



The Effect of Corn Replacement by Sorghum in Broiler Diets on the Internal Organ

Koleta Vebriani*, Ni Gusti Ayu Mulyantini Sekar Sari, Jonas Fritz Theedens,
Ni Putu Febri Suryatni

Department of Animal Husbandry, Marine and Fisheries Faculty of Animal Science, University of Nusa Cendana,
Jl. Adisucipto, Penfui Kupang 85001 NTT Indonesia

* Corresponding Author. E-mail address: koletaetha@gmail.com

ARTICLE HISTORY:

Submitted: 18 June 2024
Revised: 20 July 2024
Accepted: 31 January 2025
Published: 1 March 2025

KATA KUNCI:

Ayam broiler
Organ dalam
Jagung
Sorghum

KEYWORDS:

Broiler chicken
Internal organ
Corn
Sorghum

ABSTRAK

Penelitian ini bertujuan untuk mengetahui pengaruh penggantian jagung dengan sorgum dalam ransum ayam broiler terhadap organ dalam. Metode yang digunakan adalah Rancangan Acak Lengkap dengan empat perlakuan dan lima ulangan, dan setiap ulangan terdapat lima ekor ayam. Perlakuan yang diberikan yaitu P0: 0% sorgum pada ransum (100% jagung sebagai kontrol), P1: 25% penggantian jagung dengan sorgum, P2: 50% penggantian jagung dengan sorgum, P3: 75% penggantian jagung dengan sorgum. Variabel yang diukur adalah bobot hati, bobot ampela, bobot usus halus, dan panjang usus halus. Data dianalisis dengan menggunakan analisis sidik ragam dan apabila terdapat pengaruh yang nyata maka dilanjutkan dengan uji lanjut Duncan untuk melihat perbedaan pada setiap perlakuan. Analisis statistik menunjukkan bahwa penggantian jagung pada level 0%, 25%, 50% dan 75% dengan sorgum tidak memberikan perbedaan yang nyata ($P>0,05$) terhadap bobot liver dan bobot ampela. Pada penggantian 50% jagung dengan sorgum dapat menurunkan ($P<0,05$) berat usus halus dan panjang usus halus, dan pada level 75% tidak berbeda ($P>0,05$) dengan perlakuan kontrol. Kesimpulannya, jagung dapat digantikan dengan sorgum sampai level 75% dalam ransum tanpa memberikan pengaruh negatif terhadap perkembangan organ liver, ampela, usus halus dan panjang usus halus.

ABSTRACT

This research aims to investigate the effect of corn replacement by sorghum in broiler diets on the internal organ. The method used was a Completely Randomized Design with 4 treatments and 5 replications, and in each replicate, there was 5 chickens. The treatments given were P0: 0% sorghum in the ration (100% corn as control), P1: 25% corn replacement with sorghum, P2: 50% corn replacement with sorghum, P3: 75% corn replacement with sorghum. The variables measured were liver weight, gizzard weight, small intestine weight and small intestine length. The data was analyzed using Analysis of Variance (ANOVA) and if there was a significant effect, Duncan's further test would be continued to see the differences in each treatment sample. Statistical analysis showed that replacing corn at levels 0%, 25%, 50% and 75% with sorghum did not make a significant difference ($P>0.05$) on liver and gizzard weight. Replacing 50% of corn with sorghum

decreased ($P < 0.05$) small intestine weight and small intestine length, and at the 75% level it was not different ($P > 0.05$) from the control treatment. In conclusion, corn can be replaced with sorghum up to 75% in the ration without having a negative effect on the liver, gizzard, small intestine weight, and small intestine length..

1. Introduction

The process of digestion of feed and absorption of nutrients in broiler chickens is influenced by the condition of their digestive organs. The feeds given to broiler chickens can affect their internal organs (Regar et al., 2018). The digestive organ system develops according to the ration given. Abnormalities in internal organs are usually characterized by physical changes in internal organs such as changes in size.

Feed requirements contribute up to 70% of the total cost of poultry production, so if feed costs decrease then the chickens farm will be more profitable. The main feed component for poultry in general is corn, its composition can even reach 50% of the ration formula. The nutritional content of corn is 8.5% protein, 2.2% crude fiber, 3.8% fat, and 3,350 kcal/kg metabolic energy (NRC, 1994). The policy of banning corn imports causes limited corn supplies and increases in local corn prices, causing production costs to soar. To overcome the fluctuating availability of corn, it is necessary to look for alternative local feed ingredients that are suitable as a substitute for corn, one of which is sorghum.

Sorghum is a cereal crop that potential to be developed in Indonesia because it has quite extensive environmental adaptation, is tolerant of drought and can produce on marginal land. The nutritional content of sorghum is 10.40% protein, 3,200 Kcal/kg metabolic energy, 3.40% fat, and 2.50% fiber (Oyerakua and Eleyinmi, 2004; NRC, 1994). To test the effect of replacing corn with sorghum in broiler chicken diets, many studies have been carried out to evaluate the extent of its impact on broiler chicken performance.

The research results of Torres et al. (2013) prove that 50% substitution of corn with sorghum can provide good growth performance in broiler chickens. This is different from the results of research by Sosiawan et al. (2018) which showed that 21% substitution of corn with sorghum tended to increase the carcass weight of 6-week-old broiler chickens. Furthermore, Sukria et al. (2022) proved that giving 100% sorghum in mixed rations provided lower performance compared to commercial rations.

Based on the results of previous research described above, it is hoped that replacing corn with more than 21% and less than 100% of corn with sorghum can improve the growth performance of chickens, especially the morphology of the digestive organs. Broiler growth performance may be enhanced by a longer small intestine length, liver weight and gizzard weight due to its increased capacity for digestibility, nutrient absorption, and possibly higher nutrient utilization. Therefore, research has been carried out to analyze the effect of giving sorghum flour as a substitute for corn flour on the internal organ weight of grower stage broiler chickens, with a substitution rate of less than 100%.

2. Materials and Methods

2.1. Time and Place of Research

This research was carried out in the litter system cage for broiler chickens in the Faculty of Animal Science, Marine and Fisheries, Nusa Cendana University from 20th February to 26th March 2024.

2.2. Experimental design

The research method used in was Completely Randomized Design (CRD) method which consisted of 4 treatments and 5 replications. So, there are 20 experimental units with each unit (80x80x80cm) containing 5 chickens. The broiler used in this research were strain CP 707. The four treatments were: P0: 0% sorghum in the ration (100% corn as control), P1: 25% corn replacement with sorghum, P2: 50% corn replacement with sorghum, P3: 75% corn replacement with sorghum.

2.3. Diet treatment

From 1-3 weeks, chickens were given commercial diet. At the hatchery, chicks were received ND vaccination. Then, feed treatment was given during the growth period (3-6 weeks). Feed was formulated with iso-protein and iso-energy based on SNI (2015) to meet the protein and energy needs of broiler chickens during the growth period (protein min 19% and EM 3100 kcal/kg). The feed ingredients and nutritional composition can be seen in Table 1.

Table 1. Ingredients and nutrition composition of feed treatment based on calculation

Ingredients (kg)	P0	P1	P2	P3
yellow corn	54	40,5	27	13,5
white sorghum	-	13,5	27	40,5
broiler concentrate	41	41	41	41
vegetable oil	2	2	2	2
lysine	1	1	1	1
methionine	1	1	1	1
premix	1	1	1	1
Total	100	100	100	100
ME (kkal/kg)	3.150	3.134	3.119	3.104
crude protein (%)	19,21	19,40	19,59	19,78
crude fat (%)	4,10	4,05	3,99	3,94
crude fibre (%)	4,22	4,22	4,22	4,22

2.4. Variable measured

The variables observed in this research were liver weight, gizzard weight, small intestine weight, and small intestine length. Data collection was carried out when the chickens were five weeks old. Before being slaughtered, the chickens were fasted for approximately 8 hours then weighed to determine the final weight. From each cage unit, two chickens were taken which had a body weight close to the average weight to obtain slaughter weight. After that, the chicken is cut, then the carcass is cleaned, then the internal organs are separated for analysis. The weight of the liver, gizzard and small intestine was weighed using an analytical balance with a sensitivity of 0.1 mg, the length of the small intestine was measured using a measuring tape with a sensitivity of 0.1 cm.

2.5. Statistical analysis

The research results were analyzed using Analysis of variance (ANOVA) using SPSS 21. If there is a treatment that has a real effect, then continue with Duncan's further test to see the differences in each treatment sample. The significant level was set at $P < 0.05$.

3. Result and Discussion

The effect of corn replacement with sorghum on liver weight, gizzard weight, small intestinal weight and intestinal length can be seen in Table 2.

Table 2. The effect of feed treatment on liver weight, gizzard weight, small intestine weight and small intestinal length

Feed treatment	Liver (g)	Gizzard (g)	Small intestine (g)	Small intestine (cm)
P0	33,87±5,24 ^a	27,78±5,63 ^a	55,61±8,15 ^b	173,00±16,45 ^b
P1	34,70±4,06 ^a	25,85±2,25 ^a	47,92±9,01 ^b	134,42±13,23 ^a
P2	34,65±3,97 ^a	23,82±4,04 ^a	39,69±5,53 ^a	137,80±14,68 ^a
P3	34,71±3,28 ^a	25,66±2,29 ^a	47,99±11,82 ^b	158,74±23,82 ^b
P value	0,54	0,98	0,08	0,00

Values with different superscripts within the same column mean significant difference at $P < 0,05$

P0: 0% sorghum in the ration (100% corn as control), P1: 25% corn replacement with sorghum, P2: 50% corn replacement with sorghum, P3: 75% corn replacement with sorghum.

3.1. The effect of treatment on liver weight

The lowest liver weight was obtained in treatment P0 as control (33.87 ± 5.24 g) and the highest liver weight was obtained in treatment P3 (34.71 ± 3.28 g). The results of the analysis of variance showed that replacing corn 0%, 25%, 50%, and 75% with sorghum did not have a significant effect ($P > 0.05$) on the liver weight of broiler chickens.

This study show that corn can be replaced up to 75% by sorghum without affecting the liver weight of broiler chickens. This is different from the result of Mabelebele et al. (2018) who discovered that adding 75% sorghum in form of pelleted diet had higher liver weight than mash diet in broilers at 35 days. Increased liver size in broiler fed pelleted diets caused by higher availability of nutrients in hepatocytes due to higher feed intake (Zaefarian et al., 2019). In our study the form of experimental diet was in mash diet, so maybe that is one factor what causes the difference in results with Marbelebe et al. (2018). The greater mass of the liver is considered as a positive indicator and associated with higher metabolic activity because nutrients are synthesised or stored in the liver (Zaefarian, et al., 2019)

According to Zaefarian et al. (2019), antinutritional substances, such as tannin in sorghum cause alterations in the morphology of gastrointestinal organs, which has a negative impact on the animal's health, productivity, and ability to digest food. The liver is one of the body's most sensitive organs to toxic factors (Marzo et al., 2002). Emiola et al. (2007) reported that the anti-nutritional factors in raw and processed kidney beans reduced the relative weights of the liver. In this study show that replacing corn by sorghum up to 75% did not cause alteration in liver size might be the sorghum used in this study was low tannin variety which are comparable to maize.

3.2. The effect of treatment on gizzard weight

Treatment without using sorghum (P0) resulted in the most considerable gizzard weight (27.78 ± 5.63 g). However, there was a decrease respectively in P1 (25.85 g), P3 (25.66 ± 2.29 g), and P2 (23.82 g). The results of analysis variance showed that replacing corn with sorghum up to 75% had no significant effect ($P > 0.05$) on gizzard weight. This result supports the findings of Malebele et al. (2018) who reported that whole sorghum inclusion (75%) in the broiler diet did not affect the relative weight of the gizzard. Contrary to the above findings, Manyelo et al. (2019) found that the absolute and relative weights of gizzard of birds offered 100% sorghum replacement level were heavier ($P < 0.05$) than those on 0% level at ages 1– 21 days. The greater weight of the gizzards obtained for mash diets perhaps correlate with the frequency of contraction to reduce the particle size

In this research, the crude fiber content based on analysis in the laboratory was around 4%. This composition provides the requirements set by SNI (2015) where the crude fiber requirement for broiler chickens is a maximum of 6%. The crude fiber content of the diet in this research did not make the ventricular muscle contractions work hard to break down the fibrous feed particles so that the resulting gizzard weight did not show a significant difference. Jha and Mishra (2021) stated that increasing crude fiber in the ration results in the gizzard working more intensively to digest crude fiber, which can result in an increase in gizzard weight. This is in accordance with the opinion of Suparjo (2003) who stated that the gizzard is a place to digest food mechanically like the liver and heart, the gizzard responds to high crude fiber in the feed. Jhia and Mishra (2021) added that gizzard has the function of breaking down and grinding large sized particles into smaller ones to facilitate the digestive process at the next stage. Dharmawanti and Ari (2012) state that the increase in gizzard weight is not due to increasing growth but because of its quite heavy function in grinding food ingredients into smaller particles and mixing the feed ingredients with digestive enzymes produced by the proventriculus and bile, the crude fiber content of the feed ingredients strongly influences gizzard enlargement.

3.3. The effect of treatment on small intestinal weight

Table 2 shows that the averages weight of the small intestine in treatment P0 (control) has the largest weight compared to other treatments, while treatment P2 showed the lowest intestinal weight with an average of 39.69 ± 5.53 g. Analysis of variance showed that the giving of sorghum in the ration had a significant effect ($P < 0.05$) on the weight of the small intestine. Duncan's further test results showed that 50% corn replacement by sorghum (P2) decreased weight of small intestine significantly ($P < 0.05$)

The results obtained in this study differ from those of Fernandes et al. (2013) who observed an increase in the relative weight of the small intestine in 42-day-old broilers fed 50 or 100% in replacement of corn. According to Garcia et al. (2013), there was no change in intestine relative weight when sorghum was substituted for corn. Those authors noted that intestinal weight and size are influenced by dietary particle size, as shown by Benedetti et al. (2011). Studies indicate that while sorghum-based diets can support growth comparable to corn-based diets, there may be differences in the adaptation to intestinal morphology.

The size of the small intestine influences its capacity to digest and absorb food substances. Nyamambi et al., (2007) state that the performance of intestinal villi is influenced by several factors including the type of feed substance, feed chemicals and feed additives. Yao et al., (2006) stated that intestinal weight is influenced by the length of the intestine itself. In this research, the increase in weight and length is also accompanied by an increase in the size of the cavity in the small intestine and an increase in the surface area of the small intestine.

3.4. The effect of treatment on small intestinal length

The largest average length of the small intestine of broiler chickens was achieved in treatment P0 (control) with an average $173,00 \pm 16,45$ cm. The lowest length was achieved in treatment P1, with an average 134.42 ± 13.23 cm. The analysis of variance showed that the giving of sorghum in the diet had a significant effect ($P < 0.05$) on the length of the small intestine. Duncan's further test results showed that the length of the small intestine in chickens fed diet P1 and P2 (25% and 50% replacement of corn with sorghum) was significantly lower ($P < 0.05$) than without sorghum (P0).

These findings contrast with those of Fernandes et al. (2013) who discovered that the inclusion of whole sorghum grains in the diet had no effect on small intestine length when compared to maize grains. Garcia et al. (2013) also found that diet consisting of corn or sorghum with varying levels of tannin had no effect on the length of the broiler's small intestine. While, Jones and Taylor (2001) obtained that feeding entire sorghum grain to the animals resulted in a considerable increase in cecum length. The response of the bird's digestive tract to the particle size may account for the longer ceca observed as the presence of whole grains in the diet, indicating an effort to maximize the digestive process.

The presence of non starch polysaccharide (NSP) in sorghum may influence the size of the small intestine in chickens, with a higher NSP level increasing both the length of the tract and the relative weights of small intestine which may reduce the efficiency of feed utilisation (Steenfedt, 2001).

The feed consumed by livestock is one of the factors that influences the growth of the small intestine, mainly feed that contains crude fibre. Feed containing crude fibre will induce the small intestine to become unstable and the small intestine will become thicker and longer.

Bell and Weaver (2002) stated that the small intestine of an adult chicken is around 140 cm, while Suprijatna et al. (2008) noted that the length of the average small intestine is around 150 cm. Lenhart and Mozes (2003) stated that the high growth of small intestinal villi is related to the potential of the small intestine to absorb nutrients. The largest small intestinal villi, have the most considerable effectiveness of nutrient absorption through the small intestinal epithelium. Wang et al., (2016) stated that a longer small intestine is an indication of a larger area for digestion and nutrient absorption.

4. Conclusion

Giving sorghum as a substitute for corn up to a level of 75% in feed formulation did not have negative effect on the liver weight, gizzard, small intestine weight, and small intestine length.

References

- Bell and Weaver. 2002. *Commercial Chicken Meat and Egg Production*. 5th Ed. Springer Science and Business Media.
- Benedetti MP, Sartori JR, Carvalho FB, Pereira LA, Fascina VB, Stradiotti AC, Pezzato AC, Costa C, Ferreira JG. 2011. Corn Texture and Particle Size in Broiler Diets. *Brazilian Journal of Poultry Science*. 13(4) : 227-23
- Dharmawati, S dan J.K. Ari. 2012. Pengaruh penggunaan tepung daun alang (*Imperata cylindrica*) dalam ransum terhadap kadar lemak kolesterol karkas dan organ pencernaan itik alabio Jantan. *Jurnal Ziarah*. 34(2): 150-160.
- Emiola, I.A.; Ologhobo, A.D.; Gous, R.M. 2007. Performance and histological responses of internal organs of broiler chicken fed raw, dehulled, and aqueous and dry-heated kidney bean meals. *Journal of Poultry Science*, 86 :1234–1240
- Fernandes EA, Pereira WJS, Hackenhaar L, Rodrigues RM, Terra R. 2013. The use of whole grain sorghum in broiler feeds. *Brazilian Journal of Poultry Science*. 15(3):217-22
- Garcia RG, Mendes AA, Almeida Paz ICL, Komiyama CM, Caldara FR, Nääs IA, Mariano WS. 2013. Implications of the use of sorghum in broiler production. *Brazilian Journal of Poultry Science*. 15(3): 257-26
- Jha, R., and P. Mishra. 2021 Dietary fiber in poultry nutrition and their effects on nutrient utilization, performance, gut health, and on the environment: a review. *Journal of Animal Science and Biotechnology*. 12:51
<https://doi.org/10.1186/s40104-021-00576-0>
- Jones GPD, and Taylor RD. 2001. The incorporation of whole grain into pelleted broiler chicken diets: production and physiological responses. *British Poultry Science*. 42(4):477-483
- Lenhart, L. and S. Mozes. 2003. Morphological and Functional Changes of the Small Intestine in Growth Stunted- Broilers. *Acta Vet. Brno*. 72:353-358.
- Mabelebele, M.; Gous, R.M.; Masey O'Neil, H.V.; Iji, P.A. 2018. Whole sorghum inclusion and feed form on performance and nutrient digestibility of broiler chickens. *Journal of Applied Animal Nutrition*, Vol. 6; e5. p.1-8
- Manyelo, T.G., J.W. Ng'ambi, D. Norris, and M. Mabelebele. 2019. Substitution of Zea mays by Sorghum bicolor on Performance and Gut Histo-Morphology of Ross 308 Broiler Chickens Aged 1–42 d. *J. Appl. Poult. Res*. 28:647–657
- Marzo F. Urdaneta E., Santidrián S. 2002. Liver Proteolytic Activity in Tannic Acid-Fed Birds. *Journal of Poultry Science*. Vol. 1 (1) : 92-94
- NRC. 1994. Nutrient Requirement of Poultry. National Academy Science, Washington.
- Nyamambi, B., L.R. Ndlovu, Y.S. Naik, and N.D. Kock. 2007. Intestinal Growth and Function of Broiler Chicks Fed Sorghum Based Diets Differing in Condensed Tannin Levels. *S. Afr. J. Anim. Sci*. 37:202–214.
- Oyarekua, M.A., and A.F. Eleyemi. 2004. Comparative Evaluation of the Nutritional Quality of Corn, Sorghum and Millet Ogi Prepared by a Modified Traditional Technique. *Food Agric Environ*. 2(2): 94-99
- Regar, N.M., Kowel, S. H. Y. B., Betty dan E. A. S. Moningkey. 2018. Pemberian Kombinasi Kunyit, Bawang Putih dan Mineral Zink terhadap Bobot Organ Dalam Ayam Pedaging yang Diinfeksi E. Colli. *Prosiding Seminar Nasional Unggas Local: Pengembangan Unggas Local di Indonesia*. 2: 168-172

- Silva MCA., Carolino, ACXG., Litz FHI., Fagundes NS., Fernandes E de A., Mendonça GA. 2019. Effects of Sorghum on Broilers Gastrointestinal Tract. *Brazilian Journal of Poultry Science*. 17(1). 95-102
- Steenfeldt S. 2001. The dietary effect of different wheat cultivars for broiler chickens. *British Poultry Science*, 42: 595-609
- SNI. 2015. Standar Nasional Indonesia. Pakan ayam ras pedaging. Badan Standarisasi Nasional 8173.2:2015
- Sosiawan, B. I. G. A. S. Rejeki, N. K. Mardewi. 2018. Pemakaian sorgum (*Sorghum Bicolor I.*) Sebagai Bahan Substitusi Jagung (*Zea Mays I.*) Pada Ransum Terhadap Berat Bagian-Bagian Karkas Ayam Broiler Umur 6 Minggu. *Jurnal Gema Argo*, Vol. 23, 2 (2018): 124-128.
- Sukria, H. A., Risyahadi, S. T., Aditama, R. S., Salahuddin, M. H. 2022. Evaluasi Pakan Sumber Energi Berbasis Sorgum, Geplek dan Sagu Sebagai Substitusi Jagung Dalam Ransum Ayam Broiler. *Jurnal Ilmu Nutrisi dan Teknologi Pakan*, 20(2): 66-72.
- Suparjo. 2003. Pengaruh Penggunaan Pakan Berserat Kasar Tinggi Dalam Ransum Ayam Pedaging Terhadap Organ Dalam. *Jurnal Ilmiah Ilmu-Ilmu Peternakan*. 6(1).
- Suprijatna, E., U. Atmomarsono dan R. Kartasudjana. 2008. Ilmu Dasar Ternak Unggas. Penebar Swadaya, Jakarta.
- Thomas D.V and Ravindran, V. 2008. Effect of cereal type on the performance, gastrointestinal tract development and intestinal morphology of the newly hatched broiler chick. *Journal of Poultry Science*. 45:46-50
- Torres, K. A. A. M. Pizauro, C. P. Soares, G. A. Silva, W. C. L. Nogueira, D. M. B. Campos, R. L. Furlan, and M. Macari. 2013. Effects of corn replacement by sorghum in broiler diets on performance and intestinal mucosa integrity. *Journal of Poultry Science* 92 :1564–1571
- Wang, X., Y. Z. Farnell, E. D. Peebles, A. S. Kiess, K. G. S. Wamsley and W. Zhai. 2016. Effects of Prebiotics, Probiotics, and their Combination on Growth Performance, Small Intestine Morphology, and Resident Lactobacillus of Male Broilers. *Journal of Poultry Science* 95: 1332 – 1340.
- Yao, Y., Xiaoyan, T, X. Haibo, K. Jincheng, X. Ming, and W. Xiaobing. 2006. Effect of Choice Feeding on Performance Gastrointestinal Development and Feed Utilization of Broilers. *Asian-Aust. J. Anim. Sci.* 19:91-96.
- Zaefarian F., M.R. Abdollahi, A. Cowieson and V. Ravindran. 2019. Avian Liver: The Forgotten Organ : Review. *Animals*, 9 (63). DOI:10.3390/ani9020063