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PHYSICAL AND CHEMICAL QUALITIES OF CORN WITH DIFFERENT MOISTURE LEVELS SUPPLEMENTED WITH MOLD INHIBITOR

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ABSTRACT

Corn grain is used as the main energy source in poultry diet formulation. The quality of corn is easy to deteriorate during storage because of insect, fungal, and mycotoxin contamination. Efforts should be made to maintain the quality of corn during storage. The present study aimed to evaluate the physical and chemical qualities of different moisture levels of corn supplemented by a mold inhibitor. A total of 750 kg of corn grains was used in the present study. A commercial mold inhibitor was used with a dose of 0.045%. The experimental design used was a 3 x 2 factorial complete randomized design. The first main factor was the different moisture levels (ML) of corn (≤ 10%, 10.0-10.9%; 11.0-11.9%), while the second main factor was mold inhibitor (MI, - or +). Thus, there were six treatment combinations, and each treatment comprised five replications. The results showed that ML, MI, and ML x MI interaction significantly ($P < 0.05$ to 0.001) affected the percentage of grain damage and fungal grain but not ($P > 0.05$) the moisture level of corn during 90 days of storage. Except for crude protein content, the ML did not affect ($P > 0.05$) the proximate composition (PC) and gross energy (GE) content of corn. Except for dry matter (DM), the PC and GE content of corn were not affected ($P > 0.05$) by MI. ML x MI interaction did not affect ($P > 0.05$) the PC and GE content. The aflatoxin B1 (AFB1) content was similar ($P > 0.05$) among all treatments. Except for histidine and lysine contents, the amino acid contents of corn were not affected by ML, MI, or ML x MI combination. In conclusion, the supplementation of MI in corn with different ML improved the physical quality, DM, ash, and GE content of corn grain during the storage; MI maintained the DM content but did not reduce the AFB1 content of corn. Except for histidine and lysine, the supplementation of MI in corn with different ML did not affect the amino acid content of corn.

Keywords: corn, moisture levels, mold inhibitor, quality

INTRODUCTION

Corn as a feed ingredient is the dry seeds of *Zea mays* L that have been removed and cleaned from the cobs (National Standardization Agency 2013). Furthermore, it was explained that based on the color, corn kernels are classified into two types, namely white corn, and yellow corn. Both yellow and white corn is the main energy source in poultry diet formulation in Indonesia.

The proportion of corn used in poultry and monogastric diets ranges from 50 to 60%. The quality of corn as a feed ingredient is determined based on its nutrient content and the presence or absence of unwanted materials (National Standardization Agency 2013). Corn is categorized into two levels of quality. The first and second qualities of corn contain maximum 14 and 16% moisture content, respectively (National Standardization Agency 2013). Corn grain having high moisture content is often associated with aflatoxin content. In Indonesia, freshly harvested corn usually has a high moisture content, approximately 31.28%, so that if it is not immediately and properly dried, it will very quickly become contaminated with various fungi including *Aspergillus flavus* and Fusarium (Hausufa & Rusae 2018; Mukkun *et al.* 2018).

The growth of *Aspergillus flavus* is influenced by various factors such as initial moisture content, relative humidity, temperature,

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atmospheric gases, light, oxygen, carbon dioxide, pH, mechanical damage, contamination, and competitive effects of other molds (Kumar *et al.* 2021; Muga *et al.* 2019; Mukkun *et al.* 2018). *Aspergillus flavus* can live well at a temperature range of 20 - 35 ºC, pH 4-6, relative humidity 80 to 90%, aerobic atmosphere conditions, and 18% water content (Talanca & Mas'ud 2009; Muga *et al.* 2019). Daou *et al.* (2021) reported that the optimal temperatures for *Aspergillus flavus* to grow and to produce toxins were 35 and 33 ºC, respectively.

The pathogenic fungal species infesting corn during the storage will utilize corn nutrients for their growth and development, leading to a decrease in physical and chemical qualities of corn (Elsamra *et al.* 2012; Talanca & Mas'ud 2009). The decrease in the physical quality of corn can be identified through odor, color, and texture (Talanca & Mas'ud 2009). The decrease in chemical quality of corn was identified through the decrease in nutrient content and the presence of aflatoxin.

Aflatoxins, which are the most potent fungal toxins (mycotoxins), are carcinogenic and teratogenic. The aflatoxins are produced during the infection and growth of *Aspergillus flavus* and *Aspergillus parasiticus* in several food/feed ingredients, such as maize and beans (Fountain *et al.* 2015). Aflatoxins also adversely affect the growth of livestock and humans. In terms of livestock, the toxicity of aflatoxin depends on the level of aflatoxin in the feed and the impact is different for each type of livestock. Chickens are the most resistant to acute aflatoxicosis compared to other poultry (Monson *et al.* 2015). When poultry is exposed to aflatoxins it does not cause mortality or morbidity, but considerable losses are experienced by the poultry industry because of hepatotoxicity.

Strategies to suppress the growth and development of pathogenic fungi is a major concern, which should lead to serious efforts in maintaining the physical and chemical quality of corn during storage. The efforts should also suppress the production of fungal toxins produced by corn so that the danger of aflatoxicosis can be reduced or even eliminated. Several strategies can be applied, such as immediately drying the harvested corn, the use of antagonistic microbes such as *Neurospora* sp. and *Rhizopus* sp., the use of chemicals (mold inhibitors) such as ammonia and propionic acid, and natural materials such as clove powder (Elsamra *et al.* 2012; Talanca & Mas'ud 2009; Wang *et al.* 2019; Oliveira *et al.* 2020). The results of research by Elsamra *et al.* (2012) showed that the use of clove powder as a natural fungal inhibitor can suppress the growth of *Aspergillus flavus* and also reduce the crude fat content of corn. The same research also proved that the use of Fix-a-tox is also effective in suppressing the growth of *Aspergillus flavus* and reducing the content of some amino acids in corn.

The adverse effects of aflatoxin and strategies for preventing and eliminating aflatoxins are still a global issue. Indonesia's tropical environmental conditions strongly support the growth of pathogenic fungi, such as *Aspergillus* spp. According to Weinberg *et al.* (2008), the harvested grains are vulnerable to molding leading to rapid decline of quality under humid and warm conditions. Therefore, it is very important to find the appropriate strategy to prevent the growth activity of these pathogenic fungi. Based on these considerations, a study has been conducted to evaluate the physical and chemical qualities of corn grains having different moisture contents supplemented by commercial mold inhibitor during storage.

MATERIALS AND METHODS

Feed Ingredients

The yellow corn grains having different moisture content (< 10%, 10.0 - 10.9%, and 11.0 - 11.0%) and a commercial mold inhibitor was used in this study. The yellow corn grains were obtained from farmers in South Central Timor Regency. The mold inhibitor product was provided by a feed producer. The product contains 57% propionic acid, 30 mg/kg lead, and 0.54 mg/kg arsenic. The dose used in this study was 450 g/ton of feed.

Experimental Design

This study was designed using a factorial completely randomized design with a 3 x 2 factorial pattern with 3 levels of corn moisture content (< 10%, 10-10.9%, and 11.0-11.9%) and 2 levels of fungal inhibitors (-, +), resulting to six treatment combinations altogether. Each treatment consisted of five replications (25 kg of corn per replication). The treatments were:

Corn (<10% moisture content)

Corn (<10% moisture content) + mold inhibitor (0.045%)

Corn (10.0-10.9% moisture content)

Corn (10.0-10.9% moisture content) + mold inhibitor (0.045%)

Corn (11.0-11.9% moisture content)

Corn (11.0-11.9% moisture content) + mold inhibitor (0.045%)

Experimental Procedure

The initial moisture content of corn was measured with a grain moisture meter. Then, the corn grains with different moisture contents (< 10%, 10.0-10.9%, 11.0-11.9%) without mold inhibitors were put into polyethylene bags (5 bags per treatment; 25 kg corn per bag). Meanwhile, the treatments with mold inhibitor were conducted as follows: corn grains were added with mold inhibitor 0.045%, mixed, and then put into a polyethylene bag (25 kg/bag). All treatment bags were then placed on pallets and stored for three months in a feed storage room which had been cleaned and sanitized. A thermo-hygrometer was placed on the wall to control the temperature and humidity. On day 90, the moisture content of the corn grains was measured using a grain moisture meter. The sampling of corn was carried out using the Cone and Quartering method (Campos-M & Campos-C 2017) and was followed by sample reduction using a seed sampler to obtain laboratory samples. Laboratory samples were packed in sealed plastic bags, labeled, and sent to the laboratory for chemical analysis.

Chemical Analysis

The dry matter, crude protein, crude fat, and ash contents were determined using the AOAC Official Method (AOAC 2005). Gross energy (GE) level was determined using an Automatic Bomb Calorimeter (IKA C2000). The analysis of aflatoxin (B1, B2, G1, and G2) content of corn grains was conducted at the Food and Feed Laboratory of SEAMEO BIOTROP in Bogor using Thin Layer Chromatography (TLC) (Bainton *et al.* 1980). The limit of aflatoxin detection with TLC was 3.01 ppb for AFB1, 3.50 ppb for AFB2, 0.54 for AFG1, and 1.0 ppb for AFG2.

The amino acid content of corn samples was analyzed using High-Performance Liquid Chromatography (HPLC, ICI Instrument/ Shimadzu SCL-10A/Shimadzu CBM 20A) with four main steps, namely the manufacture of protein hydrolyzate, drying, derivatization, and injection into HPLC. The analysis procedure was as follows: corn sample was hydrolyzed with 10 mL of 6 N HCl at 100 ^{o}C for 24 hours. The results of the hydrolysis were transferred to the evaporator flask and rinsed with 2 mL of 0.01 N HCl. This process is done 2 - 3 times. Then the sample was dried using a Rotary Evaporator for 15 - 30 minutes to convert cysteine into cystine. The dried sample was added with 5 mL of 0.01 N HCl, then filtered. The derivatization solution was prepared by adding potassium borate buffer pH 10.4 to the sample in a ratio of 1:1. A total of 50 mL of the sample was put into an empty vial and added with 250 mL of Orthoflaaldehyde, left for one min, and then filtered. Subsequently, 5 mL of the sample was injected into the HPLC and then made a standard chromatogram using ready-to-use amino acids that underwent the same treatment as the sample.

Measurements

1. Insect-damaged seed (%): Corn grains from each plastic bag was sampled and reduced several times to get to 1.5 kg of samples by using the cone and quartering method (Campos-M & Campos-C 2017). Then, the insect-damaged seeds were taken from the reduced sample and weighed. The percentage of insect-damaged seeds was then calculated using the following formula (Nyarko *et al.* 2021):

$$\text{\% insect-damaged seeds} = \frac{\text{insect-damaged seeds (g)}}{\text{total weight of corn sample (g)}} \times 100\%$$

2. Moldy Seeds (%): The sampling procedure to quantify the moldy seeds was similar to the sampling method for insect-damaged seeds. The moldy seeds were characterized by color change (Shahbazi & Shahbazi 2018). The percentage of moldy seeds was calculated by the formula:

$$\text{\% moldy seeds} = \frac{\text{moldy seeds (g)}}{\text{total weight of corn sample (g)}} \times 100\%$$

Statistical Analysis

The data obtained were analyzed by using the two-way analysis of variance (ANOVA) following the General Linear Model procedure of SAS (SAS OnDemand of the SAS System). Significance was determined at $P < 0.05$ and the Duncan test was then conducted to determine the significant differences between mean values.

RESULTS AND DISCUSSIONS

Effect of Mold Inhibitor on Physical Quality of Corn

Physical and chemical damages to corn kernels during storage can be caused by various factors, such as the initial moisture content of corn during storage, the temperature, humidity, corn variety, and warehouse pests (Mutungi *et al.* 2019; Mukkun *et al.* 2018; Muga *et al.* 2018; Li *et al.* 2014; Suleiman *et al.* 2013). Table 1 shows the effect of treatments on the physical quality and moisture content of corn stored for 90 days.

The results showed that a significant ($P < 0.05$) interaction was found between the moisture level (ML) and mold inhibitor (MI) in the percentage of insect-damaged seeds and moldy seeds. On the other hand, no significant interaction ($P > 0.05$) between the moisture level (ML) and mold inhibitor (MI) was observed in the moisture content of corn harvested on day 90.

Table 1 shows that corn with different moisture contents (10.1 - 10.9% and 11.0 - 11.9%) supplemented with mold inhibitor had a significant lower percentage of damaged seeds and moldy seeds ($P < 0.05$) compared to the group of corn with the same moisture contents without mold inhibitor. The reduction of the damaged seeds and moldy seeds ranged from 1.46% to 77.9% and 16.9% to 80.5%, respectively (Table 1). The percentage of reduction increased in the group of corn with a higher moisture content supplemented by mold inhibitor. This phenomenon indicates that the mold inhibitor works more effectively to prevent physical damage to corn with high moisture content (Figs. 1 & 2).

Table 1 The effect of treatments on the physical quality and the moisture content of corn during 90 days of storage

Moisture Level (ML)	Mold Inhibitor (MI)	Insect-damaged seed (%)	Moldy grain (%)	Moisture content (%)
< 10.0%	-	2.73^{c}	1.24^{b}	10.38
	+	2.69^{c}	1.03^{b}	10.42
10.0-10.9%	-	8.86^{b}	2.92^{a}	10.42
	+	5.05^{c}	1.58^{b}	10.48
11.0-11.9%	-	19.25^{a}	3.94^{a}	10.38
	+	4.25^{c}	0.77^{b}	10.30
SEM		0.828	0.457	0.533
Main factors				
Moisture Level (ML)				
≤ 10.0%		2.71^{c}	1.14^{c}	10.40^{b}
10.0-10.9%		6.96^{b}	2.25^{b}	10.45^{a}
11.0-11.9%		11.75^{a}	2.35^{a}	10.34^{c}
SEM		0.585	0.323	0.037
Mold Inhibitor (MI)	-	10.28^{a}	2.70^{a}	10.39
	+	3.99^{b}	1.13^{b}	10.40
SEM		0.478	0.264	0.307
Probability P > F				
ML		***	*	NS
MI		***	***	NS
ML × MI		***	*	NS

Notes: Different superscripts in the same column indicate significant differences ($P < 0.05$); * = significantly different at $P < 0.05$; *** = significantly different at $P < 0.001$; NS = not significantly different ($P > 0.05$); SEM = Standard Error of Mean.

Figure 1 Stored corn grains without mold inhibitor

Figure 2 Stored corn grains with mold inhibitor

Results of the present study was in agreement with those conducted by Elsamra *et al.* (2012) who reported that the addition of mold inhibitor reduced the percentage of damaged seeds (80%). Damaged corn is generally characterized by the appearance of holes and maize weevil (*Sitophilus zeamais*). Cannepele *et al.* (2003) stated that the damage of cereal grains due to *Sitophilus zeamais* has an impact on weight loss, decreased physical and chemical qualities of seeds, and reduced germination. Bhusal and Khanal (2019) reported that the presence of maize weevil leads to the increase of *Aspergillus flavus* infestation in corn. Mukkun *et al.* (2018) reported from their experiment that *Aspergillus flavus*, *A. niger, A. fumigatus, Fusarium* spp., *Penicillium* spp., *Rhizophus* spp., and *Mucor* spp. were the fungal species identified in corn during the storage.

The mold inhibitor used in the present study contains some active compounds, namely propionic acid (≥ 57%), lead (≤ 30 mg/kg), arsenic (≤ 0.54 mg/kg) which can inhibit fungal growth. Choojun and Yoonprayong (2011) stated that propionic acid is able to inhibit the growth of fungi (having antifungal activity), such as *Aspergillus* spp., *Rhizopus* sp., *Penicillium* sp., and *Zygosaccharomyces rouxii*. Telaumbanua (2019) in his literature review stated that propionic acid can inhibit the respiration process of grains and the metabolic activity of grain microorganisms. Yun and Lee (2016) in their literature review explained that the mechanism of propionic acid (CH_3CH_2COOH) in killing fungi is through mitochondrial apoptosis (programmed cell death).

Regarding the lead (Pb) compound, Amari *et al.* (2017) reported that lead (Pb) binds into the cell wall or cell membrane of fungi causing damages to the plasticity of the cell wall of fungal cell membrane so that the mitotic activity of fungal cells is reduced. Meanwhile, the arsenic (As) compound changes the pH of the corn medium to acid so that fungi cannot grow (Ceci *et al.* 2020).

Results of the present study are in agreement with those carried out by Nahm (1991) who reported that mold inhibitor was effective in preventing the growth of fungi and reducing the percentage of moldy seeds. The insignificant differences in moisture content of corn can be attributed to the temperature and humidity factors during the 90-day storage remains stable. These findings agreed with those conducted by Telaumbanua *et al.* (2019).

Effect of Mold Inhibitor on Proximate Composition and Gross Energy Content of Corn

The effect of treatments on the proximate composition and gross energy content of corn grains stored for 90 days is presented in Table 2. The results showed that the interaction between moisture level (ML) and mold inhibitor (MI) did not affect ($P > 0.05$) the proximate composition and gross energy of corn during the experiment. However, the content of dry matter, ash, and gross energy of corn tended to be lower in a group of corn without a mold inhibitor supplementation. On the other hand, the crude protein and crude lipid contents tended to decrease in a group of corn added with mold inhibitor.

Table 2 The effect of treatments on the proximate composition and gross energy content of corn during 90 days of storage

Moisture Level (ML)	Mold Inhibitor (MI)	Dry matter	Crude protein	Crude lipid	Ash	Gross energy
		……………..% (as fed)……………….				(kcal/kg DM)
<10.0%	-	89.02	7.01	4.96	0.922	2914
	+	89.70	6.94	4.74	0.935	3004
10.0-10.9%	-	89.10	7.71	4.93	1.082	2971
	+	89.77	7.35	4.69	1.250	2994
11.0-11.9%	-	89.33	7.38	4.74	1.067	3002
	+	90.05	7.04	4.91	1.250	3014
SEM		0.166	0.195	0.103	0.137	995
Main Effects						
Moisture Level (ML)						
<10.0%		89.36	6.97[b]	4.85	0.929	2959
10.0-10.9%		89.43	7.52[a]	4.81	1.166	2983
11.0-11.9%		89.67	7.21[a]	4.82	1.159	3008
SEM		0.117	0.138	0.072	0.097	703
Mold Inhibitor (MI)	-	89.15[b]	7.36	4.87	1.024	2962
	+	89.83[a]	7.11	4.78	1.145	3004
SEM		0.095	0.112	0.059	0.079	574.2
Probability P> F						
ML		NS	*	NS	NS	NS
MI		***	NS	NS	NS	NS
ML × MI		NS	NS	NS	NS	NS

Notes: Different superscripts in the same column indicate significant differences ($P < 0.05$); * = significantly different at $P < 0.05$; *** = significantly different at $P < 0.001$; NS = not significantly different ($P > 0.05$); SEM = Standard Error of Mean.

Except for crude protein content, the first main effect of moisture level (ML) did not affect ($P > 0.05$) the proximate composition and gross energy content of corn over the 90-day storage period. Significant differences ($P < 0.05$) in crude protein (CP) content were observed between the 10% ML and the other two moisture content (10.0 - 10.9% and 11.0 - 11.9%). The low CP content of corn with ML < 10% was an unexpected result.

The second main effect of mold inhibitor was that the mold inhibitor affected ($P < 0.001$) the dry matter (DM) content, but it had no significant effect ($P > 0.05$) on the content of crude protein, crude fat, ash, and gross energy of corn during the 90-day storage period. Corn supplemented with mold inhibitor had a higher DM content ($P < 0.05$) than those without mold inhibitor supplementation. The present results indicated that mold inhibitor supplementation was effective in inhibiting the growth of fungi and maize weevil (*Sitophillus zeamais*) so that the dry matter was not used by these living organisms to propagate.

The insignificant difference in crude protein content was in agreement with the finding of Telaumbanua *et al.* (2019). However, the insignificant effect of crude lipid, ash, and gross energy did not agree with those found by Telaumbanua *et al.* (2019). The difference was probably due to the difference in the method applied, especially the duration of the experiment and the type and dose of mold inhibitor used.

Effect of Mold Inhibitor on Aflatoxin Content of Corn

According to Negash (2018), there are six types of aflatoxin, involving aflatoxin B1, B2, G1, and G2, M1 (a metabolite of B1), and M2. Among all types of aflatoxin, aflatoxin B1 (AFB1) is the most dangerous type of aflatoxin, which can cause several harmful effects in humans and animals, such as enlarged liver, liver cancer, and hepatitis B virus infection (Nalle *et al.* 2021; Benkerroum 2020). In addition, Nalle *et al.* (2021) also reported that even at the low level, the AFB1 reduced the fat digestibility and feed efficiency, and changed the liver color. Thus, it is important to minimize the adverse effect of AFB1 in poultry feed ingredients.

Table 3 The effect of treatments on the aflatoxin content of corn during 90 days of storage

Moisture Level (ML)	Mold Inhibitor (MI)	AFB1*	AFB2**	AFG1***	AFG2****
		……ppb……			
≤10.0%	-	1.72	nd	nd	nd
	+	1.15	nd	nd	nd
10.0-10.9%	-	1.72	nd	nd	nd
	+	1.72	nd	nd	nd
11.0-11.9%	-	1.15	nd	nd	nd
	+	1.15	nd	nd	nd
SEM		1.462			
Main Effects					
Moisture Level (ML)					
≤10.0%		1.43	nd	nd	nd
10.0-10.9%		1.72	nd	nd	nd
11.0-11.9%		1.15	nd	nd	nd
SEM		1.033			
Mold Inhibitor (MI)	-	1.52	nd	nd	Nd
	+	1.34	nd	nd	Nd
SEM		0.844			
Probability P> F					
ML		NS	NS	NS	NS
MI		NS	NS	NS	NS
ML × MI		NS	NS	NS	NS

Notes: NS = not significantly different (P > 0.05); SEM = Standard Error of Mean; * = The limit of detection of AFB1 was 3.01 ppb; ** = The limit of detection of AFB2 was 3.50 ppb; *** = The limit of detection of AFG1 was 0.54 ppb; **** = The limit of detection of AFG2 was 1.0 ppb.

Table 3 depicts the effect of treatments on the content of aflatoxins B1, B2, G1, and G2 in corn stored for 90 days. The results proved that the interaction between the level of moisture (ML) and mold inhibitor (MI) did not significantly ($P > 0.05$) affect the aflatoxin content (B1, B2, G1, and G2) of corn during the trial period. The inefficacy of mold inhibitor in reducing the aflatoxin content of corn presumably because the aflatoxin level in corn was too low. However, it seems that the addition of mold inhibitor in corn grain with < 10% ML reduced the AFB1 level during the storage.

The main effect of moisture level (ML) or mold inhibitor (MI) had no significant effect ($P > 0.05$) on the content of aflatoxins (B1, B2, G1, and G2). However, the group of corn supplemented with mold inhibitor had lower AFB1 concentration (1.34 ppb) compared to those that were not added with a mold inhibitor (1.54 ppb). The numerical reduction in aflatoxin level was in agreement with the findings of Telaumbanua *et al.* (2019) who found that the aflatoxin level in the group of corn grains supplemented with mold inhibitor (propionic acid) was lower than that of control treatment.

Effect of Treatments on the Amino Acid Content of Corn

Amino acid is the building block of protein and plays an important role in protein cell synthesis in animal and human beings. Table 4 describes the effect of treatments on the indispensable amino acid content of corn stored for 90 days. The results showed that except for histidine and lysine, the interaction of moisture level (ML) and mold inhibitor (MI) did not significantly ($P > 0.05$) affect the indispensable amino acid content of corn during the 90-day storage period. The comparison was difficult to be made due to the difficulties in finding the references which conducted similar research.

Table 4 The effect of treatments on the indispensable amino acid content of corn during 90 days of storage

Moisture Level (ML)	Mold Inhibitor (MI)	Arginine	Histidine	Isoleucine	Leucine	Lysine	Methionine	Phenylalanine	Threonine	Valine
		……….% as fed……								
<10.0%	-	0.710	0.545	0.480	1.200	0.510	0.300	0.595	0.245	0.265
	+	0.710	0.565	0.485	1.210	0.560	0.365	0.580	0.300	0.370
10.0-10.9%	-	0.690	0.510	0.440	1.190	0.510	0.355	0.575	0.235	0.300
	+	0.710	0.530	0.495	1.200	0.505	0.295	0.575	1.065	0.265
11.0-11.9%	-	0.710	0.620	0.445	1.190	0.535	0.345	0.590	0.205	0.310
	+	0.680	0.525	0.455	1.195	0.520	0.345	0.615	0.240	0.255
SEM		0.008	0.013	0.023	0.014	0.006	0.002	0.020	0.338	0.043
Main Effects										
Moisture Level (ML)										
<10.0%		0.710	0.555^{a}	0.482	1.205	0.535^{a}	0.332	0.587	0.273	0.317
10.0-10.9%		0.700	0.520^{b}	0.467	1.195	0.507^{b}	0.325	0.575	0.650	0.282
11.0-11.9%		0.695	0.572^{a}	0.450	1.192	0.527^{a}	0.345	0.602	0.222	0.282
SEM		0.006	0.009	0.016	0.010	0.004	0.015	0.014	0.239	0.031
Mold Inhibitor (MI)	-	0.703	0.558	0.455	1.193	0.518	0.333	0.587	0.228	0.292
	+	0.700	0.540	0.478	1.202	0.528	0.335	0.590	0.535	0.297
SEM		0.005	0.007	0.013	0.008	0.004	0.012	0.011	0.195	0.025
Probability P> F										
ML		NS	*	NS	NS	*	NS	NS	NS	NS
MI		NS	NS	NS	NS	NS	NS	NS	NS	NS
ML × MI		NS	***	NS	NS	***	NS	NS	NS	NS

Notes: Different superscripts in the same column indicate significant differences (P < 0.05); * = significantly different at P < 0.05; *** = significantly different at P < 0.001; NS = not significantly different (P > 0.05); SEM = Standard Error of Mean.

The main effect of moisture level (ML) significantly affected (P < 0.05) the content of histidine and lysine, but it did not affect (P > 0.05) the other indispensable amino acid content of corn during the trial period. The histidine and lysine content of corn with 10.1 - 10.9% ML was lower (P < 0.05) than the histidine and lysine content of two other treatments.

The main effect of mold inhibitor (MI) did not affect (P > 0.05) all indispensable amino acid content of corn during the experimental period. This proves that the use of mold inhibitor with a dose of 0.045% did not have an adverse impact on the indispensable amino acid content of corn.

Table 5 shows the effect of treatment on the dispensable amino acid content of yellow shelled corn stored for 90 days. The results of the analysis of diversity showed that the interaction of moisture level (ML) and mold inhibitor (MI) did not significantly (P > 0.05) affect the essential amino acid content of dry shelled yellow corn which was stored for 90 days.

Table 5 The effect of treatments on the dispensable amino acid content of corn during 90 days of storage

Moisture Level (ML)	Mold Inhibitor (MI)	Alanine	Aspartic Acid	Cysteine	Glycine	Glutamic Acid	Proline	Serine	Tyrosine
		……….% as fed……							
≤10.0%	-	0.825	0.625	0.205	0.805	1.900	0.200	0.585	0.290
	+	0.845	0.620	0.205	0.815	1.900	0.205	0.630	0.350
10.0-10.9%	-	0.835	0.590	0.215	0.835	1.535	0.205	0.595	0.295
	+	0.890	1.120	0.200	0.820	1.855	0.215	0.605	0.290
11.0-11.9%	-	0.855	0.605	0.200	0.805	1.920	0.230	0.620	0.300
	+	0.855	0.620	0.195	0.805	1.865	0.230	0.615	0.305
SEM		0.023	0.217	0.010	0.012	0.150	0.019	0.010	0.018
Main Effects									
Moisture Level (ML)									
<10.0%		0.835	0.622	0.205	0.810	1.900	0.225	0.607	0.320
10.0-10.9%		0.862	0.855	0.207	0.827	1.695	0.210	0.600	0.292
11.0-11.9%		0.855	0.612	0.197	0.805	1.892	0.230	0.617	0.302
SEM		0.016	0.154	0.007	0.008	0.106	0.013	0.008	0.013
Mold Inhibitor (MI)	-	0.838	0.606	0.207	0.815	1.785	0.232	0.600	0.295
	+	0.863	0.787	0.200	0.813	1.873	0.212	0.617	0.315
SEM		0.013	0.125	0.006	0.007	0.087	0.010	0.006	0.010
Probability P> F									
ML		NS	NS	NS	NS	NS	NS	NS	NS
MI		NS	NS	NS	NS	NS	NS	NS	NS
ML × MI		NS	NS	NS	NS	NS	NS	NS	NS

CONCLUSION

The supplementation of mold inhibitor (MI) in corn with different moisture levels (ML) is effective to maintain the physical quality, the dry matter (DM), ash and energy content of corn grains during the 90-day storage period. The concentration of crude protein and crude lipid tended to decrease in the group of corn with different moisture level supplemented with mold inhibitor. The addition of mold inhibitor maintained the DM content but was not effective to reduce the AFB1 content of corn during the storage. Except for histidine and lysine, the supplementation of MI in corn with different ML did not affect the amino acid content of corn. Further research is needed to evaluate the mold inhibitor-treated corn on the growth performance of broilers and other poultry.

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