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Effect of Cassava Silage Diet on Performance and Internal Organs of Male Ducks

Sofia Sandi[1]*, Eli Sahara[1], Erika Budiarti Laconi[2], Asep Sudarman[2], I Komang Gede Wiryawan[2], and Djumali Mangunwijaja[3]

[1]*Department of Technology and Livestock Industry, Faculty of Agriculture, Sriwijaya University, Indralaya, South Sumatera, Indonesia*
[2]*Department of Nutrition and Feed Technology, Faculty of Animal Science, Institut Pertanian Bogor, Indonesia*
[3]*Department of Agricultural Industrial Technology, Faculty of Agricultural Technology, Institut Pertanian Bogor, Indonesia*

*Corresponding author's Email: sofiasandi@unsri.ac.id

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ABSTRACT

It would be beneficial to consider supplementary feeding of livestock as a means of increasing production, although this may be constrained by the residues produced. Silage is one of the forage feed conservation techniques that has also been the subject of interest in recent years concerning poultry feed. The present study aimed to gain insight into the potential impact of feeding cassava-based silage (CS) on the internal organs and performance of male ducks. The study was conducted using 200 male local ducks aged one day, which were then reared in cages for 10 weeks. The research design was based on a completely randomized design (CRD) with five treatments and four replications. The treatments were arranged based on the amount/percentage of silage used in the basal ration and were as follows S0 (silage ration 0% CS/control), S25 (silage ration 25% CS), S50 (silage ration 50% CS), S75 (silage ration 75% CS), and S100 (silage ration 100% CS). In further observations, several variables were considered, including body weight gain (BWG), ration consumption, ration conversion, abdominal fat percentage, spleen percentage, liver percentage, kidney percentage, heart percentage, gizzard percentage, pancreas percentage, thyroid percentage, serum thiocyanate levels, and mortality, as well as serum thiocyanate. The results indicated a notable decline in performance ($p < 0.05$) in BWG observations when CS was provided in amounts exceeding 25% and consumption exceeded 50%. Furthermore, there was a notable increase in the weight of internal organs, which appeared to coincide with an increase in the level of use of cassava-based silage in duck rations. Based on the results of the study the use of cassava-based silage could be considered as a potential alternative or replacement for up to 50% of basal rations, without necessarily resulting in significant changes in the performance and internal organs of livestock.

Keywords: Body weight, Complete ration, Cassava, Silage, Internal organ, Male duck.

INTRODUCTION

Domestic ducks represent a potential source of both eggs and meat in Indonesia. The domestic duck population in Indonesia is estimated to have reached 58.35 million heads, with meat production of 4,725.80 thousand tons and egg production of 6,322.55 million tons (Ditjennak, 2021). However, national duck egg and meat production is still relatively low compared to similar products from poultry farms. Some related factors are assumed to include the feed consumed by ducks whose development is relatively inadequate when compared to other competitors, such as broilers and layers. this can be seen from the last few years of research related to supplementation innovation is still very minimal and only focuses on the supply of protein in the ratio (Sjofjan et al., 2020; Suwignyo et al., 2021; Pramestya et al., 2021; Suwignyo et al., 2023; Mappanganro et al., 2024). Physiologically ducks have an advantage in terms of the ability to digest fiber better when compared to poultry production (El-katcha et al., 2021).

Based on these advantages, in-depth attention is needed to produce feed innovations that can increase duck productivity through the use of its physiological advantages. Furthermore, the process of extracting information for the production of quality feed is constrained by the high dependence on the use of soybean meal as a source of protein and corn as a source of energy. From an economic point of view, these are still very expensive because they are imported commodities. Therefore, efforts are needed to reduce import dependence by optimizing the production of feed. It would be beneficial to consider alternative sources of raw materials. Some potential feed ingredients that have been demonstrated to be effective in livestock diets are non-conventional agricultural by-products, such as cassava (tubers, leaves, and skins) and tapioca processing waste, which is locally known as onggok.

In the last two years, studies on the tuber, peel, or industrial waste (onggok) part of cassava, which is rich in carbohydrates, conducted as an energy source for poultry (Soeprijanto et al., 2022; Hasanudin et al., 2023). On the other hand, leaves are a source of protein, vitamins, minerals, and essential amino acids (Pereira et al., 2016; Li et al., 2019), which can be used by poultry in their daily activities. Furthermore, according to Hermanto and Fitriani (2019), the protein concentration in cassava leaves is between 20% and 36%. Calcium content is 1.10-1.14% and phosphorus content is 0.25-0.30% (Fasae and Yusuf, 2022). Given the considerable impact of this potential, the utilization of cassava as a raw material for animal feed has been widely implemented. However, this is still limited by the high cyanide content, which can adversely impact poultry productivity. Consequently, there is a clear necessity for a method that can effectively reduce the cyanide content. A promising technique for achieving this is through cassava-based silage technology, which involves the addition of rumen fluid enzymes and Leuconostoc mesenteroides bacteria (Hawashi et al., 2019; Khota et al., 2023; Mukhtar et al., 2023).

The combination of cassava and its waste through silage processing, with the addition of rumen fluid enzymes and leuconostoc mesenteroides bacteria, has been identified as the most effective strategy for optimizing the use of cassava. This approach is believed to reduce the content of toxins in feed through acid hydrolysis, which is then expected to support optimal duck productivity. Toxin compounds in the form of cyanide contained in cassava can reduce the productivity of poultry (Bakare et al., 2021). In addition, the present study was conducted to provide new insights and data for the poultry feed industry in developing feed processing methods and maximizing the use of local raw materials. Therefore, it is necessary to conduct a study on the utilization of cassava-based complete ration silage on the performance and internal organs of male ducks.

MATERIALS AND METHODS

Ethical approval

An investigation was conducted at the experimental station of the Department of Animal Science, Faculty of Agriculture, Sriwijaya University, South Sumatra, Indonesia. The animals were treated in accordance with the Animal Welfare Guidelines of the Indonesian Institute of Sciences. The experiment was granted approval by Sriwijaya University, reference number KPPHP-2023-2.

Experimental design and duck preparation

The research design was a completely randomized design (CRD) composed of five treatments and four replications. The treatments represented a combination of basal/control rations with the addition of cassava silage (CS) at a specified percentage and were designated as coded S (silage). The proportions used were as follows included S0 (0% CS/100% control ration), S25 (25% CS ration), S50 (50% CS ration), S75 (75% silage ration), and S100 (100% CS ration). As a source of observation/data collection, 200 one-day-old male ducks were used in this study and housed in 2 square meter cages for 10 weeks, with each cage containing 10 ducks. Moreover, the preparation of the DODs involves the provision of water dissolved in sugar at a concentration of 1-2% for the initial four hours, whereby the energy source serves to restore the condition of the DODs due to the effects of transport stress. Subsequently, the wing band was attached to one side of the duck's wing. Subsequently, the DODs were weighed and randomized based on their initial body weight. Immediately following this, the sugar water was replaced with drinking water, and the treatment ration was distributed. During the maintenance period, rations and drinking water were provided twice daily, in the morning and evening. The observations conducted as part of this study were carried out over 10 weeks, with the duck's body weight and consumption of treatment rations weighed weekly.

Diets and silage production process

The preparation of silage was conducted in accordance with the methodology proposed by Ogbuewu and Mbajiorgu (2023). Before the formulation of feed rations, the initial step was the preparation of cassava raw materials (CS). This process involved the cutting of each raw material, including leaves, skin, and tubers, into a uniform size of 1-2 cm. Following the cutting process, each ingredient was washed with running water and subsequently treated with rumen fluid enzyme at a dose of 1% (b/v) for each raw material. The ingredients were then stirred until homogeneous and incubated in a 10 kg plastic bag with a thickness of 1.5 mm for 24 hours at room temperature in a closed room. Once the incubation period had elapsed, each ingredient was transferred to a 10 kg silo bag and the Leuconostoc mesenteroides inoculum was added at a dose of 1% (10-6 cells/ml) by spraying gradually. Subsequently, the silo was compacted to prevent the ingress of oxygen and was then incubated for 30 days in a closed room at room temperature. After this period, the silage was opened and dried in an oven for three days. The raw materials from the silage process that had been dried were then ground with a milling machine and used as a mixture of duck rations.

The second stage was the preparation of the ration, which began by analyzing the nutritional content of the raw materials that make up the ration through proximate analysis. The results of the nutrient composition analysis obtained were used as a reference in the preparation of the ration. The ration prepared in this study was based on the recommendations of NRC (1995) with protein content (16%) and metabolic energy (2,900 kcal/kg). The percentage values of ration composition along with the nutrient content of the experimental rations were presented in Tables 1 and 2.

Table 1. Experimental ration composition of male ducks

Raw materials	Control (%)	Treatment (%)
Corn	50.60	-
Fine bran	21.75	-
Coconut meal	3.65	-
Soybean meal	10.00	-
Leaves	-	35.00
Peels	-	23.00
Tubers	-	17.10
Onggok	-	10.20
Fish meal	10.00	10.00
Vegetable oil	3.31	3.31
Premix	0.69	0.69
DL-methionine		0.35
L-lysine		0.30

Table 2. The male duck ration ingredients used in the present study

Nutrients \ Treatment	S_0	S_{25}	S_{50}	S_{75}	S_{100}
Dry matter (%)[1]	88.34	88.50	88.09	88.21	87.53
Crude protein (%)[1]	19.91	17.24	17.30	18.50	18.25
Crude Fat (%)[1]	8.68	7.83	7.62	4.91	4.35
Crude Fiber (%)[1]	7.73	7.06	7.21	7.58	7.91
Ca (%)[2]	1.22	1.07	0.82	0.77	0.68
P (%)[2]	0.48	0.40	0.41	0.41	0.40
GE (Kcal/kg)[3]	4 091.55	4 085.92	4 054.93	4 008.45	4 019.72
HCN/Cyanide (ppm)[2]	0	15.69	21.77	25.07	27.80
Methionine (%)[2]	0.37	0.37	0.37	0.37	0.37
Lysine (%)[2]	0.99	0.89	0.92	0.94	0.85

S0: 100% control ration, S25: 25% CS silage ration, S50: 50% CS silage ration, S75: 75% CS silage ration and S100: 100% CS silage ration. [1]Analysis results of PAU laboratory of IPB,[2] Analysis results of Dairy Animal Nutrition Laboratory, Faculty of Animal Husbandry, IPB,[3] Analysis results of Feed Technology and Industry Laboratory, Faculty of Animal.

Observed variables

The measured variables in the present study were body weight gain, ration consumption, and ration conversion referring to the method used by Palupi et al. (2023). Moreover, the characteristics of the digestive organs, including the percentage of abdominal fat, the percentage of spleen, the percentage of liver, the percentage of kidney, the percentage of heart, the percentage of gizzard, and the percentage of pancreas, were determined using the method proposed by Huang et al. (2022). while thyroid levels and thiocyanate levels in serum based on the method used by Pettigrew and Fell (1972).

Feed consumption

The investigated parameters included consumption of ration (g/head/day), which was measured based on the difference between the ration given (g) and the rest of the ration given (g) during a specific period (days)

Body weight gain

body weight gain (g/head/day), which was measured by weighing the difference between body weight at the end of the study (g) and the initial body weight (g), then divided by the length of rearing time (days)

Feed conversion ratio

Feed conversion ratio (FCR), is measured based on the ratio between weight gain and ratio consumption.

Digestive organ characteristics

To calculate the percentage of abdominal fat, spleen, liver, kidney, heart, gizzard, and pancreas in poultry, it was first necessary to weigh each organ separately after the slaughtering process was complete. The weight of each organ should be recorded in grams using a precision scale. Additionally, the total body weight of the chicken prior to slaughter should be recorded as a reference point for calculating the percentage of each organ. Once the data on organ weight and total chicken weight have been obtained, the percentage can be calculated using the following formula:

Organ percentage = (organ weight/total chicken weight) × 100 (Formula 1)

To illustrate, if the total weight of the chicken was 2000 grams and the weight of the chicken liver was 50 grams, the liver percentage was calculated as (50/2000) × 100, which equates to 2.5%. This process was repeated for each additional organ, including abdominal fat, spleen, kidney, heart, gizzard, and pancreas. This allows for the calculation of the percentage of each organ relative to the total body weight of the chicken.

Thyroid and thiocyanate

The methodology employed comprises a series of steps for the determination of thiocyanate levels in biological fluids. The initial step involved the collection of a plasma or urine sample. To separate the plasma from the blood, the anticoagulant lithium heparin was employed. Subsequently, the sample was subjected to a deproteination process, whereby trichloroacetic acid was added. Subsequently, the test solution was treated with bromine water, which serves to oxidize thiocyanate into intermediate compounds, such as bromosyanide. The residual bromine was then neutralized with an arsenic oxide solution. Following this, the pyridine-p-phenylenediamine reagent was added, resulting in a pink color reaction. Measurements were then taken using a spectrophotometer at a wavelength of 520 nm. The concentration of thiocyanate in the sample was calculated based on the resulting absorbance of the test solution in comparison to the thiocyanate standard solution. The accuracy and specificity of this procedure have been tested through a series of recovery experiments, both for plasma and urine, in order to ensure that the method was effective in the precise detection of thiocyanate.

Statistical analysis

The data obtained will be processed to obtain an analysis of variance (ANNOVA) using Statistical Product and Service Solutions (SPSS) software version 20 (2018) according to the design used. If there were differences between treatments, the Duncan Multiple Range Test (DMRT) will be tested.

RESULTS AND DISCUSSION

Body weight gain

Cassava silage (CS) in the ration had a significant effect on reducing the value of body weight gain of ducks ($p < 0.05$). The decrease in BWG value in this study was strongly suspected to be due to the presence of cyanide content in all parts of cassava which further takes an important role in disrupting metabolism in the digestive system of ducks. The growth of ducks fed between 25% and 50% showed high weight gain. However, after feeding 75% silage, the weight gain achieved decreased. These results proved that ducks can be fed CS silage at the limit of 50% silage content without resulting in a decrease in body weight gain. Olayemi and Oso (2018) reported that the substitution of a mixture of cassava tubers and leaves with corn by up to 25% increased body weight gain but at the 50% substitution level decreased the body weight of ducks. Furthermore, Li et al (2019) stated that goose body weight gain decreased with increasing levels of cassava leaf feeding in the diet. Similarly, Sekarsari (2022) reported that the inclusion of cassava tubers in broiler rations can result in a reduction in body weight gain.

A reduction in the rate of body weight gain was observed in the 75% silage diet (S_{75}), which may be due to the presence of 25.07 ppm cyanide in the ration or 2.89 mg/kg/day cyanide consumption. The observed decrease in body weight gain (BWG) may have resulted from thyroid gland disorders and increased serum thiocyanate levels. This was evidenced by the increase in thyroid gland weight and thiocyanate levels with increasing levels of CS silage use. The increase in thyroid gland weight can be assumed to be due to increased activity in producing thiocyanate. The detoxification of cyanide in the body produces thiocyanate, and an increase in thiocyanate causes sulfur amino acids to be depleted (Njankouo et al., 2023). The function of thyroxine hormone plays the most important role in growth due to its contribution to metabolism and skeletal maturation. Thyroxine in performing its role in growth works together with growth hormones such as somatotropin and somatropin. The thyroid gland produces thyroxine hormone using the basic ingredients of iodine. Iodine in thyroxine hormone was bound to the penol ring of tyrosine which was the active component. The cyanide acid contained in CS contains CN- which was a rival to the thyroid gland in transferring iodine. If the CN ingested by ducks was too high or exceeded the tolerance level, the thyroid gland's ability to produce thyroxine hormone was disrupted, which directly affects growth. Moreover, increased thiocyanate also inhibits the intra-thyroidal uptake of iodine, which causes an increase in thyroid-stimulating hormone (TSH) secretion and a decrease in the concentration of thyroxine which is necessary for growth (Muderawan et al., 2023).

Ration intake/consumption

The application of CS in the ration had a significant effect on reducing the value of ration consumption ($p < 0.05$). Average feed consumption during the study was lowest in the 100% CS treatment (S100) at 7227.18 g/head and the highest was achieved by ducks treated with 0% CS (S0) at 7789.30 g/head. These results indicated that the higher level of CS in the ration causes the duck's ration consumption to decrease linearly and has the same pattern of decreasing duck body weight presented in Table 3.

Table 3. Average body weight gain, feed consumption, and feed conversion of ducks with cassava silage diets

Variables \ Treatment	S_0	S_{25}	S_{50}	S_{75}	S_{100}	p-value
BWG (g/head)	1132.76±161.38[ab]	1201.88±34.90[a]	1080.58±84.38[b]	1030.25±37.93[bc]	977.52±30.36[c]	0.01
Consumption (g/head)	7789.33±65.44[a]	7709.51±70.21[a]	7686.86±80.12[a]	7472.45±161.68[b]	7227.18±201.12[c]	0.03
Convert	6.98 ± 0.98	6.42±0.22	7.15±0.59	7.26±0.38	7.40±0.42	0.66

S_0: 100% control ration, S_{25}: 25% CS silage ration, S_{50}: 50% CS silage ration, S_{75}: 75% CS silage ration and S_{100}: 100% CS silage ration. [a, b] different superscripts in the same row indicate significant differences ($p < 0.05$).

Table 4. Internal organ weight and thiocinates in serum of male ducks with cassava silage diets

Variables \ Treatment	S_0	S_{25}	S_{50}	S_{75}	S_{100}	p-value
Abdominal Fat (%)	1.23 ± 0.17[a]	1.10 ± 0.06[a]	1.12 ± 0.08[a]	0.81 ± 0.04[b]	0.76 ± 0.02[b]	0.03
Spleen (%)	0.05 ± 0.02[b]	0.06 ± 0.02[b]	0.08 ± 0.02[ab]	0.08 ± 0.01[ab]	0.09 ± 0.01[a]	0.03
Liver (%)	2.80 ± 0.39[b]	2.91 ± 0.69[b]	3.06 ± 0.34[b]	3.30 ± 0.37[ab]	3.81 ± 0.20[a]	0.04
Kidney (%)	0.69 ± 0.22	0.71 ± 0.24	0.76 ± 0.11	0.90 ± 0.16	1.01 ± 0.12	0.058
Heart (%)	0.74 ± 0.11	0.70 ± 0.04	0.77 ± 0.34	0.77 ± 0.09	0.84 ± 0.12	0.08
Gizzard (%)	5.37 ± 0.94	5.46 ± 1.06	5.50 ± 0.53	5.83 ± 0.40	6.17 ± 1.21	0.1
Pancreas (%)	0.31 ± 0.87[b]	0.34 ± 0.03[b]	0.34 ± 0.03[b]	0.37 ± 0.05[ab]	0.43 ± 0.03[a]	0.04
Thyroid (%)	0.08 ± 0.00[c]	0.02 ± 0.01[b]	0.02 ± 0.00[b]	0.03 ± 0.00[a]	0.03 ± 0.00[a]	0.04
Thiocyanate (μmol/l)	0.00 ± 0.00[d]	23.57 ± 3.97[c]	36.41 ± 4.94[b]	42.92 ± 1.08[a]	45.03 ± 1.57[a]	< 0.01
Mortality (tail)	0	2	0	1	0	

S0: 100% control ration, S25: 25% CS silage ration, S50: 50% CS silage ration, S75: 75% CS silage ration and S100: 100% CS silage ration. [a,b] different superscripts in the same row indicate significant differences ($p < 0.05$).

The reduced feed consumption was thought to be because the feed composed of CS was more friable and turned into a paste when wet. In this study, leaves were the largest contributor to the CS ratio and are a large component of feed (Nova et al., 2021; Phoncharoen et al., 2022). These feed conditions indirectly cause the ducks to stop consuming because the capacity of the digestive tract has been reached, even though they still need additional energy. As a result, the ducks lack energy and other essential nutrients, which ultimately affect growth.

On the other hand, reduced feed consumption was also suspected to be due to the presence of cyanide in the CS diet. Generally, cyanide content correlates with bitter taste, although this is not absolute (Bakare et al., 2021). The bitter taste of cassava raw materials makes the ration less palatable, causing ducks to reduce the amount of feed consumption. Abouelezz et al (2022) found that duck ration consumption decreased due to the presence of antinutritional substances such as cyanide, therefore limiting the use of cassava as animal feed (Widowati et al., 2022).

The cyanide content in the diet varied widely from 0-27.80 ppm, so it can be concluded that the higher the level of CS in the diet, the more cyanide was consumed by the ducks. Based on the assumption of the illustration obtained, the cyanide consumed by ducks every day in treatment S_{25} (25% CS silage) amounted to 1.73 mg/kg/day, S_{50} (50% CS silage) amounted to 2.39 mg/kg/day, S_{75} (75% CS silage) amounted to 2.67 mg/kg/day and S100 (100% CS silage) amounted to 2.87 mg/kg/day. However, the cyanide consumed by ducks daily during the study did not exceed the tolerance limit so the giving of CS up to 100% level did not cause mortality. As reported by Njankouo et al., (2023) who stated that the tolerance limit of broiler chickens to Hidrogen cyanide (HCN) administration was 2000 mg/kg. In another statement, Jayanegara et al., (2019) recommend that the HCN content in cassava should not be more than 10 mg HCN/kg cassava when given in poultry diets.

Feed conversion ratio

Analysis of variance results showed that providing CS in the diet had no significant effect on feed conversion. Bakare et al. (2021) reported that there was no difference in ration conversion with increasing levels of cassava tubers up to 20% in the ration in broilers. Moreover, It was reported that there was no difference in ration conversion when cassava peels were given up to 30% of local ducks (Ritonga and Munandar, 2018). But different from the results of research by Olayemi and Oso (2018) the substitution of a mixture of cassava tubers and leaves with corn up to 100% level gave significant results on the value of ration conversion. The average ratio conversion of this study ranged from 6.24-7.18. This conversion value was higher than the results of previous studies as reported. Ritonga and Munandar (2018), reported that the average ration conversion of local ducks fed with cassava peel flour was 4.13-4.32. The results of the study by Olayemi and Oso (2018) showed that the value of ration conversion in corn substitution and a mixture of cassava tubers and leaves ranged from 3.20-3.73. There were significant differences between these different ration conversions when the rations were made up of different types of feed (Depawole and Sudarma, 2020). This high rate of feed conversion was indicative of the ducks' uneconomic and inefficient use of feed, resulting in poor feed efficiency.

The lowest ration conversion was achieved in treatment S25 with 25% CS silage at 6.24, followed by treatment S0 (0% CS silage) at 6.78, S50 (50% CS silage) at 6.94, S75 (75% CS silage) at 7.06 and the worst was treatment S100 (100% CS silage) at 7.18. This result showed that the higher the use of cassava-based silage, the higher the feed conversion ratio, and that this was influenced by low feed intake which was not followed by adequate body weight gain. In addition, low feed intake reduces the amount of nutrients available to the body, which in turn affects growth.

Abdominal fat

The application of CS in the ratio had a significant effect on reducing the percentage of abdominal fat ($p < 0.05$). The highest percentage of abdominal fat was found in ducks fed 0% CS silage (S0) which amounted to 1.23% and the lowest in the treatment of 100% CS silage (S100) which amounted to 0.76%. These results indicated that the percentage of abdominal fat decreased linearly with increasing CS in the ratio. The results of the study by Widowati et al. (2022) showed that increasing the level of fermented cassava leaf flour in the ration reduced the percentage of abdominal fat in broilers. In this study, the decrease in abdominal fat percentage was also attributed to the low-fat content of the diet for relatively the same energy content of the diet. This can be seen in Table 1 low ration fat content will cause a low percentage of abdominal fat, otherwise high ration fat content will enhance a high percentage of abdominal fat. Widowati et al. (2022) stated that carcass fatness was influenced by the fat content in the ration. Furthermore, the presence of dietary cyanide, which increased with increasing CS silage in the diet, could be another reason for the decrease in abdominal fat percentage. Bakare et al. (2021) stated that the presence of antinutrients in the ration will inhibit the digestibility of protein, fat, and carbohydrates, which causes pathological changes in the intestines and liver tissue, thus affecting metabolism, inhibiting some enzymes, and binding nutrients which making it unavailable. El-Zayat et al. (2019) mentioned that the loss of body fat was affected by the inhibition of lipid synthesis in the liver and stomach tissues.

Spleen weight

The application of CS in the diet had a significant effect on increasing the percentage of spleen weight ($p < 0.05$). The lowest spleen weight percentage in the provision of 0% CS silage (S0) amounted to 0.05% and the highest in the treatment of 100% CS silage (S100) amounted to 0.09% were obtained. Prasetya et al. (2015) reported that the percentage of spleen weight of male Balinese ducks was 0.12% of live weight. These results showed that the percentage of spleen continues to increase linearly along with the increase in the provision of CS silage in the ratio. The presence of toxic substances in the form of cyanide, which increases as CS silage is increasingly included in diets, influences the increase in the percentage of spleen weight. According to Ardiansyah et al. (2021), the size of the spleen can increase or decrease by effective factors such as diseases and antinutrition. In the case of rations containing toxic substances such as cyanide, the spleen will produce lymphocyte cells which will produce antibody substances. Lee et al. (2022) explained that the swelling that occurs in the spleen is a response to an infection that stimulates the lymphocyte cells in the lymphoid organs to produce antibodies.

Heart weight

The application of CS in the ration had a significant effect on increasing the percentage of liver weight ($p < 0.05$). The percentage of liver weight in this study ranged from 2.80-3.81%. This range was higher than that reported by Prasetya et al. (2015) in the percentage of duck liver weight was 2.62% of live weight. These results indicated that the percentage of liver weight increased linearly along with the increase in the provision of CS silage in the ration. The increasing percentage of liver weight in this study was due to an increase in cyanide content along with the increasing level of cassava raw material provision into the ration. Kadiri and Asagba (2019) reported that there was an increase in liver organs in chickens fed rations containing cyanide. According to Jayanegara et al. (2019), toxic compounds were subject to a process of detoxification in the liver. Excessive toxic compounds cannot be detoxified perfectly in the liver because the liver has a very complex function including bile secretion, and metabolic processes such as protein, fat, and carbohydrate metabolism, so its ability to neutralize toxins entering the body is very limited. Cyanide detoxification makes liver cells more active as a response to high thiocyanate concentrations. This active liver work was thought to allow adaptation of liver flexibility so that it will increase liver size. Cosmos et al. (2020) expressed that the detoxification process of cyanide poison in the liver was catalyzed by the enzyme rodanase which converts the thiosulfate-cyanide complex into thiocyanate which is then excreted from the body.

Kidney weight

The range of kidney weight percentage in the current study was 0.69%-1.01% of live weight. The average percentage of kidney weight was higher, as Kusmayadi et al. (2019) reported that the percentage of kidney weight of local ducks ranged from 0.51 to 0.86% of live weight. The feeding of CS silage, which increases in the ratio, leads to an increase in the average percentage of kidney weight, although it does not have a statistically significant effect. When toxic substances enter the body, the kidneys work harder to neutralize the toxins. According to Aqsa et al. (2016), one of the functions of the kidneys is to maintain the balance of blood composition by removing substances such as excess water, metabolic wastes, organic salts, and foreign substances dissolved in the blood. The kidneys were responsible for the maintenance of the integrity of the extracellular fluid volume, the process was the conservation of water and other substances, the material needed by the body will be returned to the body fluids, while the excess will be excreted in the urine. Furthermore, the kidneys remove nitrogen from protein metabolites, ions, and complex organic compounds, both endogenous and exogenous (Suzumoto et al., 2023).

The average percentage of heart weight obtained from this study ranged from 0.70-0.84%. This percentage was lower than that reported by Kokoszyński et al. (2019), which was the percentage of duck heart weight around 11-12.4% of live weight. The inclusion of more CS silage in the diet also increased the average percentage of heart weight, although the results of the analysis of variance were not significant. This shows that ducks fed with CS silage rations up to 100% produce the same percentage of heart weight as the control. The results of the study by Bakare et al. (2021) reported that giving cassava tuber waste did not affect duck heart weight. Aqsa et al. (2016) stated that the heart was a very sensitive organ to the poisons and anti-nutrients contained in the diet and that changes in the size of the heart were common in those affected by disease or poisoning. Rations with high cyanide content cause blockages in blood vessels so that the work of the heart muscle increases resulting in enlargement of the heart size from normal. Rosanti et al. (2021) indicated that enlargement of the heart was usually characterized by an increase in the size of the heart muscle, which could occur as the muscle adjusts to the excessive contractions of the heart.

Gizzard weight

The average percentage of gizzard weight obtained from this study ranged from 5.37 to 6.17%. The average percentage had a higher value than the one reported by Kusmayadi et al (2019), which ranged from 2.28 to 3.03% of live weight. Providing increasing amounts of CS silage in the diet also increased the average percentage of gizzard weight, although the effect was not statistically significant. This showed that diets containing up to 100% CS silage (S100) produced the same percentage of gizzard weight as the control. Besides foreign bodies such as cyanide, crude fiber also interferes with the functioning of internal organs. In case the given ratio has a high crude fiber content, the work of the gizzard will be heavier and can increase the size and weight of the gizzard. The results of this study indicated that feed treatment affects the function and development of duck gizzard because the provision of CS silage up to 100% (S100) has a high crude fiber content (7.06-7.91%). Han et al. (2017) stated that increasing the percentage of crude fiber in duck rations can increase the percentage of gizzard weight to live weight. The increase in gizzard weight was due to its heavy function to digest feed containing high crude fiber (Kusmayadi et al., 2019). Jha and Mishra (2021) explained that the increased activity of the gizzard in grinding up incoming food can cause the muscles in the gizzard tissue to become thicker due to the contractions that occur so that the size of the gizzard also increases.

Pancreas weight

The application of CS in the ratio significantly influenced increasing the percentage of pancreas weight ($p < 0.05$). The lowest percentage of pancreas weight was treated with 0% CS silage (S0) at 0.31% and the highest treatment was 100% CS silage (S100) at 0.43%. The results of the study by Kusmayadi et al. (2019) showed that the percentage of pancreas weight of local ducks ranged from 0.21 to 0.45% of live weight. This result showed that the percentage of pancreas continues to increase linearly along with the increase in the provision of CS silage in the diet. Kadiri and Asagba (2019) reported that there was an increase in pancreatic organs in chickens fed rations containing cyanide. The increase in the percentage of the weight of the pancreas occurs as a form of adaptation effort by the organ to continue to produce digestive enzymes so that the digestive process can take place normally in the digestive tract. Furthermore, The increase in cyanide content in line with the increasing level of cassava raw materials into the ration causes disruption of the pancreas function in secreting digestive enzymes

Thyroid and thiocyanate weights in serum

Providing CS in the diet showed a significant effect on reducing the weight percentage of the thyroid gland and increasing the serum thiocyanate concentration. ($p < 0.05$). The lowest percentage of thyroid gland weight in the treatment of 0% CS silage (S0) amounted to 0.08% and the highest treatment of 100% CS silage (S100) amounted to 0.03%. Based on the pattern formed, it can be seen that an increase in the supply of CS silage in the diet leads to a linear increase in the decrease in thyroid gland weight and the increase in thiocyanate concentration. The increased thyroid gland weight and serum thiocyanate concentration are due to the presence of cyanide in the ration. The higher the CS silage causes the higher the cyanide content in the ration.

Mondal and Chandra (2019) suggested that the relationship between cyanide content in the ration and thiocyanate concentration in serum illustrated the function of the cyanide detoxification system in the body and the increase in thyroid gland weight. Thiocyanate levels in serum increase due to the provision of rations containing cyanide which accumulates continuously in cassava rations. According to Supapong et al. (2022), cyanide in the body will be converted into thiocyanate with the help of the function of rhodanese. Sulfur from dietary sulfur amino acids affects the ability of the animal's body to convert cyanide to thiocyanate. While Słupczyńska et al. (2023) have shown that there was a close relationship between the level and source of iodine in the animal's diet and thyroid activity, the presence of dietary compounds that may reduce iodine utilization, such as goitrogenic substances in some feed ingredients, should also be considered. Increased thyroid weight indicates increased activity of its epithelial cells to maintain the production of the thyroid hormones that ducks need to grow.

CONCLUSION

Based on the results of the study it can be concluded that giving 25% CS in the ratio gives the best results on the performance of male ducks and giving 100% CS can have a significant impact on the value of internal organs and thyroid and thiocinate levels in male ducks. The recommendation for giving cassava silage rations can be given a maximum of 50% with the lowest impact on performance compared to other treatments.

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Competing interests

The authors declare that they have no competing interests.

Authors' contributions

Asep Sudarman, Komang Gede Wiryawan, and Djumali Mangunwijaya designed this research. Sofia Sandi contributed to the design and data analysis of this study and drafted the manuscript. Eli Sahara and Anggriawan Naidilah Tetra Pratama helped to improve the English version of the manuscript. All authors approved the final version of the manuscript

Availability of data and materials

The original contributions presented in the study are included in the article/supplementary material. For inquiries, please contact the corresponding author/s.

Ethical considerations

All authors have reviewed the manuscripts for ethical concerns, such as plagiarism, consent to publish, misconduct, data fabrication and falsification, double publishing and submission, and redundancy.

REFERENCES

Abouelezz KFM, Wang S, Xia WG, Chen W, Elokil AA, Zhang YN, Wang SL, Li KC, Huang XB, and Zheng CT (2022). Effects of dietary inclusion of cassava starch-extraction-residue meal on egg production, egg quality, oxidative status, and yolk fatty acid profile in laying ducks. Poultry Science, 101(9): 1-9. DOI: https://www.doi.org/10.1016/j.psj.2022.102015

Aqsa AD, Kiramang K, and Hidayat MN (2016). Organ profile in broiler that we give to the betel leaves meal (Pipper Betle Linn) as feed additives. Journal of Animal Husbandry Science and Industry, 3(1): 149-159. DOI: https://www.doi.org/10.24252/jiip.v4i2.9860

Ardiansyah P, Suprijatna E, and Kismiati S (2021). Effect of adding cassava peel and lactic acid bacteria as a feed additive to the weight of immune organs of super native chicken. Jurnal Sain Peternakan Indonesia, 16(4): 334-339. DOI: https://www.doi.org/10.31186/jspi.id.16.4.334-339

Bakare AG, Zindove TJ, Iji PA, Stamatopoulos K, and Cowieson AJ (2021). A review of limitations to using cassava meal in poultry diets and the potential role of exogenous microbial enzymes. Tropical Animal Health and Production, 53(4): 1-13. DOI: https://www.doi.org/10.1007/s11250-021-02853-6

Cosmos A, Erdenekhuyag BO, Yao G, Li H, Zhao J, Laijun W, and Lyu X (2020). Principles and methods of bio detoxification of cyanide contaminants. Journal of Material Cycles and Waste Management, 22(4): 939-954. DOI: https://www.doi.org/10.1007/s10163-020-01013-6

Depawole RR and Sudarma MA (2020). Effect of feeding different protein levels on production performance of 2-10 week old ducks in East Sumba. Jurnal Sain Peternakan Indonesia, 15(3): 320-326. DOI: https://www.doi.org/10.31186/jspi.id.15.3.320-326

Ditjennak (2021). Livestock and animal health statistics. Directorate General of Animal Husbandry and Animal Health Ministry of Agriculture., Indonesia, pp 1-240. Available: https://pusvetma.ditjenpkh.pertanian.go.id/upload/statistik/1644549920.Buku_Statistik_2021.pdf

El-Zayat SR, Sibaii H, and El-Shamy KA (2019). Physiological process of fat loss. Bulletin of the National Research Centre, 43(1): 208. DOI: https://www.doi.org/10.1186/s42269-019-0238-z

El-katcha MI, Soltan MA, Shewita R, Abdo SE, Sanad AS, Tufarelli V, Alagawany M, and El-naggar K (2021). Dietary fiber and lysolecithin supplementation in growing ducks: Effect on performance, immune response, intestinal morphology and lipid metabolism-regulating genes. Animals, 11(2873): 1-15. DOI: https://www.doi.org/10.3390/ani11102873

Fasae OA and Yusuf AO (2022). Cassava leaves and peels: Nutritional value and potential productivity in West African dwarf breeds of sheep and goats– A review. Nigerian Journal of Animal Production, 49(3): 305-315. DOI: https://www.doi.org/10.51791/njap.v49i3.3562

Han HY, Zhang KY, Ding XM, Bai SP, Luo YH, Wang JP, and Zeng QF (2017). Effect of dietary fiber levels on performance, gizzard development, intestinal morphology, and nutrient utilization in meat ducks from 1 to 21 days of age. Poultry Science, 96(12): 4333-4341. DOI: https://www.doi.org/10.3382/ps/pex268

Hasanudin U, Safira ND, Nurainy F, Utomo TP, and Haryanto A (2023). Improving biogas production in tapioca industry by using onggok as co-substrate. International Journal of Renewable Energy Research, 13(2): 741-749. DOI: https://www.doi.org/10.20508/ijrer.v13i2.13814.g8748

Hawashi M, Aparamarta H, Widjaja T, and Gunawan S (2019). Optimization of solid state fermentation conditions for cyanide content reduction in cassava leaves using response surface methodology. International Journal of Technology, 10(3): 624. DOI: https://www.doi.org/10.14716/ijtech.v10i3.2923

Hermanto H and Fitriani F (2019). Utilisation of cassava peel and leaf waste as a mixture of poultry feed ingredients. Jurnal Riset Teknologi Industri, 13(2): 284. DOI: https://www.doi.org/10.26578/jrti.v13i2.5610

Huang Q, Wen C, Yan W, Sun C, Gu S, Zheng J, and Yang N (2022). Comparative analysis of the characteristics of digestive organs in broiler chickens with different feed efficiencies. Poultry Science, 101(12): 102184. DOI: https://www.doi.org/10.1016/j.psj.2022.102184

Jayanegara A, Ridla M, Laconi EB, and Nahrowi (2019). Antinutrient Components in Feed. IPB Press., Indonesia, pp. 1-75.

Jha R and Mishra P (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(1): 51. DOI: https://www.doi.org/10.1186/s40104-021-00576-0

Kadiri HE and Asagba SO (2019). The chronic effects of cyanide on oxidative stress indices in the domestic chicken (*Gallus domesticus* L.). The Journal of Basic and Applied Zoology, 80(30): 30. DOI: https://www.doi.org/10.1186/s41936-019-0098-y

Khota W, Kaewpila C, Suwannasing R, Srikacha N, Maensathit J, Ampaporn K, Patarapreecha P, Thip-uten S, Sawnongbue P, Subepang S et al. (2023). Ensiling cyanide residue and *in vitro* rumen fermentation of cassava root silage treated with cyanide-utilizing bacteria and cellulase. Fermentation, 9(2): 1-13. DOI: https://www.doi.org/10.3390/fermentation9020151

Kokoszyński D, Wasilewski R, Saleh M, Piwczyński D, Arpášová H, Hrnčar C, and Fik M (2019). Growth performance, body measurements, carcass and some internal organs characteristics of pekin ducks. Animals, 9(963): 1-19. DOI: https://www.doi.org/10.3390/ani9110963

Kusmayadi A, Prayitno CH, and Rahayu N (2019). The internal organ percentage of Cihateup duck that given rationcontaining combination of mangosteen peeland turmeric flour. Jurnal Peternakan Nusantara, 5(1): 1-12. DOI: https://www.doi.org/10.30997/jpnu.v5i1.1630

Lee JH, Lee B, Rousseau X, Gomes GA, Oh HJ, Kim YJ, Chang SY, An JW, Go Y Bin, Song DC et al. (2022). Stimbiotic supplementation modulated intestinal inflammatory response and improved boilers performance in an experimentally-induced necrotic enteritis infection model. Journal of Animal Science and Biotechnology, 13(1): 1-17. DOI: https://www.doi.org/10.1186/s40104-022-00753-9

Li M, Zhou H, Xu T, and Zi X (2019). Effect of cassava foliage on the performance, carcass characteristics and gastrointestinal tract development of geese. Poultry Science, 98(5): 2133-2138. DOI: https://www.doi.org/10.3382/ps/pey567

Mappanganro R, Ananda S, Mappanganro N, and Ardiansyah W (2024). Supplementation of turmeric flour (*Curcuma longa*) in feed from the grower to laying phase on the productivity of Mojosari ducks. Journal of Animal Science, 6(1): 1-12. DOI: https://www.doi.org/10.20956/hajas.v6i1.32793

Mondal C and Chandra AK (2019). Goitrogenic/antithyroidal potential of moringa leaves (*Moringa oleifera*) and spinach (*Spinacia oleracea*) of Indian origin on thyroid status in male albino rats. Brazilian Journal of Pharmaceutical Sciences, 55: 1-11. DOI: https://www.doi.org/10.1590/s2175-97902019000218005

Muderawan IW, Karyasa IW, Tika IN, and Beni Widana GA (2023). Chemistry and biology of cyanides: A literature review. Indonesian Journal of Chemistry and Environment, 6(2): 63-82. DOI: https://www.doi.org/10.21831/ijoce.v6i2.67030

Mukhtar A, Latif S, Barati Z, and Müller J (2023). Valorization of cassava by-products: Cyanide content and quality characteristics of leaves and peel. Applied Sciences, 13(10): 6340. DOI: https://www.doi.org/10.3390/app13106340

National research council (NRC) (1995). Nutrient Requirements of Poultry. Vol. 74 DOI: https://www.doi.org/10.3382/ps.0740224

Njankouo YN, Nyegue MA, Njingou I, Moundipa PF, and Mounjouenpou P (2023). Toxic potential of crude extract from cassava cortex containing scopoletin and cyanide on Wistar rats and broilers. Dose-Response, 21(3): 1-10. DOI: https://www.doi.org/10.1177/15593258231203587

Nova K, Tantalo S, Sutrisna R, Darmawan A, Kusuma MFV, and Hasiib EA (2021). The introduction of cassava leaf flour in commercial feed on performance of KUB chickens. Jurnal Ilmiah Peternakan Terpadu, 9(1): 108. DOI: https://www.doi.org/10.23960/jipt.v9i1.p108-119

Ogbuewu IP and Mbajiorgu CA (2023). Utilisation of cassava as energy and protein feed resource in broiler chicken and laying hen diets. Tropical Animal Health and Production, 55(3): 161. DOI: https://www.doi.org/10.1007/s11250-023-03579-3

Olayemi W and Oso A (2018). Effect of fermented cassava root-leaf meal as a replacement for maize on performance, carcass yield and gut microflora of ducks. Tropical Animal Production Investigations, 23(1): 35-44. Available: http://tapianimalsci.ui.edu.ng/index.php/journal/article/view/139

Palupi R, Lubis FNL, Pratama ANT, and Muhakka (2023). Effects of lactobacillus-fermented feed on production performance and carcass quality of broiler chickens. Journal of World's Poultry Research, 13(1): 127-135. DOI: https://www.doi.org/10.36380/jwpr.2023.14

Pereira IG, Vagula JM, Marchi DF, Barão CE, Almeida GRS, Visentainer JV, Maruyamab SA, and Júnior OOS (2016). Easy method for removal of cyanogens from cassava leaves with retention of vitamins and omega-3 fatty acids. Journal of the Brazilian Chemical Society, 27(7): 1290-1296. DOI: https://www.doi.org/10.5935/0103-5053.20160027

Pettigrew AR and Fell GS (1972). Simplified colorimetric determination of thiocyanate in biological fluids, and its application to investigation of the toxic amblyopias. Clinical Chemistry, 18(9): 996-1000. DOI: https://www.doi.org/10.1093/clinchem/18.9.996

Phoncharoen P, Banterng P, Vorasoot N, Jogloy S, and Theerakulpisut P (2022). Determination of cassava leaf area for breeding programs. Agronomy, 12(12): 1-15. DOI: https://www.doi.org/10.3390/agronomy12123013

Pramestya NR, Hidanah S, Lamid M, Soepranianondo K, Lokapirnasari WP, Al-Arif MA, and Soeharsono (2021). Supplementation of fermented moringa leaf powder (*Moringa oleifera*) on feed consumption, egg weight and feed conversion ratio (FCR) in laying duck. Jurnal Medik Veteriner, 4(1): 78-83. DOI: https://www.doi.org/10.20473/jmv.vol4.iss1.2021.78-83

Prasetya F, Setiawan I, and Garnida D (2015). The Exterior and interior characteristic of Balinese duck (case on Maniksari duck breeder in Lepang Halmet, Takmung Village, Banjarangkang Subdistrict, Klungkung Regency, Bali). Students e-Journal, 4(1): 1-8. Available: https://jurnal.unpad.ac.id/ejournal/article/view/5809

Ritonga MZ and Munandar DA (2018). Providing cassava (Manihot UtilissimaPohl) skin tubes in the ransum on the performance of local duck (Anas Sp). Jurnal Kajian Ekonomi dan Kebijakan Publik, 3(1): 21-30. DOI: https://www.doi.org/10.30997/jpnu.v5i1.1630

Rosanti I (2021). The effect of the substitution of cassava leaves (*Manihot utilissima*) in the ratio on the percentage of organts in broiler chicken. Jurnal Green Swarnadwipa, 10(1): 171-175. DOI: https://www.doi.org/10.30997/jpnu.v5i1.1630

Sekarsari NGAMS (2022). Xylanase enzyme on broiler performance fed cassava based diet in forms of pellet and mash. Proceedings of the 6th International Seminar of Animal Nutrition and Feed Science (ISANFS 2021), pp. 304-308.

Sjofjan O, Natsir MH, Adli DN, Adelina DD, and Triana LM (2020). Effect of symbiotic flour (*Lactobacillus* Sp. and FOS) to the egg quality and performance of laying hens. IOP Conference Series: Earth and Environmental Science, 465(1): 1-7. DOI: https://www.doi.org/10.1088/1755-1315/465/1/012033

Słupczyńska M, Jamroz D, Orda J, Wiliczkiewicz A, Kuropka P, and Król B (2023). The thyroid hormone and immunoglobulin concentrations in blood serum and thyroid gland morphology in young hens fed with different diets, sources, and levels of iodine supply. Animals, 13(158): 158. DOI: https://www.doi.org/10.3390/ani13010158

Soeprijanto S, Qomariyah L, Hamzah A, and Altway S (2022). Bioconversion of industrial cassava solid waste (Onggok) to bioethanol using a saccharification and fermentation process. International Journal of Renewable Energy Development, 11(2): 357-363. DOI: https://www.doi.org/10.14710/IJRED.2022.41332

Supapong C, Sommai S, Khonkhaeng B, Suntara C, Prachumchai R, Phesatcha K, Chanjula P, and Cherdthong A (2022). Effect of rhodanese enzyme addition on rumen fermentation, cyanide concentration, and feed utilization in beef cattle receiving various levels of fresh cassava root. Fermentation, 8(146): 146. DOI: https://www.doi.org/10.3390/fermentation8040146

Suwignyo B, Rini EA, Fadli MK, and Ariyadi B (2021). Effects of alfalfa (*Medicago sativa* L.) supplementation in the diet on the growth, small intestinal histomorphology, and digestibility of hybrid ducks. Veterinary World, 14(10): 2719-2726. DOI: https://www.doi.org/10.14202/vetworld.2021.2719-2726

Suwignyo B, Rini EA, Wahyudi U, Suryanto E, Rusman, and Suhartanto B (2023). Tropical alfalfa (*Medicago sativa* cv. Kacang Ratu BW) supplementation for reducing cholesterol and improving quality of carcass and meat of hybrid duck. Animal Production Science, 63(5): 471-479. DOI: https://www.doi.org/ 10.1071/AN22018

Suzumoto Y, Zucaro L, Iervolino A, and Capasso G (2023). Kidney and blood pressure regulation-latest evidence for molecular mechanisms. Clinical Kidney Journal, 16(6): 952-964. DOI: https://www.doi.org/10.1093/ckj/sfad015

Widowati M, Sutrisna R, Septinova D, and Nova K (2022). The effect of fermented casssava (*Manihot utillisima*)aspergillus niger leaf flour substitucion on life weight, carcass weight, and fat Joper chicken abdominal age 8 weeks. Jurnal Riset dan Inovasi Peternakan, 6(4): 407-417. DOI: https://www.doi.org/10.23960/jrip.2022.6.4.407-417