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Effect of various packaging materials for storing ground yellow corn of hybrid C-1 variety on water and amylum content

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Abstract. This research aims to investigate the effect of various packaging materials (cotton sack and perforated plastic sack) and the storing time on ground corn quality that were assessed from water and amylum contents. The research method was experimental using Completely Randomized Design that consisted of: A (control), B (cotton sack, stored for 20 days), C (cotton sack, stored for 40 days), D (cotton sack, stored for 60 days), E (perforated plastic sack, stored for 20 days), F (perforated plastic sack, stored for 40 days), and G (perforated plastic sack, stored for 60 days). The treatments were replicated 3 times. The results showed that the longer storing time on cotton sack and perforated plastic sack resulted in higher water content and lower amylum content.

1. Introduction

Corn is a popular ration material for all types of livestock, especially poultry. This corn foodstuffs material could come from domestic production and imports. The usage of corn in poultry can reach 51 percent of the total ration [1]. [1] further stated that in 2019 the national feed production was 20.8 million tons, in other words the need of corn for animal feed production in Indonesia was 700,000 tons per month. According to [2], corn production in Indonesia, on the one hand, has a good market potential, but in fact many corn products at the farmer level are not absorbed by the industry due to several things such as: high water content, damaged corn grain, non-uniform grain color, broken grains and other impurities which cause the low quality of corn produced.

This condition is affected by the weather conditions of our country which relatively in high humidity (70-80 percent), so it is support the growth of fungi, especially of the Aspergillus, spp. In the grain storage, the most important biological conditions that affect the growth and production of fungal metabolites (mycotoxins) are water activity, temperature, and gas composition [3]; [4]. With the good corn storage techniques by maintaining a low water content, safety sacks and floor mats are needed to prevent from animal attack damage and mold growth. [5] stated that storing corn in sack packaging with a base can reduce the aflatoxin content stored for 21 days.

This is in line with the statement of [6] that aflatoxin contamination occurs because of inappropriate post-harvest handling, for example when corn is stored. One of the efforts to improve post-harvest handling with good corn storage techniques is to store the product by placing it on a mat. For packaged products, it is recommended to use a package that has pores for air circulation and placed on a board base. The corn that used as animal feed is generally yellow corn because it has a high carotene content. Carotene affects poultry as a form of egg yolk color, shank color and skin fat color. Yellow corn used for poultry feed is generally ground corn. The smaller particle size of the corn allows it to be easily digested.

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Ground corn that is used as concentrate feed for livestock will have disadvantages when it is stored compared to whole corn, such as reduced nutrient content and palatability, so it is necessary to pay attention on how to overcome this problem. One aspect that influences the storage of ground corn is the packaging material. This packaging itself aims to protect the material against mechanical forces from outside, reduce evaporation or water absorption, reduce the possibility of microbial contamination or pest attack, thus the packaging can prolong the shelf life of corn.

During storage the ground corn will undergo physical and chemical changes. These changes can reduce the quality of ground corn. Physical changes, namely by increasing water content, while chemical changes, namely by decreasing amylum. One of the ways to inhibit the change process requires storage using the appropriate type of packaging. Packages that can be used include cotton sacks and perforated plastic sacks. The characteristic of cotton sacks is a large porosity while perforated plastic sacks have a smaller porosity. Therefore, which type of packaging can maintain water and amylum content to be developed.

2. Methodology

The materials used in the study were ground yellow corn varieties C-1 hybrids, cotton sacks, perforated plastic sacks, spectrophotometer, stirrer, desiccator, analytical scales, oven, room thermometer, amylum standard, absolute alcohol, 1 N NaOH, 1 N iodine solution and 1 N acetic acid. The research method was experimental using Completely Randomized Design consisted of A (control), B (cotton sack, stored for 20 days), C (cotton sack, storage for 40 days), D (cotton sack, stored for 60 days), E (perforated plastic sack, stored for 20 days), F (perforated plastic sack, stored for 40 days), and G (perforated plastic sack, stored for 60 days). The treatments were replicated 3 times. Determination of water content of ground corn using the [7] method and measurement of amylum content using a spectrophotometer [8].

3. Result and Discussion

3.1 The physical condition of ground corn before and after storage

The physical condition of ground corn before storage is fresh, which has characteristics of corn, fresh yellow color, does not clot and no insects were found. Stored for 60 days with storage warehouse temperatures ranging from 24-28 ^{o}C and relative humidity of 75-80 percent. This condition is still suitable for grain storage, this is in line with the statement by [9] that a good storage temperature for grain is 25-27 ^{o}C with an air humidity of 70-75 percent. However, there will be limitations in maintaining the quality of the materials during the storage period. Therefore, although the ground corn that stored was previously has a low water content, the water content of the stored corn will increase as well.

In the process of storing feed raw materials, there will be a balance between the water content in the feed ingredients and the water content in the room, meaning that if the water content of the feed ingredients is low while the water content in the storage room is high, the water content of the feed ingredients will gradually increase so that at the end will be balanced. Physical characteristics of ground corn during storage including discoloration, odor, clumping and insect attack are shown in Table 1.

Table 1. Physical characteristics of ground yellow corn during storage

Kinds of packaging	Physical characteristics	Long of storage (days)			
		0	20	40	60
Cotton sack	Color	-	+	++	+++
	Odor	-	-	+	++
	Clot	-	+	++	+++
	Insect	-	-	++	+++
Perforated plastic sack	Color	-	+	+++	++++
	Odor	-	+	+	++
	Clot	-	+	+++	++++

Insect	-	+	+++	++++

Note: - nothing changes, + little change, ++ moderate change, +++ a lot of change, ++++ very changed

The physical characteristics of ground corn (Table 1), the longer of the storage period, using cotton or perforated plastic sacks, tended to experience a decrease in the quality of ground corn. The storage time for ground corn still shows good physical characteristics when stored for 20 days.

3.2 Water content

The water content of ground corn during 60 days of storage is increased, both in cotton and perforated plastic sacks. The increase in water content of stored ground corn with cotton sacks was not different with the increase in water content of ground corn that occurred in storage with perforated plastic sacks. The average of water content of ground corn during storage (Table 2).

Table 2. The water content of ground corn during storage

No	Treatment	Water content (%)
1	A (control)	12.23 ± 0.20
2	B (cotton sack, stored for 20 days)	12.67 ± 0.25
3	C (cotton sack, storage for 40 days)	13.77 ± 1.21
4	D (cotton sack, stored for 60 days)	14.46 ± 0.49
5	E (perforated plastic sack, storage for 20 days)	12.62 ± 0.06
6	F (perforated plastic sack, stored for 40 days)	13.71 ± 0.25
7	G (perforated plastic sack, stored for 60 days)	14.82 ± 0.16
	Average	13.47 ± 1.03

The average water content of ground corn during storage for each type of packaging was increased, at storage with cotton sacks the water content of ground corn was from 12.23-14.46 percent and in storage with perforated plastic sacks the water content of ground corn was from 12.23-14.82 percent. The water content of stored ground corn is still low because the value of equilibrium moisture content (EMC) reach the equilibrium number of grains when stored at a temperature of 32 ^{o}C with 80 percent humidity indicates a water content of 15.5 percent [10].

Therefore, the longer of round corn is stored, the water content will increase. The increase in water content of ground corn during storage was caused by a balance between water content of ground corn and water in the storage warehouse. Based on the research results, temperature and humidity of the storage warehouse showed between 24-28 ^{o}C temperatures and 76-82 percent humidity. The water content of grain ingredients such as corn must be dried to a 14% water content to be safe during storage [4]. Other opinions from [11] stated that the water content of feedstuffs depends on the amount of main ingredients used. The water content that meets the quality requirements of corn is a maximum of 14%, before storage until the 21st day of storage [12].

The high humidity will also lead absorption of water vapor from the air which will result in moist material which affects the increase of water content [13]. The humidity is inversely related to air temperature. The higher of air temperature caused the smaller of humidity [14]. According to [15] 23-31 ^{o}C is the optimum growth temperature for *Aspergillus flavus*, aflatoxins can be produced with 7 days of an incubation periods. According to [10] that the water content of ground corn is 13.47 percent and the storage room temperature is 24-28 ^{o}C, the storage of ground corn can last up to 6 months. This is because a close relationship between storage room temperature of 27 °C and corn water content of 14 percent, so the corn can be stored for 6 months.

In line with the statement of [10], [10] further stated that the water content of the materials stored in the warehouse is closely related to humidity or water migration, feed ingredients which originally had a low water content if stored in a room with higher humidity then their water content would increase up to the point of equilibrium. This increase in water content will continue to gradually occur on the following days.

The increase in water content is caused by corn were being stored in the form of ground corn state so that it is easier to absorb water from the air. If seen physically, ground corn has smaller particles than the original size and has a hollow structure so that the ground corn has the higher ability to absorb water from the air and makes ground corn easily invest by insects. [16] stated that corn kernels are hygroscopic, so they always adjust to humidity and environmental temperature.

When viewed from the humidity of the warehouse during storage, which is 76-82 percent, it causes the ground corn to respire, thus the water content of ground corn will increase so that there will be an increasing of insect investment and microbial growth during storage. Storage of ground corn that packed with cotton sacks, water content is relatively still the same as ground corn that packed in perforated plastic sacks.

Shrinkage of the material during storage cannot be avoided because of the heating process and the discharge of water from the material. When the water leaves the material, there is an imbalance pressure inside the material and the outside which causes contraction and thus triggers shrinkage, changes of shape and occasionally breaks or cracks the material [17].

3.3 Amylum content

The amylum content of ground corn that stored for 60 days in cotton sacks or in perforated plastic sacks has decreased, this is presumably due to the damage to the carbohydrates. The average amylum content of ground corn during storage is shown in Table 3. The decrease in amylum content is caused by the presence of enzymatic activity which hydrolyzes carbohydrates into starch and then reducing sugars such as glucose and fructose, resulting in sugar accumulation. Amylum of ground corn contains 28 percent amylose and 72 percent amylopectin [18]. Amylum of corn is a fine powder, has a large surface area.

This is because natural amylum contains a lot of amylose so it is dry, less sticky and tends to absorb a lot of water [19]. Storing ground corn in cotton sacks causes a decreasing of amylum content lower than those stored in perforated plastic sacks. This is presumed by the greater humidity in the perforated plastic sack which causes a greater change of carbohydrates, among others, due to oxidation from incoming light, the large number of microorganisms that live at high humidity. The optimum temperature for the growth of microorganisms such as fungi is 25-30 ^{o}C with an air humidity of 65-93 percent [10]. In the storage process, corn grain still undergoes a respiratory process and produce carbon dioxide, water vapor, and heat [20].

Table 3. The Amylum content of ground yellow corn during storage

No	Treatment	Amylum content (mg/ml)
1	A (control)	5.50 ± 0.21
2	B (cotton sack, stored for 20 days)	4.73 ± 0.53
3	C (cotton sack, storage for 40 days)	3.69 ± 0.46
4	D (cotton sack, stored for 60 days)	2.73 ± 0.40
5	E (perforated plastic sack, stored for 20 days)	3.71 ± 0.30
6	F (perforated plastic sack, stored for 40 days)	2.82 ± 0.35
7	G (perforated plastic sack, stored for 60 days)	1.66 ± 0.12
	Average	3.55 ± 1.26

Chemical damage is caused by chemical decomposition during storage such as a decrease in carbohydrate and protein levels due to metabolic processes by both insects and microbes [21]. Furthermore, according to [21], the damage that occurs during storage and the main factors causing quality degradation include : Physical damage due to changes in water content during storage caused by changes in weather, granules become broken and susceptible to pests, biological damage caused by biological activities during storage such as pests, fungi and microbes, chemical damage is caused by chemical decomposition during storage such as decreased levels of carbohydrates and protein due to metabolic processes by both insects and microbes. The amylose content in carbohydrates also affects

the reduction of starch levels in ground corn. This is because amylose is able to absorb water so that it affects the starch development process [22].

4. Conclusion

The storage of ground yellow corn with cotton sack is relatively the same as perforated plastic sack to maintain water and amylum contents.

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