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Evaluation of Physical Quality Test, Proximate Test, and Production Performance Test of Sorghum and Corn Substitute Pellets with Enzymatic Treatment

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ABSTRACT. The purpose of this study is to determine the effect of enzymatic treatment on the physical quality test, proximate test, and performance test of pellets given enzymatic treatment on sorghum and corn. This study was conducted at the Integrated Animal Husbandry Laboratory, The University of West Sulawesi, which included physical quality tests and proximate tests. The treatment in the first stage of the study, namely, enzymatic treatment on sorghum at concentrations of 0.25%, 0.50%, 0.75%, 1%, and 0% (control) cellulase enzyme, was tested to assess the effect of increasing nutrition and decreasing crude fiber. The second stage was the preparation of feed to see the quality of the pellet test with the arrangement of treatments P0: 100% corn and 0% enzymatic sorghum, P1: 25% corn and 75% enzymatic sorghum, P2: 50% corn and 50% enzymatic sorghum, P3: 75% corn and 25% enzymatic sorghum, P4: 0% corn and 100% enzymatic sorghum. This study used a Completely Randomized Design (CRD) method with research treatments consisting of 5 treatments and 5 replications. The results of the study in the first stage can be concluded that the addition of cellulase-based enzymes to sorghum can increase crude protein and can reduce the content of crude fiber, NDF, ADF, hemicellulose. The SE2 treatment and in the second stage the treatment showed the best results based on the combination of all tests was P4 (100% enzymatic sorghum), because it provides more durable physical and organoleptic quality performance.

Keywords: Sorghum, enzymatic, physical quality test, proximate test, NDF, ADF

INTRODUCTION

Corn is one of the main ingredients in poultry feed formulations. It was used in feed due to its relatively high energy content and is difficult to replace with other ingredients. Corn also has economic value and abundant availability. Its utilization in feed can reach approximately 50-80%, which significantly affects feed production costs. However, in areas such as West Sulawesi, especially Majene, corn availability is often limited despite being one of the corn-producing areas, with production tending to be sold more outside the island due to its relatively high price. This is caused by several factors, including competition for corn use for animal feed and human consumption, as well as increasing costs of corn production and distribution.

High corn prices, coupled with the high dependence on corn for poultry feed, have made feed costs as one of the largest components of poultry production. This heavy reliance on corn has left farmers facing the challenge of reducing production costs while maintaining the performance of their livestock. The ban on corn imports has also led to an increase in corn prices due to the lack of a domestic corn supply sufficient to meet feed mill requirements, leading to high prices for poultry rations (Rishahadi et al., 2022). Therefore, alternative feed ingredients are needed that can not only replace corn but also provide adequate nutrition to support poultry performance.

Sorghum is a type of plant known by the Latin name as *Sorghum Bicolor L*. This plant has a shorter harvest period and high adaptability, lower production costs from plant to harvest, and a short growing period of 100-110 days (Hidayat, 2021). Sorghum, as a grain source with similar characteristics to corn, has emerged as a potential alternative. Sorghum offers the advantage of flexibility in growing in various land conditions, including areas with low rainfall or marginal land, and is relatively resistant to pests and diseases (Anugrahwati et al., 2024). Sorghum is very suitable for cultivation in area such as West Sulawesi.

Sorghum has the potential as a feed source to replace corn, and much research has been conducted to optimize the use of sorghum in feed (Hidayat, 2021). In addition, sorghum also offers several nutritional advantages, including higher protein content and lower crude fiber content compared to corn. Sorghum has been identified as a potential substitute for corn due to its similar nutritional composition (Getachew et al., 2016). Regarding substitution, sorghum can provide better production performance, as seen in several studies showing that the use of sorghum in poultry feed can increase feed efficiency (FCR), body weight

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growth, and feed stability during storage. Sorghum's basic ability to replace corn as an energy source feed lying on its ingredient which chemically similar to corn (Saleh et al., 2019). The digestibility of nutrients in sorghum is reported to be better than that corn (Thomas et al., 2018). The results of biological testing on sorghum in broiler feed demonstrated the same good performance as broilers when fed with corn-based feed (Liu et al., 2015).

Furthermore, sorghum development in areas like West Sulawesi is crucial because this crop does not compete directly with human food needs like corn. Sorghum consumption is also relatively lower than that corn (Xiong et al., 2019). Therefore, sorghum is considered a potential alternative energy source feed ingredient. The development of sorghum cultivation can also be a solution to reduce dependence on corn imports, reduce feed production costs, and ultimately increase the competitiveness of local farmers. The weakness of sorghum as a feed ingredient is due to the presence of tannins as anti-nutritional substances; the tannin content in sorghum is quite high (0.1-4.7%) depending on the variety. In addition, sorghum also has a crude fiber content ranging from 6.5% to 8%, which is almost similar to the crude fiber content in corn. This percentage can still be reduced by providing several treatments to improve the quality of sorghum as a feed raw material (Amizar et al., 2023).

Tannin reduction can be achieved using enzymatic methods, which can reduce crude fiber and anti-nutrients, and improve the chemical composition of feed ingredients. The addition of enzymes to sorghum-based feed can increase the nutritional value of sorghum using phytase enzymes, which subsequently improve the nutritional value of broiler chicken feed containing sorghum (Selle et al., 2010). The effect of adding commercial enzymes containing a mixture of pectinase, α-glucanase and hemicellulose to sorghum-based rations showed that the ileal digestibility value for amino acids increased by 3%, while the metabolic energy value increased by more than 6% (Selle et al., 2003). Enzyme addition can be used to enhance the nutritional value of sorghum. Enzymes such as phytase in sorghum-based feeds have been reported to increase body weight gain, amino acid digestibility, starch digestibility, and broiler performance (Moss et al., 2020). Therefore, to improve the quality of sorghum, further research is needed on the enzymatic effect on the chemical quality of sorghum as a substitute for sorghum in terms of CP, CF, ADF, NDF and hemicellulose which will then be tested for physical quality in the form of pellet feed by testing density, durability, bulky and organoleptic on pellets stored for a certain period of time.

MATERIALS AND METHODS

This research was conducted in two stages. The first stage involved laboratory testing with enzymatic treatment using cellulase enzyme, which was performed over 5 days of incubation at the Integrated Animal Husbandry Laboratory, The University of West Sulawesi. This was followed by sample testing for proximate analysis and fiber fractions.

After the nutritional content test data have been obtained, the second stage will take the best results from the first stage of research, namely P2, and then make them into pellets for organoleptic, physical, and chemical tests at the Animal Husbandry Laboratory, The University of West Sulawesi.

The tools used in the research were cameras, shovels, sacks, buckets, analytical scales, measuring cups, porcelain cups, plastic, trays, pH meters, spoons, thermometers, labels, pens, hand towels, and ovens. The materials used in the research were sorghum, cellulase enzymes, corn, premix, MBM, SBM, rice bran, tapioca flour, oil, and distilled water.

The research method in stage 1 used a Completely Randomized Design (CRD) with the following treatments:
Enzymatic Treatment includes:

SE0 = (sorghum flour without enzymatic treatment)
SE1 = (sorghum flour + 0.25% enzyme + 0.25% distilled water)
SE2 = (sorghum flour + 0.50% enzyme + 0.25% distilled water)
SE3 = (sorghum flour + 0.75% enzyme + 0.25% distilled water)
SE4 = (sorghum flour + 1% enzyme + 0.25% distilled water)

Research Procedures

The process of preparing sorghum samples, sorghum seeds are ground into flour then weighed 200 grams and added enzymes and distilled water for mixing with a ratio of enzymes and distilled water as much as 0.25% enzyme and 25 mil distilled water, 0.50% and 25 mil distilled water, 0.75% enzyme and 25 mil distilled water, and 1% enzyme and 25 mil distilled water. The sorghum that has been mixed with the enzyme is then put into plastic, which is then stored in an incubator at a maximum temperature of 27-30°C for 5 days, with temperature checks 2 times in 5 days. Then, on the 6th day, drying is carried out at a temperature of 60°C for 1 hour to stop the enzymatic process. Then, sampling is carried out for the physical quality test of sorghum that has been enzymatically tested with organoleptic testing, and then taken to the laboratory for crude protein, crude fiber, and crude fiber fraction tests. Then the best treatment results will be used as feed ingredients to be made into pellets for physical quality tests of pellets, including durability, density, and bulkiness. Then the pellets will be stored for organoleptic testing at different storage times.

P0: 100% corn and 0% enzymatic sorghum
P1: 25% corn and 75% enzymatic sorghum
P2: 50% corn and 50% enzymatic sorghum
P3: 75% corn and 25% enzymatic sorghum
P4: 0% corn and 100% enzymatic sorghum

RESULTS AND DISCUSSION

The results of the research on the proximate test of sorghum crude protein and fiber fractions with cellulase enzymatic treatment can be seen in Table 1.

Table 1. Crude protein content and crude fiber fraction of enzymatic sorghum.

Test	SE0	SE1	SE2	SE3	SE4
Crude protein (%)	11.33[a]	16.88[b]	19.97[e]	17.43[c]	17.58[d]
Crude fiber (%)	3.86[c]	1.88[b]	1.12[a]	1.22[a]	1.27[a]
NDF	53.24[d]	45.76[c]	44.32[b]	43.12[a]	42.87[a]
ADF	38.71[d]	31.59[a]	33.16[b]	33.78[c]	33.6[c]
Hemicellulose	14.53[a]	12.68[b]	11.16[c]	9.34[e]	9.27[e]

Note: Different superscripts in the same row indicate different results. Data source: Integrated Laboratory, The University of West Sulawesi

Crude Protein (CP)

The crude protein content of enzymatic sorghum with the addition of cellulase can be seen in Table 1. Analysis of variance revealed that the treatment has a significant effect ($P<0.05$) on enzymatic sorghum. It can be seen from the table that the increase in crude protein content of sorghum in the SE2 treatment, with an average value of 19.97% with the percentage of cellulase enzyme administration of 0.50% had a very significant effect on the increase in crude protein of sorghum. This is due to damage to the structure of the cell wall tissue by cellulase. According to Balo et al (2022), stated that cellulase works by breaking the lignocellulose bonds and reducing lignin levels, and then releasing the proteins bound to lignin, so that it can increase the percentage of crude protein. Similar research conducted on high-fiber biomass waste materials with the addition of EM-4 to utilize the performance of microbes that can produce 1% cellulase enzymes, which were then fermented for 4 days, showed the best results with the protein content increasing by 3.53% and the crude fiber content decreasing to 13.19%. This decrease was caused by changes in the composition structure of the material, which was replaced by an increase in the content of cell proteins trapped in the crude fiber in plant tissue being released, and an increase in the percentage of protein content in the material (Indrayani et al., 2022).

Crude Fiber (CSF)

The crude fiber content of enzymatic sorghum with the addition of cellulase can be seen in Table 1. The results of the study showed that all of the treatments had significant effect ($P<0.05$) on sorghum's crude fiber content. The best crude fiber content in enzymatic sorghum was the SE2 treatment (1.12%) compared to control (3.86%). The result of crude fiber analysis also showed dissimilar reduction among treatments, with SE-2 as the lowest (0.50%) and the SE4 as the highest (1.27%) although it has the highest enzyme administration of 1%. Based on the results of the study, it is known that enzymatic treatment can reduce the crude fiber content of sorghum. This effect was the result of microorganism's fermentation by secreting cellulase digestive enzymes and convert cellulose bonds into simple sugar groups. Cellulase enzymes produced by several microorganisms such as bacteria and fungi. Cellulase works specifically in breaking down crude fiber where the enzyme only works if several criteria are met including the presence of water, neutral pH, appropriate substrates as well as the balanced of raw materials and enzymes amount. If the percentage of enzymes was higher, the performance of the enzyme will work faster. However, this fast performance sometimes only targeting fiber products that can easily degraded such as hemicellulose, so the cellulose becomes undigested during this process. Therefore, it was necessary to consider the enzyme and the substrate balance so that the enzymatic process can runs optimally (Mahanani et al., 2020).

Neutral Detergent Fiber (NDF)

The NDF content of sorghum enzymatic with the addition of cellulase can be seen in Table 1. The results of the NDF test showed that the treatments had significant effect (P<0.05). The enzymatic treatment showed the best value in the SE4 treatment (42.87). The NDF amount was highly related to digestibility and affected by cellulose, hemicellulose, lignin, silica, age, and plant parts (Fariani and Akhadiarto, 2012). The percentage of NDF value indicating the presence of enzyme reaction in breaking down the plant tissue where NDF (contains hemicellulose), ADF (contains cellulose and lignin), NDS (contains starch and protein bonds) and ADS allowed an increase in nutritional content if there is a breakdown or decrease in NDF content (Mahanani, et al. 2020).

Acid Detergent Fiber (ADF)

The ADF content of sorghum enzymatic with the addition of cellulase can be seen in Table 1. Analysis of variance showed that the treatment had significant effect (P<0.05). The best ADF content in sorghum enzymatic obtained in treatment SE1 with an average of 31.59%. According to Usman and Salah (2019), the decrease in ADF content caused by the decomposition of ADF into simpler and more soluble compounds. ADF was insoluble in acid detergents, consisting of cellulose, lignin, and silica (Van Soest, 1994). The component of ADF which has the highest digestibility is cellulose, while lignin had the lowest digestibility due to its double bonds. If the lignin content in the feed material was high, the digestibility coefficient of the feed will be low (Usman and Salah, 2019). ADF had a high percentage of lignocellulose bonds, so that the use of cellulase enzyme can loosen the lignocellulose bonds and degrade cellulose into its derivative products, thereby affecting the cellulose content in ADF and causing an overall decrease in the ADF content in the material (Mahanani et al., 2020).

Hemicellulose

The hemicellulose content of sorghum enzymatic with the addition of cellulase can be seen in Table 1. Analysis of variance showed that the treatment had significant effect (P<0.05). With the best hemicellulose content in sorghum enzymatic obtained in the SE3 (9.34%). Hemicellulose hydrolysis can be carried out by microorganisms by utilizing substrates that suitable for the enzymes they produce; one of the most common enzymes produced was cellulase. Hemicellulose breakdown will generally occur faster than cellulose due to simpler and more soluble hemicellulose bonds, so that the hemicellulose breakdown process during the initial enzymatic stage converts hemicellulose into sugar or used up energy and forms organic acids. According to Erna et al (2023), the decrease in hemicellulose content caused by the loosening of lignohemicellulose bonds during the enzymatic process. Hemicellulose had the most abundant fiber fraction found in feed ingredients and generally has simpler bonds known as soluble fiber due to its presence with plant starch. During the process, enzymes will easily break down hemicellulose due to its easily decomposed structure (Mahanani et al., 2020). Sorghum has higher hemicellulose content compared to cellulose, where sorghum contains 339 g of cellulose, 375g of hemicellulose, 162 g of lignin, and 20g of ash per kilogram of material (Hidayat, 2021).

Physical Quality Test

The results of the physical quality test of density, durability, and bulk of sorghum-based pellets can be seen in Table 2.

Table 2. Results of physical quality tests for density, durability, and bulky of sorghum pellets.

Test	Density/st	Durability	Bulky
P0	442/30.23	82	0.44
P1	453/32.98	85	0.46
P2	428/32.21	87	0.45
P3	482/31.54	87	0.46
P4	477/32.62	89	0.44

Data source: Integrated Laboratory, The University of West Sulawesi.

Density

The higher the percentage of sorghum, the higher the feed density. In the formula with 100% corn (P0), the density was recorded at 442 g/L, while with 100% sorghum (P4), the density reached 477 g/L (Amizar et al., 2023).

Feed density significantly impacts the efficiency of space use in storage, transportation, and processing, as well as affecting feed consumption and digestion by livestock. In pelleted feed, density generally depends on several factors, such as the raw materials used such as corn, soybeans, fish meal, and other ingredients, which have varying densities. Pellet size also influences density, with smaller pellets tends to have higher density than larger pellets, although this also depends on the packaging density of the pellets.

Bilqisthi (2024) stated that when filling mixers, elevators, and silos, the volume of space required for material with a certain gravity largely determined by the density of the pile, where the density of the mash affected the amount of feed materials that can be packed. Luciana (2012) added that the density of the pellet pile affected the stacking and the duration of pellet storage, making an important component in the automatic feeding process. This is because during the feeding with an automatic silo model, density will play an important role in maintaining feed quality and keeping the volume of incoming and outgoing feed remain the same.

Durability

The physical durability of the feed also increased with increasing sorghum content. Durability in P0 was 82%, while in P4 reached 89%. P4 with a percentage of 100% Sorghum has the best physical test results of density, durability (89%), and stable bulkiness. Then followed by P3, P2, P1, and P0, which has the lowest physical quality in the density and durability test. This may be due to the percentage of particles composed of sorghum being smaller, so it is stronger and tighter in contrast to corn, which is not in the form of flour but broken grains (Harahap et al., 2022).

The durability of animal feed pellets refers to their ability to maintain their shape during storage, transportation, and feeding. Good durability is crucial to prevent physical damage that can lead to feed waste, reduced feed quality, or difficulties in feeding livestock.

Durability or impact resistance is a testing procedure used to assess the capacity of pellets to withstand friction (Jaelani et al., 2016). Durability test conducted to ensure the physical resistance of pellet feed to impacts, or when pellets are dropped from a height of 2 meters to assess the feed's resistance to impact (Liu et al., 2020). The standard durability value for chicken pellet feed is 80% (Ali, 2006). The comparison of the number of undamaged pellets with the initial number of pellets before being dropped or pressed on a metal plate can be used to calculate impact resistance (Bilqisthi, 2024). Factors affecting the durability of animal feed pellets are generally related to moisture content. Pellets with low moisture content significantly affect their strength and durability. Pellets with a higher moisture content tend to be more brittle and easier to crushed, while pellets with a lower moisture content are more durable and have a denser structure. Ideally, the moisture content of animal feed pellets should range between 10-14% for optimal durability.

The use of binders also affects pellet strength. Binders, such as tapioca starch, gluten, or gum arabic, are used to increase cohesion between particles in the pellet. A good binder can increase pellet strength and reduce damage during transportation and the feeding process. An effective binder will improve pellet durability without affecting the nutritional quality of the feed. Sorghum flour has a finer texture and contains amino acids that make up its protein, which can form gluten. The gluten produced by sorghum is superior to that of corn flour, although quantitatively and qualitatively lower than that of wheat flour. This is why higher percentage of sorghum used in feed, resulted in better nutritional value and more resistant pellets to damage. Furthermore, the particle size of the feed ingredients also affected durability of sorghum-based pellets. The particle size of the feed ingredients used in pellet production also affects durability. Finer feed particles tend to produce denser and more durable pellets, while coarser particles can cause pellets to crumble easily. The quality of the raw materials used is also a factor in improving pellet durability. The quality of the raw materials used to make pellets, such as the quality of the grains (corn, wheat) or other additives, significantly affects the strength of the pellets. Drier and higher-quality raw materials will produce pellets with better durability.

Bulkiness

The results of the bulkiness test did not show any significant difference in bulkiness between corn and sorghum-based feeds (P>0.05), with values ranging from 0.44 to 0.46 in all treatments. Bulkiness in animal feed pellets is a measure or physical property of the feed that refers to the large volume or low density of a pellet. Feed with a higher level of bulkiness has more space between its particles, resulting in a larger volume despite its relatively light weight. Conversely, feed with a low or denser bulkiness has a higher density. In poultry farming, high-bulk feed is undesired because birds prefer denser and lighter feed. Bulky feed can reduce feed intake due to its larger and heavier structure, making it more difficult for birds to peck and consume in adequate amounts. The compaction density of the pile is the ratio of the weight of the material to the volume of space it will occupy after the pellets have undergone the compaction process (Bilqisthi, 2024). A higher compaction density value is influenced by the material's high compaction capacity compared to other materials. This means that the lower the compaction density level, the lower the flow rate. Highly bulky feed can result in decreased feed intake, which can inhibit growth or production such as egg production. Highly bulky feed is generally rich in fiber (e.g., straw or grass), which is beneficial in stimulating digestive activity. However, this is only beneficial for ruminants and not for poultry because fiber can hinder the digestive process by inhibiting enzymatic processes in the stomach (Mahanani et al., 2020).

Highly bulky (high-fiber) feed is less effective for poultry or fish because they are more efficient at digesting finer and denser feed. Bulky feed that is difficult to digest can inhibit nutrient absorption. The physical quality of pellets is also affected by their bulkiness. Pellets that are too bulky can be more brittle and easily crushed, especially during transportation or storage. Bulkier pellets tend to have structural weaknesses that cause them to break easily and produce a lot of dust. Pellet quality decreases because damaged or crushed pellets reduce the efficiency of feed use by livestock, especially if large amounts are wasted, preventing livestock from utilizing the feed properly. High-bulk feeds require more storage and transportation space due to their larger volume despite their relatively lower weight. Bulkier feeds require more containers or space for more efficient transportation.

The use of binders can affect the physical quality of bulkiness. Binders, such as tapioca starch and gluten, used in pellet production, can also affect bulkiness. Proper use of binders can improve the physical strength of pellets and reduce breakage, as well as reduced internal volume of pellets (reducing bulkiness). Bulkiness in animal feed pellets affects many aspects of feed production and consumption. Feed with too high in bulkiness can reduce feed consumption efficiency and livestock growth because it contains fewer calories per unit volume. Conversely, in poultry and fish, feed that is too bulky can cause decreased feed consumption and reduced growth or production efficiency.

Organoleptic Test

Color

The results of the organoleptic color test of sorghum-based pellets at different storage times can be seen in Table 3. Corn-dominated feeds are yellowish to brownish in color, while sorghum-based feeds (P3 and P4) tend to be dark brown. In the third week of storage, 100% corn feed (P0) begins to turn greenish, while sorghum-based feeds remain stable in color until the eighth week. Storage, raw material type, and pellet molding method are key to good pellet production. Proper storage of pellets extends shelf life and maintains pellet quality. Proper storage related with humidity, temperature, feed preparation method, and packaging. The type of raw material also affects pellet quality, with ingredients high in antioxidants with low water content tends to last longer. The drying method used in pellet production plays a crucial role in keeping pellets dry and mold-free (Ali, 2006). The use of sacks for animal feed tends to cause the feed to be compacted, and if stored for longer time, the tendency for the feed to spoil is increased due to the use of wrong packaging with poor air circulation, resulting in increased material temperature, higher humidity, and mold growth (Luciana, 2012). Sorghum is known to have good antioxidant content which is generally composed of phenol groups which become antimicrobial substances that cause the use of sorghum in feed will make the feed last longer when packaged and stored, this phenol group also plays a role in the color of sorghum where that the darker the sorghum, the higher the antioxidant level (Hidayat, 2021). This can also be seen in the P4 treatment, which has a darker color in the pellets produced.

Table 3. Color test of sorghum pellet.

Day	P0	P1	P2	P3	P4
0	Normal (yellowish)	Normal (brownish yellow)	Normal (brownish yellow)	Normal (brownish)	Normal (dark brown)
2	Normal (yellowish)	Normal (brownish yellow)	Normal (brownish yellow)	Normal (brownish yellow)	Normal (dark brown)
4	Normal (yellowish)	Normal (brownish yellow)	Normal (brownish yellow)	Normal (brownish yellow)	Normal (dark brown)
6	Normal (yellowish)	Normal (brownish yellow)	Normal (brownish yellow)	Normal (brownish)	Normal (dark brown)
8	Normal (yellow, slight dark)	Normal (brownish yellow)	Normal (brownish yellow)	Normal (brownish)	Normal (dark greenish brown)

Data source: Integrated Laboratory, The University of West Sulawesi.

Mold

The results of the organoleptic test of sorghum-based mushroom pellets at different storage times can be seen in Table 4. Feeds containing 100% corn (P0) are more susceptible to mold growth, which begins to appear in week 2. Sorghum-based feeds, especially P4, only show mold growth after week 4 to 8. Sorghum's inhibitory effect on mold is generally due to its antioxidant content, which acts as an antidote to microbes and mold due to its phenolic content. However, mold growth will still be seen if the ingredients have a high-water content, making drying the feed become very important (Pratiwi and Purnamasari, 2019).

Table 4. Mold test of sorghum pellet.

Day	P0	P1	P2	P3	P4
0	-	-	-	-	-
2	-	-	-	-	-
4	-	-	-	-	-
6	Slight mold	-	-	-	-
8	Mold	-	-	Slight mold	Slight mold

Data source: Integrated Laboratory, The University of West Sulawesi.

Mold in feed stored for a longer period generally caused by poor storage and also high humidity in the storage area, which makes the feed can easily damage and attacked by mold (Luciana, 2012). Mold in feed with a high percentage of corn content generally comes from the aflatoxin group, if in large quantities, resulting in adverse effects on livestock that consume it, especially poultry and causing livestock poisoning (Ali, 2006).

Aroma

The results of the Organoleptic Aroma Test of sorghum-based pellets at different storage times can be seen in Table 5. The aroma of feed with 100% corn (P0) began to change to musty in the 4th week, while feed with higher sorghum content was more resistant to aroma changes until the 8th week. Changes in the aroma of feed can be caused by the ingredients that will affect the palatability of livestock, where feed with a fresher and more attractive aroma will be preferred and desired by livestock (Telew et al., 2017). The aroma of feed that changes during the storage period also indicates changes in chemical content in the feed. Generally, feed that is damaged due to incorrect storage and improper manufacturing procedures will change in aroma. Moreover, the addition of adulterants and the use of animal raw materials will provide a more pungent aroma compared to the use of plant materials. The growth of fungi also caused changes in aroma so that the feed becomes rancid (Luciana, 2012).

Table 5. Aroma test of sorghum pellet

Day	P0	P1	P2	P3	P4
0	Normal	Normal	Normal	Normal	Normal
2	Normal	Normal	Normal	Normal	Normal
4	Normal	Normal	Normal	Normal	Normal
6	Slightly musty	Normal	Normal	Normal	Normal
8	Musty	Normal	Normal	Slightly musty	Slightly musty

Data source: Integrated Laboratory, University of West Sulawesi.

Table 6. Texture test of sorghum pellets

Day	P0	P1	P2	P3	P4
0	Normal dense	Normal dense	Normal dense	Normal dense	Normal dense
2	Normal dense	Normal dense	Normal dense	Normal dense	Normal dense
4	Normal dense	Normal dense	Normal dense	Normal dense	Normal dense
6	Fragile	Normal dense	Normal dense	Normal dense	Normal dense
8	Fragile	Fragile	Fragile	Fragile	Normal dense

Data source: Integrated Laboratory, The University of West Sulawesi.

Texture

The results of the Organoleptic Texture Test of sorghum-based pellets at different storage times can be seen in Table 6. In the 8th week, the feed dominated by corn was more fragile, while the feed with sorghum had stabler and denser texture until the last week of testing. However, P4 showed the best results of all organoleptic test treatments including color, more resistant to mold and aroma changes compared to other treatments. P3 organoleptic test: color, mold, texture, and aroma remain stable over a long period of time. P2 organoleptic test: color and aroma tend to be stable, mold does not appear until the final week, and the texture is relatively stable. P1 organoleptic test: color and aroma are stable, and mold does not appear until the end. And the lowest is P0 organoleptic test: the color begins to turn greenish, and there is mold growth started from the 2nd week, the aroma quickly becomes musty, and the texture is more fragile.

Organoleptic tests on sorghum-based feed show that texture, aroma, and color can remain stable for longer, and the feed tends to be more resistant to changes during storage (Luciana, 2012). Other studies also showed that the addition of enzymes to pelleted feed can increase physical durability, prevent color changes, and maintain texture (Ali, 2006). The texture of sorghum-based pelleted feed was better due to the shape of sorghum particles, which are powder, where the homogeneity during pelleting is much better, resulting in a much denser texture compared to corn, whose particles resemble crumble. (Utama et al., 2020).

CONCLUSION

Based on the results of the research and discussion in the first stage, it can be concluded that the addition of enzyme to sorghum can increase crude protein and can reduce the content of Crude Fiber, NDF, ADF, and Hemicellulose in SE2. Furthermore, based on the results of the research and discussion in the second stage, the best treatment based on the combination of all tests is P4 (100% Sorghum), because it provides more durable physical and organoleptic quality performance.

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