Research Article

Effect of Dietary Papaya Peel on Performances of Naturally Strongylus-Infected Priangan Lambs

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Abstract | The inclusion of Papaya peel silage (PPS) is believed to improve the nutritional quality of dietary paddy straw silage (PSS) in sheep, showcasing its potential as an anthelmintic. A total of 18 naturally Strongylus-infected Priangan male lambs (initially with an average mean of 120 ± 31.8 eggs/g feces) were allocated using a completely randomized design. The objective was to compare three different as-fed doses of PPS inclusion, comprising 0% (PPS-0), 50% (PPS-50), and 75% (PPS-75) in a PSS-based diet. This comparison aimed to evaluate lamb performances both before (Phase 1, a 30-day trial) and after (Phase 2, a 42-day trial) an anthelmintic treatment, with each phase having six replicates (n = 6). Before the anthelmintic treatment, PPS inclusion showed no significant impact (P > 0.05) on the average daily gain (ADG, g/head/day) of the infected sheep. However, the total dry matter intake (DMI, g/head/day) was reduced (P < 0.001). The inclusion of dietary PPS-50 and PPS-75 effectively maintained fecal egg counts (FEC, eggs/g feces) of Strongylus sp. within the mild infection category. Additionally, fecal oocyte counts (FOC, eggs/g feces) of Coccidia were consistently lower for PPS-50 and PPS-75 compared to PPS-0. After the anthelmintic treatment, dietary PPS-75 significantly increased (P < 0.05) the ADG of sheep without adversely affecting the total DMI compared to the control group. This suggested that PPS had the potential to serve as both a feed supplement and an anthelmintic agent.

Keywords | Coccidia, Paddy straw silage, Papaya peel silage, Priangan sheep, Performances; *Strongylus* sp.

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INTRODUCTION

Priangan sheep is one of the most favored local breeds in West Java province, thriving and adapting well to the tropical conditions of Indonesia. In 2018, the province had a total sheep population of 11,608,559, representing a substantial 66.7% of the total sheep count in the country (Ministry of Agriculture, 2018). Despite such numbers, the prevalent sheep-rearing method across West Java and other provinces remains predominantly traditional and small-scale. This method, characterized by poor feed quality and health management, results in suboptimal sheep performances not only during breeding and rearing but also in the fattening phase.

The widespread conversion of grazing lands into plantations, residential areas, and industrial zones in West Java has resulted in dwindling high-quality forage options, posing challenges for ruminant farmers. Paddy straw serves as a viable forage, given its abundant availability, specifically considering that rice becomes a primary energy source for the majority of Indonesians. However, the straw is a low-quality forage for sheep feeding (Ramdani *et al*., 2022; Idan *et al*., 2020).

In daily community life, papaya serves not only as a fruity food but is also used for traditional medicine, cosmetics, and animal feed (Pathak *et al*., 2017). Papaya peel, with a crude protein (CP) content ranging from 6.89% to 10%, qualifies to be a moderate source of dietary protein for sheep feeding (Pathak *et al*., 2017). Acknowledged for its potential to combat intestinal worms, the peel contains cysteine proteinase, alkaloids, papain enzymes, chymopapain, papaya latex extract, saponins, flavonoids, caprine, and tannins (Pathak *et al*., 2017), having various anthelmintic activities. Therefore, the inclusion of papaya (*Carica papaya* L.) peel in the diet may enhance the quality of paddy straw-based sheep feed. Sheep, susceptible to endoparasite infections such as nematode worms, face reduced productivity (Julaeha *et al*. 2021). Nematode worms, primarily infecting the digestive tract, include Haemonchus contortus, Trichostrongylus, and Cooperia (Santos *et al*., 2019). These attacks can inhibit growth, and cause weight loss, reproductive disorders, as well as death of the animals. Additionally, coccidiosis is a parasitic infection in sheep caused by Coccidia from the Eimeriidae family, comprising *E. ovinoidalis*, *E. ahsata*, and *E. bakuesnsis* (Khodakaram-Tafti and Hashemnia, 2012). It can cause economic losses due to weight loss, digestive disorders, particularly diarrhea, decreased immunity, and potential fatalities.

Endoparasite diseases often necessitate medical anthelmintic drugs incurring additional costs. An alternative control method comprises regular feeding of papaya peel, a by product of papaya processing factories, examined for its potential as both feed and an anthelmintic agent (Mansur *et al*., 2021; Pathak *et al*., 2017). However, there is insufficient information about the inclusion of the peel to enhance a low-quality paddy straw-based diet and control parasites in local Priangan sheep. Therefore, this study aims to investigate the effects of three different doses of dietary papaya peel silage (PPS) inclusion (as fed) at 0%, 50%, and 75% in a paddy straw silage (PSS) based diet on the performances of naturally Strongylus-infected Priangan male lambs before and after an anthelmintic treatment.

MATERIALS AND METHODS

Animals

A total of yearling male lambs of the Priangan breed (following the Decree of Indonesian Agricultural Minister No. 300/Kpts/SR.120/5/2017) were selected for this experiment. The lambs had natural infection with fecal egg counts (FEC) of *Strongylus* sp. Nematode, showing a mild infection level ranging from 50 to 500 eggs/g feces (mean ± SE: 120 ± 31.8 eggs/g feces). Four out of the 18 lambs had initial fecal oocyte counts (FOC) of Coccidia infection, with a mean of 36.3 ± 21.5 oocytes/g feces. The lambs commenced the analysis with an average initial body weight of 22.8 kg, showing a coefficient of variation of 7.32%. Each lambs was randomly allocated to an individual pen (dimensions: 1.5 m long × 0.8 m wide × 0.9 m high), separated by wood panels that allowed for both eye contact and partial physical interaction. Every lamb had unrestricted access to the experimental diet and ad libitum clean water. This study was conducted at the Paddy Sheep Farm in Tanjungkemuning Village, North Tarogong Subdistrict, Garut Regency, West Java. The location was selected due to its proximity to PPS and PSS sources.

Animals feeding and handling

All experimental lambs were subjected to an adaptation period of three weeks. The lambs were initially placed in a colony pen for approximately two weeks, where they were adjusted to a basal control diet containing PSS and mixed concentrate. Subsequently, the lambs were randomly transferred to individual pens and adapted to the treatment diets for an additional week, and the detailed experimental diets were outlined in Table 1.

Table 1: Ad-libitum offers of different PPS and PSS (as-fed basis) in the experimental diets.

Ingredients	Experimental diets			Offered amount
	PPS-0	PPS-50	PPS-75	
Forage				
PPS (%)	0	50	75	ad-libitum
PSS (%)	100	50	25	
Concentrate (g)	500	500	500	g/head/day

PPS= papaya peel silage; PSS = paddy straw silage.

Fresh papaya peel was consistently sourced from two local small-scale papaya processing factories in the Banyuresmi and Leles Subdistricts of Garut Regency, West Java. Simultaneously, fresh paddy straw was regularly obtained from rice farms situated in the Banyuresmi and North Tarogong subdistricts of the Garut Regency. The collected papaya peel was placed on a cement floor overnight. Following this, the peel was transferred to a 120 L capacity of blue plastic barrels, and compacted as much as possible to create an oxygen-free environment. The barrels were tightly sealed with metal fasteners and stored for 5-7 days to produce PPS. A similar method was used to prepare PSS with a longer storage time of 21 days. A mixed commercial concentrate was procured from a local feed mill in Wanaraja Subdistrict, Garut Regency. Each sample of PPS, PSS, or concentrate was randomly collected from different parts of the barrels (PPS, PSS) and plastic bags (concentrate). The samples were pooled, transported to the laboratory, oven-dried (60°C, 48 hours), and ground to pass through a 1 mm sieve.

During the adaptation phase, each lambs received no anthelmintic or vitamin B complex treatments. A day before the commencement of Phase 1 of the feeding trial (day 0), initial measurements of FEC for Strongylus sp. (eggs/g feces), FOC for Coccidia (oocyte/g feces), and body weight (kg/ head) were recorded. On day 21 of the feeding trial, FEC and FOC analyses were repeated to assess the impact of treatments on Strongylus sp. and Coccidia infections. Additionally, body weight measurements were repeated on day 30 to calculate the average daily gain (ADG, g/head/ day) during the initial 30 days of the feeding trial (Phase 1).

After the conclusion of Phase 1, a one-week adaptation period preceded Phase 2 of the feeding trial. During this adaptation, each lambs received a vitamin B complex injection (1 ml/head, Injekbit B-Plex®, PT. Medion Farma Jaya) and an anthelmintic drug orally (Kalbazen®-SG, PT. Kalbe Farma) on the first day (5 ml/head) with a repeat dose on the third day (5 ml/head). A day before the onset of Phase 2 of the feeding trial, each lambs was weighed (day 0) and their body weighing was repeated on day 42 (Phase 2, a 42-day feeding trial).

All lambs were fed with experimental diets twice daily (50% in the morning and 50% in the afternoon). Daily intake of PPS, PSS, and concentrate was calculated based on the difference between the offered and refused amounts in grams of dry matter (g DM). Body weight measurements were conducted before morning feeding using a digital weight scale (Avery weigh-Tronix).

Proximate analyses

Each ground samples of PPS, PSS, and concentrate was examined using standard protocols of the Association of Official Analytical Collaboration (AOAC, 2005) to analyze dry matter (DM), crude protein (CP, AOAC 990.03), ash (AOAC 942.05), ether extract (EE, AOAC 920.39), and crude fiber (CF, AOAC 962.09). The neutral detergent fibre (NDFom) was analysed using the procedure of Van Soest *et al.* (1991) without using amylase and decalin while acid detergent fibre (ADFom) was determined using the method of Van Soest (1973). All chemical compounds were express as percentage DM except DM was expressed as a percentage fresh sample and NDFom and ADFom were expressed as percentage OM (organic matter). Nitrogen-free extract (NFE) was calculated using the following formula: NFE = 100 – (CA + CP + CF + EE). Total digestible nutrients (TDN) for concentrate was calculated using the following formula: TDN = 70.6 + (0.259 × CP) + (1.01 × EE) – (0.76 × CF) + (0.0991 × NFE), while TDN for PPS and PSS were predicted using the following formula: TDN = (–26.685) + (1.334 × CF) + (6.598 × EE) + (1.423 × NFE) + (0.967 × CP) – (0.002 × (CF2)) – (0.67 × (EE2)) – (0.024 × (CF × NFE)) – (0.055 × (EE × NFE)) – (0.146 × (CF × CP)) + (0.039 × ((CF2) × CP)) (Hartadi *et al.*, 1980; Ramdani *et al.*, 2020).

Feces collection and fecal egg counts

Fecal samples were obtained through a grab sampling procedure from the rectum of each sheep on days 0 and 21 of Phase 1 of the experiment. The FEC *Strongylus* sp. and FOC Coccidia analyses were conducted at the Animal and Veterinary Public Health Center, operated by the Food Security and Livestock Services of the West Java government, situated in Cikole-Lembang, West Bandung. This center held accreditation from the National Accreditation Committee of Indonesia (LP-331-IDN). The McMaster egg counting method was used for the FEC analysis, following the Royal Veterinary College procedure (van Wyk and Mayhew, 2013).

Briefly, approximately 3 g of feces were dissolved in a flotation solution containing a mixture of salt (400 g NaCl) and sugar (500 g C6H12O6) in 2 L water after being stirred and dissolved. A total of 60 ml of the solution was homogenized by pouring from one glass to another three times, then placed into the Mc Master counting chamber using a Pasteur pipette. Microscopic examination was performed with a magnification of 10 x 10 to determine FEC Strongylus sp. (total number of eggs per gram of feces) and FOC Coccidia (total oocysts per gram of feces) using the following formula:

$$FEC \text{ or } FOC = (n/bf) \times (Vtot/Vhit)$$

Vtot = Volume of 3 g feces with flotation solution; Vhit = Volume of counting room (2 x 0.5); Bf = Weight of feces (3 g); n = Number of eggs or oocytes found.

Statistical analysis

Each proximate compound of the feed materials was calculated as an average from duplicate analyses (n = 2). A completely randomized design was adopted to compare three different as-fed doses of dietary PPS inclusion at 0% (PPS-0), 50% (PPS-50), and 75% (PPS-75) in a PSS-based diet. The aim was to assess lamb performances before (Phase 1, 30 days trial) and after (Phase 2, 42 days trial) an anthelmintic treatment, with six replicates. The data were analysed using one-way ANOVA in MINITAB 19 statistical software. Furthermore, Tukey's test was applied to compare the average means, and statistical significance was considered at P < 0.05. The residual data were assessed for normality through the Anderson–Darling normality test, with significance assumed at P > 0.05.

RESULTS AND DISCUSSION

Table 2 presented the mean proximate contents of PPS, PSS, and concentrate. On average, PPS was qualified as a wet feed material with lower DM content (10.1%) compared to PSS (39.5%). However, PPS had higher CP, ether extract (EE), and total digestible nutrients (TDN) but lower crude fiber (CF) compared to PSS. PPS was categorized as a protein source with a feed material content of 21.4% CP. On the other hand, concentrate was a dry feed material (80.0% DM) with high TDN (78.7%) and low CF (13.3%) while being moderate in CP (8.19%) content.

Table 3 outlined the mean of ADG, DMI, FEC, and FOC of Strongylus-infected lambs fed with varying as-fed doses of PPS during a 30-day feeding trial. It was observed that dietary PPS had no effect (P > 0.05) on ADG and FEC but significantly reduced (P < 0.001) the total DMI compared to the control group (PPS-0). Dietary PPS-50 (340 ± 129 eggs/g feces) and PPS-75 (225 ± 44.5 eggs/g feces) maintained FEC Strongylus sp. in the mild infection category (< 500 eggs/g feces) when compared to the control diet (565 ± 238 eggs/g feces). On average, FOC Coccidia was lower for PPS-50 (339 ± 96.6 oocytes/ g feces) and PPS-75 (274 ± 96.8 oocytes/g feces) compared to the control group (482 ± 212 oocytes/g feces).

Table 2: Mean proximate contents (% DM or otherwise stated, n = 2) of feed materials.

Contents	PPS	PSS	Concentrate
DM (% sample)	10.1	39.5	80.0
Ash	10.7	18.7	12.7
CP	21.4	5.81	8.19
EE	6.14	3.75	10.5
CF	17.9	28.4	13.3
NDFom	28.5	56.2	44.5
ADFom	37.9	38.2	28.0
NFE	43.9	43.3	55.3
TDN	73.5	53.7	78.7

PPS = papaya peel silage; PSS = paddy straw silage; DM = dry matter; CP = crude protein; EE = ether extract; CF = crude fiber; NDFom = neutral detergent fiber based on organic matter; ADFom = acid detergent fiber based on organic matter; NFE = nitrogen free extract; TDN = total digestible nutrients.

Table 4 detailed the mean of ADG and DMI of anthelmintic-treated lambs fed with different as-fed doses of PPS during a 42-day feeding trial (Phase 2). Dietary PPS-75 increased (P < 0.05) ADG of sheep without affecting (P > 0.05) the total DMI when compared with the control diet. The daily feed intake of livestock was known to positively correlate with daily body weight gain. Sheep weight gain was not only influenced by nutrient intake but also by several factors, including breed, age, sex, genetics, health, environment, and operational management (Janoš *et al*., 2018).

Table 3: Means (n = 6) ADG (g/head/day), DMI (g/head/day), and FEC (eggs/g feces) of Strongylus-infected lambs fed with different as fed doses of PPS at 0 (PPS-0), 50% (PPS-50), and 75% (PPS-75) in PSS based diet during a 30-days feeding trial (phase 1).

Measurements	PPS-0	PPS-50	PPS-75	SEM	P- value
Performances					
Initial body weight (kg)	24.3	23.3	23.6	1.15	0.822
Final body Weight (kg)	22.5	21.5	22.9	1.19	0.682
ADG (g/head/day)	-58.3	-59.4	-24.4	20.1	0.405
Total DMI (g/head/day)	1571^{A}	1227^{B}	1049^{B}	51.5	< 0.001
PPS (g/head/day)	0.00^{A}	168^{B}	282^{C}	12.9	< 0.001
PSS (g/head/day)	1171^{A}	659^{B}	367^{C}	40.9	< 0.001
Concentrate (g/head/day)	400	400	400	n/a	n/a
FEC and FOC					
Strongylus (eggs/g feces)	565	340	225	158	0.330
Coccidia (oocytes/g feces)	482	339	274	146	0.600

Mean values were not significantly different at P > 0.05 and were highly significant different at P < 0.001; n = number of replicates; SEM = standard error of mean; n/a = not available; ADG = average daily gain; DMI = dry matter intake; FEC = fecal egg counts; FOC = fecal oocyte counts; PPS = papaya peel silage; PSS = paddy straw silage.

Table 4: Means (n = 6) ADG (g/head/day) and DMI (g/head/day) of lambs fed with different as-fed doses of PPS at 0 (PPS-0), 50% (PPS-50), and 75% (PPS-75) in PSS based diet during a 42-days feeding trial (phase 2).

Measurement	PPS-0	PPS-50	PPS-75	SEM	P- value
Initial Body weight (kg)	24.80	22.97	23.567	1.33	0.621
Final Body Weight (kg)	26.45	25.58	27.31	1.35	0.668
ADG (g/head/day)	39.3^{B}	62.3^{AB}	89.3^{A}	11.7	0.027
Total DMI (g/head/day)	1137	1174	1115	39.3	0.572
PPS (g/head/day)	0.00^{C}	157^{B}	310^{A}	7.30	<0.001
PSS (g/head/day)	737^{A}	617^{A}	405^{B}	34.4	<0.001
Concentrate (g/head/day)	400	400	400	n/a	n/a

Mean values were not significantly different at P > 0.05 and were significantly different at P < 0.001 and P < 0.05; n = number of replicates; SEM = standard error of mean; n/a = not available; ADG = average daily gain; DMI = dry matter intake; PPS = papaya peel silage; PSS = paddy straw silage.

The heightened endoparasite infections in both Strongylus and Coccidia observed in all experimental sheep during Phase 1 might have been attributed to reduced immunity induced by physiological stress during adaptation. Throughout this phase, the lambs were concurrently experiencing endoparasite infections without any anthelmintic drug treatment. A reduction in the immune response could have elevated the vulnerability of the host to parasites and pathogens, and high levels of physiological stress might have increased parasitic infections (Romeo *et al*., 2020).

The predominant nematode worms affecting all the experimental sheep belonged to the Strongylus family. Strongylus infection led to a condition known as Strongyloidiasis, a digestive tract ailment characterized by anorexia, diarrhea, lethargy, weakness, and death (Foreyt, 2001). Endoparasite infections can manifest in various clinical signs, including anemia, inadequate food intake, reduced blood serum albumin concentration, severe small intestine lesions, and compromised immune function (Kapnisis *et al*., 2022; Diakou *et al*., 2021). The circumstances could result in significant performances and economic losses.

Papaya peel feeding did not lead to a reduction in the level of Strongylus sp. and Coccidia infections in all experimental sheep. However, it showed the capacity to hinder the increase, maintaining the level of Strongylus infection within a mild category. Treating helminthiasis required a judicious selection of drugs that effectively combat a broad spectrum of endoparasites while being devoid of harmful impacts and cost-effective (Goswami *et al*., 2013). Anthelmintics should possess the capacity to eliminate or expel parasitic worms (Laudisi *et al*., 2020; Zamanian and Chan, 2021). Concerns associated with chemical anthelmintic drugs include cost implications (Vennila *et al*., 2015), potential side effects (Gogoi *et al*., 2014; Bochala *et al*., 2016), and drug resistance (Wath *et al*., 2014). Therefore, herbal remedies served as potential alternative anthelmintics, particularly in tropical countries (Shelke *et al*., 2020; Julaeha *et al*., 2021).

Papaya was rich in carotenoids, phenolics, vitamins A, C, E, and B pantothenic acid, minerals, particularly potassium and magnesium, folate, fiber, tannins, and cysteine proteinases, which had various beneficial health effects, including an alternative anthelmintic property (Anjana *et al*., 2018; Pathak *et al*., 2017; Santos *et al*., 2014). Despite their minimal presence, tannins offer various health benefits (Chukwuka *et al*., 2013). Tannins could bind to free proteins in the host, depriving endoparasite larvae of a nutritional source, potentially leading to larvae starvation and death (Jualeha *et al*., 2021). Cysteine proteinases (CPs) had a potential anthelmintic property against intestinal nematodes *in vitro*. Oral administration of CPs has been reported to reduce nematode parasite egg outputs and worms in monogastric animals such as rodents (Mansur *et al*., 2021). The study of Njom *et al*. (2021) explained that the CP enzyme could damage the cuticle of the nematode larvae, thereby hindering their movements.

During the Phase 2 feeding trial, all lambs received oral deworming, enabling a swift and effective response to nutrients and resulting in higher body weight gain compared to the Phase 1 analysis, under endoparasite infections. After the anthelmintic treatment, the inclusion of dietary papaya peel in a paddy straw-based diet showed an enhancement in lamb performances without affecting feed intake. The improvement could be attributed to the higher protein and lower fiber contents of papaya peel in comparison with paddy straw (Sheikh *et al*., 2018), leading to increased feed digestibility. Papaya peel, being rich in protein and low in fiber (Chukwuka *et al*., 2013), were more easily digested than paddy straw. Conversely, paddy straw, due to its high lignin and silica content, was less palatable, less nutritious, and not easily digested by rumen microbes (Eun *et al*., 2005; Van Soest, 2006; Khan and Chaudhry, 2010). All experimental lambs received a similar amount of concentrate, characterized by relatively high nutritional values, particularly for the fattening phase. This concentrate feeding, specifically beneficial for lambs fed with papaya peel, helped compensate for their body weight losses during the Phase 2 feeding trial after experiencing weight reductions under endoparasite infections in the Phase 1 analysis.

CONCLUSION AND RECOMMENDATIONS

Papaya peel inclusion into a paddy straw-based diet does not significantly reduce the level of nematode worm and Coccidia infections in Priangan sheep, but being able to effectively maintain the nematode worm and Coccidia infections within the mild category. Dietary papaya peel silage up to 75% (as-fed) to replace paddy straw has the potential to serve as both a feed supplement and an anthelmintic agent.

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NOVELTY STATEMENT

This study found that papaya peel can potentially serve as not only a dietary supplement but also a natural anthelmintic in ruminant's diets. Papaya peel is a waste product and its advantageous utilization can help to reduce the environmental issues.

AUTHOR'S CONTRIBUTION

DR, conceptualization, methodology, supervision, validation, writing review and editing. DCB, SDR and NM, conceptualization. KRR and MFS, resources. RSR, formal analysis, writing original draft, writing review and editing.

Conflict of interest

The authors have declared no conflict of interest.

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