duration of corn storage has a positive pattern on crude fiber content of corn except for the treatment using aluminum phosphide.

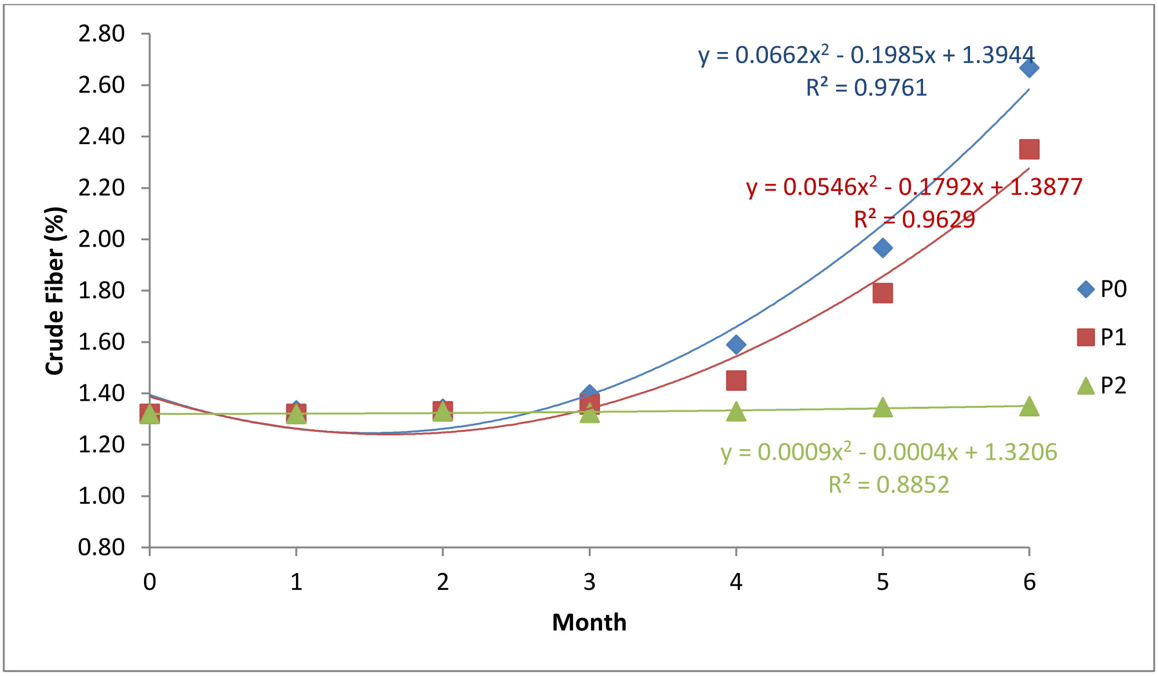

Figure 3. Effect of addition of propionic acid and aluminum phosphide and storage time on crude fiber of stored corn

From Figure 3, it can be seen that the highest increase in crude fiber in the stored corn was in treatment P0 and followed by treatment P1. In P2 treatment, there was no significant increase in crude fiber. The effect of adding aluminum phosphide can inhibit the growth of weevils which can damage the quality of corn.

The factor that caused the percentage of crude fiber to increase in P0 and P1 treatments was the high weevil population. Without the protection of aluminum phosphide in corn, weevils would consume the nutrients in corn such as protein, fat and carbohydrate. This is in accordance with Nonci et al. (2006) that *Sitophilus zeamais* laid their eggs in corn seeds before the stage of harvesting or during storage.

Ash content

Addition of propionic acid and aluminum phosphide as well as storage time did not show any significant effect on corn ash content (P>0.05). Ash content was not affected by any treatment P0, P1 and P2 (Table 5).

Table 5. Effect of addition of propionic acid and aluminum phosphide and storage time on ash content of stored corn

Storage time (mo)	Treatment			Mean ash content (%)
	PO	P1	P2	
0	1.19	1.19	1.19	1,19±0,00
1	1.18	1.20	1.18	1,19±0,01
2	1.19	1.20	1.20	1,20±0,00
3	1.19	1.21	1.21	1,20±0,01
4	1.20	1.22	1.21	1,21±0,01
5	1.18	1.22	1.21	1,20±0,02
6	1.19	1.20	1.21	1,20±0,01
Mean	1,19±0,01	1,21±0,01	1,20±0,01	

P0: Corn control
P1: Corn + 1.5% propionic acid
P2: Corn + 1.5% propionic acid + aluminum phosphide (fumigation)

Total aflatoxin

The results showed that the addition of propionic acid and aluminum phosphide and storage time on stored corn showed significant effects ($P<0.05$) on the aflatoxin content (Table 6). Aflatoxin is a class of toxic compounds harmful to livestock. Aflatoxin is often found in grains in the tropics such as corn.

Table 6. Effect of addition of propionic acid and aluminum phosphide and storage time on total aflatoxin of stored corn

Storage time (mo)	Treatment			Mean total aflatoxin (ppb)
	PO	P1	P2	
0	5.19	5.19	5.19	5.19^{a}±0.00
1	7.44	5.91	5.91	6.42^{a}±0.88
2	11.94	10.04	8.67	10.21^{b}±1.64
3	15.83	11.52	11.34	12.90^{c}±2.55
4	19.77	15.60	15.90	17.09^{d}±2.32
5	25.77	20.23	18.67	21.56^{e}±3.73
6	38.40	28.10	24.93	30.48^{f}±7.04
Mean	17.76^{b}±11.52	13.80^{a}±8.22	12.94^{a}±7.25	

P0: Corn control
P1: Corn + 1.5% propionic acid
P2: Corn + 1.5% propionic acid + aluminum phosphide (fumigation)

In the treatment of P1 and P2 with the addition of propionic acid showed lower levels of aflatoxin increase compared to the control corn treatment (P0). In P2 treatment resulted in the least increase in aflatoxin because of addition of propionic acid and aluminum phosphide for weevil control. Physical damage to corn caused by weevils is one of the causes of increased aflatoxin level (Tandiabang, 2010) that weevils could physically damage the stored corn, thus there was a need to separate the damaged grains as low density grains would reduce aflatoxin contamination.

Corn stored without any treatment (P0) showed the highest level of damage. The high growth of *Aspergillus flavus* in stored grain is an indication of increasing aflatoxin level. The addition of propionic acid in the feed industry is very important in suppressing the growth of *Aspergillus flavus* that propionic acid or a mixture of propionic acid and acetic acid can inhibit seed respiration and microorganism activity in some types of high-water granules (Stevenson, 1982). The longer the corn is stored, the higher the level of aflatoxin in the corn (Mulyawanti, 016) that the concentration of aflatoxin would not decrease during storage, but would not increase.

There was a significant interaction between the addition of propionic acid and aluminum phosphide and the duration of storage on aflatoxin level (Figure 4). This could be seen from the increase in aflatoxin level in all treatments. Thus it can be concluded that the longer corn is stored, the higher is the level of aflatoxin in the corn. The aflatoxin level in corn depended on the treatment imposed on the corn.

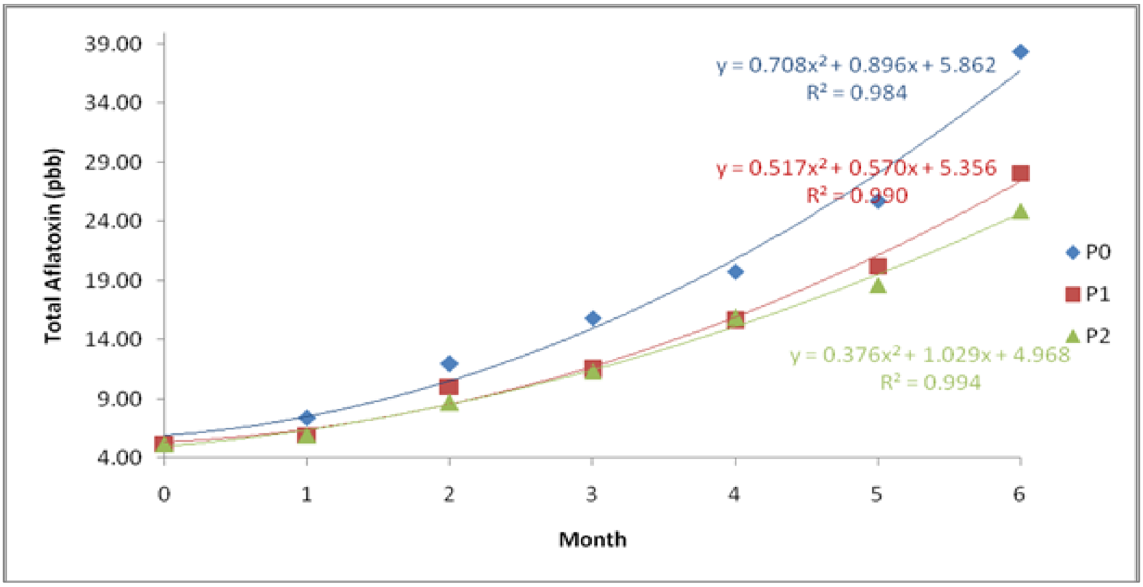

Figure 4. Effect of addition of propionic acid and aluminum phosphide and storage time on total aflatoxin of stored corn

From Figure 4 it can be seen that the most significant increase in total aflatoxin occurred in the P0 treatment, while in the P1 and P2 treatments the decrease was lesser. The addition of propionic acid was very influential in suppressing the growth of the fungus *Aspergillus flavus* which produced aflatoxin. The longer the corn was stored the higher the aflatoxin level in the corn. This is in accordance with Mulyawanti (2016) that the concentration of aflatoxin would not decrease during storage, but would increase or remain stagnant.

T-2 toxin

The study showed that the addition of propionic acid and aluminum phosphide and storage time did not show significant effect (P>0.05) on the content of T-2 toxin (Table 7).

T-2 toxin is a class of toxic compounds that are harmful to livestock. T-2 toxin is often found in grain crops in the sub-tropical region. *F. sporotrichiodes* or *F. graminearum* fungi that produce the T-2 toxin grow well in optimal temperatures between 24^0 - 26^0C and more vigourous growth is often seen in sub-tropical regions, while Indonesia has temperatures ranging from 30^0 – 33^0C.

Table 7. Effect of addition of propionic acid and aluminum phosphide and storage time on T-2 toxin in stored corn

Storage time (mo)	Treatment			Mean T-2 level (pbb)
	PO	P1	P2	
0	3.98	3.98	3.98	3.98±0.00
1	3.97	3.97	3.98	3.97±0.01
2	3.97	3.98	3.98	3.98±0.00
3	3.98	3.97	3.97	3.97±0.00
4	3.97	3.98	3.97	3.98±0.00
5	3.97	3.97	3.98	3.97±0.01
6	3.97	3.97	3.97	3.97±0.00
Mean	3.97±0.00	3.98±0.00	3.98±0.00	

P0: Corn control
P1: Corn + 1.5% propionic acid
P2: Corn + 1.5% propionic acid + aluminum phosphide (fumigation)

This finding is supported by Bennet and Klich (2003) that T-2 toxin produced mainly by *F. sporotrichiodes* or *F. graminearum* thrived in optimal temperature between 24 - 26^0C and Binder et al (2007) that T-2 toxin contamination was only 1% while the highest was aflatoxin at 34%.

Longer period of storage of corn tended to cause increased fungal growth and weevil infestation. According to Surtikanti (2004) corn seeds often experienced a loss of both excessive quality and quantity after experiencing storage for quite a long period of time. In Indonesia, yield loss due to warehouse pests was estimated at 26-29%.

Corn gross energy

The length of storage of corn also affected the energy content of stored corn (Table 8). The addition of propionic acid and aluminum phosphide and storage time showed significant effect on value corn gross energy (P<0.05). P2 treatment with the addition of propionic acid and aluminum phosphide showed the least decrease in gross energy. The physical condition of the corn not damaged by weevils and the slight growth of fungi, caused the nutrients of corn to be maintained well. One of the causes of deterioration in the quality of corn was contamination of fungi and weevil pests.

Table 8. Table 8. Effect of addition of propionic acid and aluminum phosphide and storage time on corn gross energy

Storage Time (mo)	Treatment			Mean GE (Kcal)
	PO	P1	P2	
0	3390	3390	3390	3390^{e}±0.00
1	3386	3385	3388	3386^{e}±1.71
2	3379	3380	3385	3381de±2.83
3	3369	3370	3374	3371^{d}±2.78
4	3338	3346	3364	3349^{c}±13.18
5	3317	3325	3358	3333^{b}±22.05
6	3282	3307	3340	3309^{a}±29.27
Mean	3352^{a}±40.86	3358^{b}±32.33	3371^{c}±18.39	

P0: Corn control
P1: Corn + 1.5% propionic acid
P2: Corn + 1.5% propionic acid + aluminum phosphide (fumigation)

In the P0 treatment there was a significant decrease in gross energy during storage. Physical condition of maize damaged by weevil and increased growth of *Aspergillus flavus* caused the nutritional value of corn to decrease. Fungi use the energy content in corn for metabolic purposes. This is consistent with Kennedy (2003) that corn was easily contaminated by fungi, especially *Aspergillus flavus* and *A. parasiticus*, which can produce secondary metabolites in the form of aflatoxin. In the P0 treatment without the addition of any preservative there was a significant decrease in gross energy during storage.

There is an interaction between the addition of propionic acid and aluminum phosphide and storage time on gross energy (Figure 5). The addition of propionic acid and aluminum phosphide could maintain the quality of maize from weevil infestation and fungal contamination. This is supported by Desrosier (1988) that propionic acid is a colorless, oily, water-soluble, odor-stimulating liquid, effective against mold and slightly inhibits bacteria and yeast. Wahab et al. (2008) also added that the use of aluminum phosphide is very fast developing into one of the most commonly used materials as fumigants because of its properties which are considered to be ideal poisons for all insects - very effective, does not affect seed viability, free from toxic residue and leaves little residue in food grains.

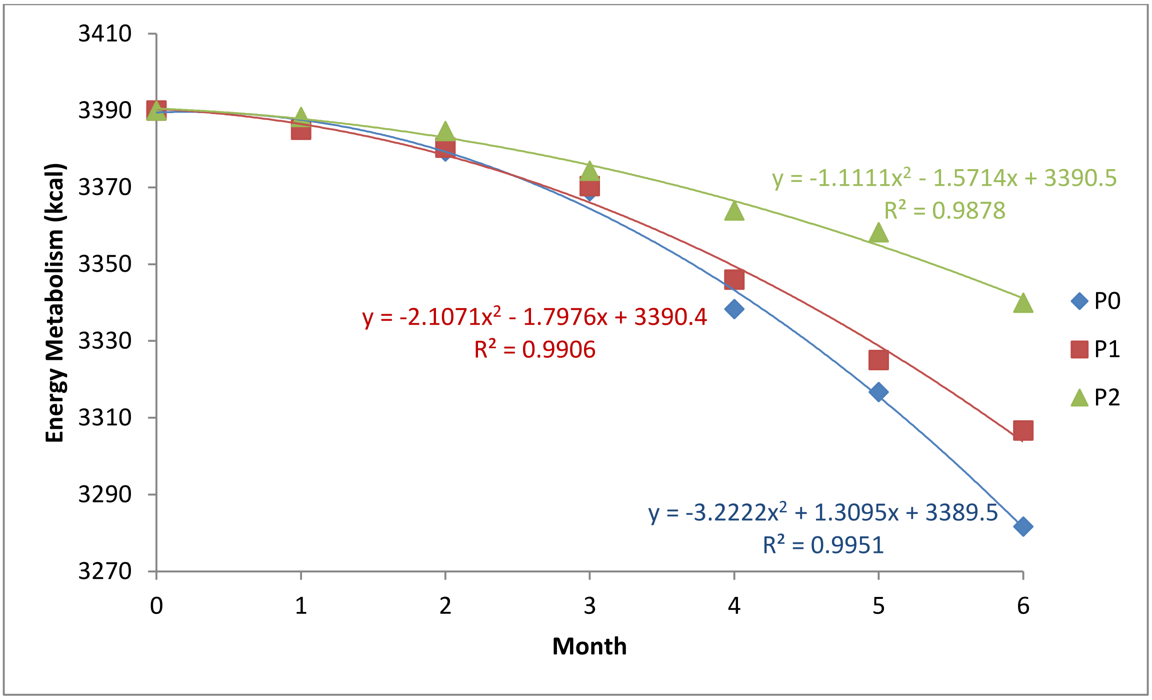

Figure 5. Effect of addition of propionic acid and aluminum phosphide and storage time on gross energy of stored corn

This can be seen from the decrease in metabolic energy which showed a negative pattern during storage for all treatments. Thus, it can be concluded that the longer the corn is stored, the lower the metabolic energy in it. The size of the decrease in metabolic energy in corn depends on the treatment given to corn.

Weevil contamination scoring

Table 9. Weevil contamination scoring

Storage time	Weevil Contamination Scoring		
	P0	P1	P2
Month 1	+	+	-
Month 2	++	++	-
Month 3	++	++	-
Month 4	+++	+++	-
Month 5	+++	+++	-
Month 6	+++	+++	-

P0 : Corn control
P1 : Corn + 1.5% propionat acid
P2 : Corn + 1.5 % propionat acid + aluminum phosphide phosphide
(-) = no cont., (+) = mild cont., (++) = medium cont., (+++) = high contamination


Figure 6. Corn physical condition after 6 months of storage without any addition (P0)


Figure 7. Corn physical condition after 6 months of storage with addition propionic acid (P1)


Figure 8. Corn physical condition after 6 months of storage with addition propionic acid and aluminum phosphide (P2)

Conclusion

Corn without treatment (control) reduced crude protein from 8.41to 6.95%, crude fat from 4.28 to 3.69%, gross energy from 3390 to 3282 kcal for 6 mo of storage. While total aflatoxin increased from 5.19 to 38.40 pbb and crude fiber increased from 1.32 to 2.67%. But the addition of preservative (propionic acid) and fumigation agent using anti-weevil (aluminum phosphide) could slow the process of damage of corn.

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