Jurnal Agripet
p-ISSN: **1411-4623** | e-ISSN: **2460-4534**
available online at http://jurnal.usk.ac.id/agripet

Vol 24 (2): 156-161, October 2024
Accredited: 152/E/KPT/2023

Performance and Physiological Responses of Pre-Weaning Peranakan Etawa Goats Fed Milk Replacer with Maggot Flour

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ABSTRACT. Pre-weaning growth is crucial for achieving high weaning weights, which are expected to positively correlate with the overall performance of does/ewes. Milk replacer, designed to meet the nutritional needs of pre-weaning kids, offers a solution to this challenge. This study aimed to analyze and evaluate the impact of incorporating maggot flour into milk replacer on the performance of pre-weaned Peranakan Etawa (PE) crossbreed goats. The parameters observed included milk replacer intake, nutrient consumption, body weight gain, weaning weight, rectal temperature, respiratory rate, and feed cost per gain. The study involved 10 two-week-old local pre-weaned PE goats, each with an average body weight of 5.33 ± 0.93 kg, divided into two treatment groups with five replicates each. The treatments included a commercial milk replacer (P0) and a milk replacer containing maggot flour (P1). Data were analyzed using an independent t-test at a 5% significance level. The results showed that daily body weight gain in pre-weaned PE goats fed milk replacer containing maggot flour did not differ significantly (P>0.05) from those fed the commercial milk replacer. The physiological responses of the pre-weaned goats, including rectal temperature and respiratory rate, were similar between treatments and did not negatively affect their physiological status. The lowest feed cost per gain was observed in the group fed the maggot flour-based milk replacer (P1), indicating its potential economic advantage.

Keywords: black soldier fly (BSF), milk replacer, Peranakan Etawa (PE) goat, performance, physiological response

INTRODUCTION

Pre-weaning mortality is a significant concern in goat production, particularly among twin births, where competition for maternal milk is intensified. Inounu (2011) highlighted that the pre-weaning period (0–3 months) is marked by a high mortality rate, especially in twin-born offspring, due to this competition. Mortality rates are notably higher in female kids (58.06%) compared to males (41.94%), possibly due to the latter's generally stronger energy levels, which enhance their ability to compete for milk during suckling.

Skim milk is commonly used as a primary component of milk replacer for goat kids, largely due to its high lactose content (50%), which is essential for pre-weaning animals. Lactose is the primary carbohydrate digestible by pre-weaned livestock, especially in the first three weeks of life, and contributes to about 40% of the caloric content of whole milk. The proportion of skim milk in the milk replacer is directly related to the growth rate of pre-weaned animals. According to Krishnamoorthy and Moran (2011), a milk replacer containing 63% skim milk leads to greater daily live weight gain in goat kids compared to a replacer with a 30% skim milk content. Beyond being a vital energy source, skim milk also provides a significant amount of protein, with a content of 45% (Astuti, 2022).

In recent years, insect-based protein sources have emerged as a promising alternative in animal nutrition, offering both economic and environmental benefits. Van Huis (2013) suggested that insect protein not only enhances the performance of weaned goat kids by 11% compared to cow's milk but also presents a sustainable option that does not compete with human food sources. Among these, the larvae of the Black Soldier Fly (BSF), *Hermetia illucens*, have gained attention due to their favorable nutrient profile and potential as a sustainable alternative to traditional animal protein sources.

Given these considerations, this study aims to investigate the effects of a milk replacer incorporating BSF maggot flour on the performance and physiological responses of pre-weaned Peranakan Etawa (PE) goat kids. By evaluating parameters such as growth performance, physiological status, and cost-effectiveness, the study seeks to determine the viability of BSF maggot flour as an alternative protein source in milk replacer formulations.

MATERIALS AND METHODS

Milk Replacer Formulation

This study involved 10 two-week-old male Peranakan Etawa (PE) goat kids, each with an average body weight of 5.33±0.93 kg. Two types of milk replacer were administered: a commercial

**Corresponding author*: maruf_tafsin@usu.ac.id
Received: 17 July 2023
Revised: 29 February 2024
Accepted: 22 August 2024
DOI: https://doi.org/10.17969/agripet.v24i2.33140

milk replacer (P0) and a milk replacer formulated with maggot flour (P1). The maggot flour was derived from Black Soldier Fly (BSF) larvae, which were reared on palm kernel meal. The larvae were processed into flour, and a proximate analysis was conducted to determine its nutrient composition.

Experimental Setup and Equipment

The study was conducted using colony cages, each equipped with feeders and drinkers. The following equipment was used: Digital Scale: A scale with a 150 kg capacity was used to measure the body weight of the goat kids. Feed Scale: A scale with a 2 kg capacity was employed to measure the ingredients for the milk replacer and to monitor feed intake. Milk Bottles: 250 ml bottles were used to administer the milk replacer. Thermohygrometer: This device was used to measure environmental temperature and humidity. Physiological Response Measurement Tools Stethoscope: Used to measure the heart rate of the goat kids. Digital Thermometer: Employed to record body temperature. Stopwatch: Used to measure time for physiological assessments. Hematology Analysis Equipment Cool Box: Used for transporting and storing blood samples. Alcohol and EDTA Tubes: Utilized for sample collection and preservation. 5 ml Syringe: Used for blood collection. Eppendorf Tubes and Centrifuge: Employed for sample processing. Micropipette and Counting Chamber: Used for precise measurement and analysis of blood samples. Microscope and Hematology Analyzer: Used for detailed hematological examination.

Statistical Analysis

The experimental design consisted of two treatments, each with five replicates. The two treatments included the commercial milk replacer (P0) and the milk replacer containing maggot flour (P1). Data collected from the study were analyzed using an independent t-test at a 5% significance level to determine the differences between the two treatments.

RESULTS AND DISCUSSION

Performances

The weaning weights of the goat kids were recorded after two months of rearing. The average weaning weights observed were 9.78±1.99 kg for the commercial milk replacer group (P0) and 6.75±1.64 kg for the group fed with maggot flour-based milk replacer (P1). Statistical analysis revealed no significant difference (P>0.05) in weaning weights between the two groups (Table 1). This is consistent with findings by Praharani *et al.* (2013), who reported that the typical weaning weight for PE goats is around 11.44 kg.

Despite the lack of significant differences, the weaning weight of goat kids in the P1 group, fed with the maggot flour-based milk replacer, was lower than that of the P0 group. This outcome could be partially attributed to the lower initial body weight in the P0 group compared to the P1 group. Furthermore, physiological data (Table 2) indicated that the goat kids in the P1 group experienced higher stress levels than those in the P0 group. This was reflected in a 1.2% increase in rectal temperature, a 7.4% increase in heart rate, and a 21.9% increase in respiratory frequency in the P1 group compared to P0. These elevated stress levels may have impacted nutrient consumption and absorption during digestion, thereby affecting overall growth performance.

Table 1. Initial Weight, Weaning Weight, and Average Daily Gain (ADG) of Goat Kids During the Study

Variables	Treatment	
	Milk Replacer Commercial (P0)	*Milk Replacer* Maggot Flour (P1)
Initial Weight (kg)	5,03 ± 1,19	5,43 ± 0,64
Weaning Weight (kg)	9,78 ± 1,64	6,75 ± 0,95
Initial month ADG (g/head/day)	68,54 ± 17,86	41,86 ± 7,78
ADG during the study (g/head/day)	63,32 ± 14,81	47,04 ± 7,53

Notes: Initial month ADG refers to the daily weight gain during the first month when the goat kids were fed 100% milk replacer without the introduction of solid feed.

The mean daily body weight gain (ADG) of the goat kids during the first month, when they consumed 100% milk replacer, and throughout the study, was not significantly different between the two treatments at the 5% significance level. However, these findings differ from those of Praharani *et al.* (2013), who reported an ADG of 100 g/head/day for PE goats. The relatively lower ADG observed in this study may be attributed to variations in feed consumption and nutrient intake.

The ADG value in the group fed with the maggot flour-based milk replacer (P1) was relatively low, which could be due to the lower crude protein content in the milk replacer compared to the commercial milk replacer (P0). As shown in Tables 1 and 2, the dry matter (BK) consumption in the P1 group was higher, but the crude protein intake was lower than in the P0 group. This suggests that while the goat kids in the P1 group consumed more dry matter, the lower protein content in the milk replacer may have limited their growth.

Another factor contributing to the lower ADG in the P1 group could be the difference in the nutrient composition of the milk replacers. Astuti (2020) noted that milk replacers with high concentrations of dry matter and crude fat can lead to quicker satiety in livestock, thereby reducing overall feed intake. This reduction in intake means that the goat kids may not have consumed sufficient nutrients to support optimal growth. Additionally, the higher feed conversion ratio observed in the P1 treatment indicates that the nutrients consumed were not efficiently converted into body mass.

This inefficiency in nutrient conversion may be explained by the possibility that a significant portion of the consumed nutrients was utilized for the production of immunoglobulins, which are crucial for maintaining immune function (Ma, 2019). The commercial milk replacer (P0), on the other hand, contained nutrients that were more easily absorbed and had higher concentrations of immunoglobulins, which are essential for supporting the growth of pre-weaned goat kids (Ramadhan, 2013). This difference in nutrient absorption and immunoglobulin support likely contributed to the superior growth performance observed in the P0 group compared to the P1 group.

These findings underscore the importance of nutrient composition in milk replacers and their impact on the growth and health of pre-weaned goat kids. Further research could explore optimizing the formulation of alternative protein sources like maggot flour to improve their efficacy in supporting growth.

Physiological Responses

Physiological responses in livestock, including body temperature, heart rate, and breathing frequency, reflect how animals react to their environment, nutrition, and management practices. These responses serve as indicators of the animals' efforts to maintain homeostasis in varying conditions. The physiological responses observed in this study for the pre-weaned goat kids are presented in Table 2.

Table 2. Physiological responses of goat kids during rearing

Variables	Treatment: *Milk Replacer* Commercial (P0)	Treatment: *Milk Replacer* Maggot flour (P1)	Normal[1]
Rectal temperature (˚C)	39,87 ± 0,2^{a}	40,14 ± 0,09^{a}	38,6 - 40,2
Heart rate (times/minute)	119,21 ± 3,29^{b}	128,03 ± 3,28^{a}	70 - 135
Breathing frequency (times/minute)	28,63 ± 1,76^{b}	39,21 ± 2,27^{a}	26 - 54

Numbers followed by different letters (a, b) indicate significant differences (P<0.05) (Frandson 1996).

The statistical analysis indicated no significant difference in rectal temperature between the two treatments (P>0.05). However, the mean rectal temperature in the maggot flour-based milk replacer group (P1) was slightly higher at 40.14±0.09°C compared to 39.87±0.21°C in the commercial milk replacer group (P0). Despite this difference, both values remained within the normal physiological range, suggesting that the internal body temperature of the goat kids was well-regulated. Differences in rectal temperature between treatments may be attributed to variations in nutrient composition between the commercial and maggot flour-based milk replacers. Rectal temperature serves as an indicator of thermal balance and can be used to assess how the thermal environment affects growth, lactation, and reproduction in animals (Novianti *et al*., 2013).

Significantly higher heart rates were observed in the P1 group compared to the P0 group (P<0.05). According to Moran and Chamberlain (2017), an increased heart rate is a physiological response that helps distribute heat to cooler parts of the body, thereby preventing overheating. Factors such as increased body temperature, body weight, and young age can contribute to a higher heart rate. The breathing frequency in the P1 group was significantly higher (P<0.05) at 39.21±2.27 breaths per minute, representing an increase of 14-31% compared to the P0 group. Although the breathing frequency in the P1 group was elevated, it remained within the normal range of 26-54 breaths per minute as stated by Astuti (2019). Breathing frequency is crucial as it reflects the animal's respiratory efficiency in exchanging oxygen and carbon dioxide, particularly under varying environmental conditions.

These findings suggest that while the maggot flour-based milk replacer (P1) did not adversely affect the physiological responses of the goat kids beyond normal limits, it did induce higher heart rates and breathing frequencies, possibly indicating a higher metabolic or stress response compared to the commercial milk replacer (P0). Further studies could explore ways to optimize the formulation of alternative milk replacers to reduce physiological stress while maintaining or improving growth performance.

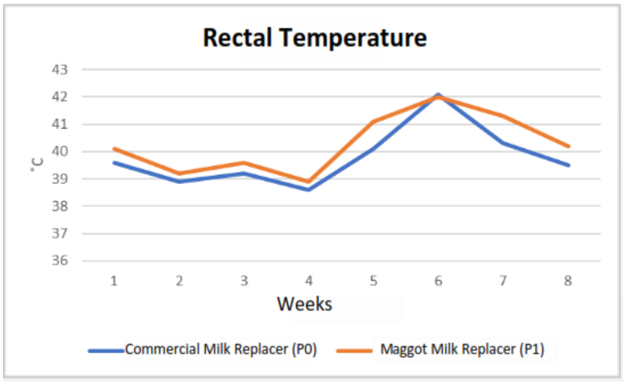

Figure 1. Rectal temperature graph of goat kids during 8 weeks of rearing

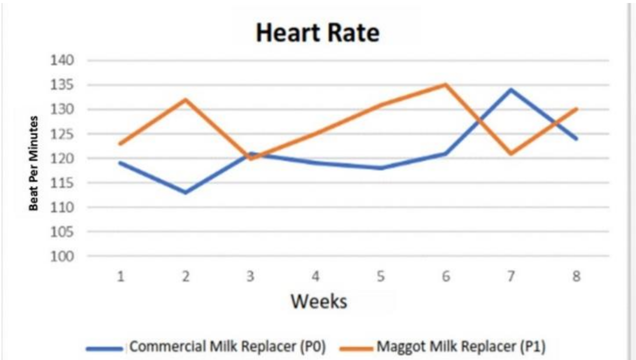

Figure 2. Heart rate graph of goat kids during 8 weeks of rearing

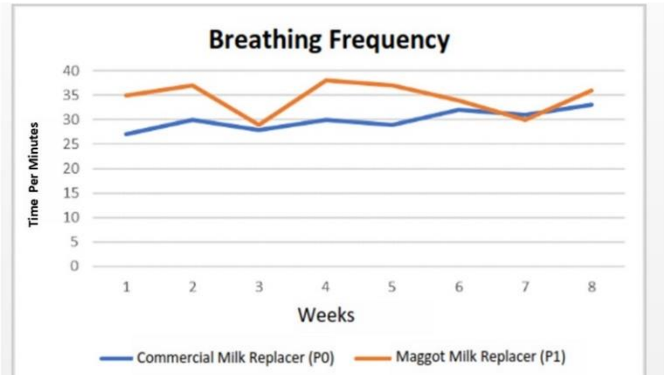

Figure 3. Graph of the breathing frequency of goat kids during 8 weeks of rearing

Figures 1, 2, and 3 illustrate that the mean physiological responses—rectal temperature, heart rate, and respiratory frequency—were higher in the P1 treatment group (maggot flour-based milk replacer) compared to the P0 treatment group (commercial milk replacer). This elevation in physiological parameters can be linked to the quality and nutrient content of the feed provided. The increased nutrient intake, as detailed in Tables 2 and 3, likely contributed to heightened body metabolism, which in turn led to an increase in pulse rate, respiratory rate, and body temperature.

The higher fat intake observed in the P1 group, as shown in Table 3, may have promoted greater fat catabolism compared to the P0 group, which consumed less crude fat. The breakdown of fat stimulates the secretion of thyroid hormones, which are known to enhance chemical reactions within body cells. When the thyroid gland releases large amounts of these hormones, the Basal Metabolic Rate (BMR) rises, leading to increased heat production. For instance, each mole of glucose generates approximately 686 kcal of energy, with any excess energy being converted into heat. Conversely, each mole of fat yields around 2340 kcal—3.5 times more than glucose—and produces up to 146 ATP molecules (Sepriadi *et al*., 2022).

Feed Cost per Gain

Feed cost per gain is an essential metric that reflects the cost of feed required to produce one kilogram of weight gain in livestock. This calculation is derived by multiplying the feed cost during the study by the feed conversion ratio for each treatment, as shown in Table 3.

Table 3. Feed cost per gain calculation (Rp/kg)

	Milk Replacer Commercial/head (P0)	*Milk Replacer* Maggot flour/head (P1)
Consumption (first month of rearing)	1307	417
Consumption with introduction feed (second month of maintenance)	3824	4096
During Research	2565	2256

Note: Feed prices according to dry matter (BK): commercial milk replacer Rp 65,000/kg; maggot flour milk replacer Rp 35,600/kg; forage Rp 800/kg; and Kanaya Farm concentrate Rp 2,800/kg.

Table 3 shows that the feed cost per gain for the P0 and P1 treatments was Rp 2565 and Rp 2256, respectively. A descriptive analysis revealed that the lowest feed cost was achieved using the maggot flour milk replacer (P1). The reduced feed cost per gain in the P1 treatment is attributed to its lower feed conversion ratio, meaning that less feed was required to achieve the same or greater weight gain. As Yoyo (2013) explained, feed cost per gain is influenced by both the price of the feed and the efficiency of its use. There are three key components in calculating feed cost per gain: the price of the feed ingredients, the quantity of feed consumed daily, and the average body weight gain achieved.

These findings suggest that while the maggot flour-based milk replacer may induce higher physiological stress, as indicated by increased body temperature, heart rate, and respiratory frequency, it remains a cost-effective alternative due to its lower feed conversion ratio and reduced overall feed costs. This makes maggot flour a viable option for reducing production costs in goat rearing, provided that its physiological impacts are carefully managed.

CONCLUSIONS

The study concluded that the daily body weight gain in pre-weaned Peranakan Etawa (PE) goats fed a milk replacer containing maggot meal was not significantly different from those fed a commercial milk replacer. Although the maggot meal-based replacer did not yield the expected increase in daily body weight gain, it did not negatively impact the physiological status of the weaned goats. Moreover, the lowest feed cost per gain was achieved by using the maggot meal milk replacer (P1), making it a cost-effective option for goat rearing.

ACKNOWLEDGMENTS

The authors express their gratitude to all individuals who contributed to the successful completion of this research. The study was funded by the Talenta USU Master Thesis Research Scheme 2021, under Agreement/Contract Letter Number: 20/UN5.2.3.1/PPM/SPP-TALENTA USU/2021, dated June 18, 2021.

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