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Exploring the Potential of Palm Oil Mill Decanter Cake in Sustainable Animal Feed Formulations

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ABSTRACT

The high cost of animal feed is a significant challenge in livestock production, particularly in developing countries, where inadequate feeding resources exacerbate the problem. This study explores the potential of palm oil mill decanter cake, an agricultural byproduct, as a cost-effective and sustainable crude protein source in ruminant feed formulations. Decanter cake was processed through drying, grinding, and mixing with other ingredients to meet the nutritional requirements for goats, followed by field testing. Nutritional analysis revealed a crude protein content of 16.05%, along with crude fiber (23%) and crude fat (14.39%). During a 23-day feeding trial, goats fed the formulated feed demonstrated a weight gain of 4.75 kg, a 14.46% increase compared to 4.15 kg in goats fed commercial feed. These findings highlight the efficacy of decanter cake as a viable alternative protein source that improves livestock performance while promoting sustainable resource utilization. Additionally, this research suggests a pathway for the commercial production of animal feed using decanter cake, with further economic feasibility studies recommended to assess its scalability.

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1.0 INTRODUCTION

The cost of animal feed is a critical factor affecting livestock farming and production, constituting a significant portion of the total production cost. Feed expenses can range from 55% to 72% of the total animal production cost, making it a substantial burden for farmers and producers [1]. In developing countries, limited feeding resources pose challenges to successful livestock production, forcing animals to rely on whatever feed is available at a minimal cost. The available feed resources in these regions, including tropical meadows, crop residues, and agro-industrial by-products, often lack sufficient digestibility and nutritional value to meet animals' requirements. Consequently, livestock in developing countries suffer from multi-nutritional deficiencies [2].

To address these issues, efficient feed management becomes crucial to ensure profitability and sustainability in livestock production. Balancing providing nutritious feed while managing costs

remains a key concern for producers. One way to optimize feed production and utilize valuable resources is through recycling domestic waste into added-value products, such as compost, biogas, and animal feed. This approach has garnered attention from various countries, as highlighted by [3]. Several studies have explored the potential of using domestic and agricultural waste as animal feed. Rezayipoor et al. study examined the impact of hatchery waste (HW) on feed intake, performance, and carcass components in fattening lambs, showing that the inclusion of HW in lamb diets improves animal performance and carcass weight, making it a suitable substitute for cotton seed meal [4].

Similarly, a study conducted by Osman et al. involved a proximate analysis of animal feed pellets containing 35% sunflower shell waste. The formulated pellet demonstrated promising nutrient composition, meeting the nutrient requirements for animals [5]. The pellets were formulated with other ingredients to increase the crude protein content required for animal feed and reduce the excessive fiber and lignin content. The results showed that the sunflower shell waste-based pellets contained approximately 16.8% crude protein, 14.5% crude fiber, and 12.25% lignin. Additional analysis revealed an ash content of 1.59%, moisture content of 9.7%, and lipid content of 5.65%. The proximate analysis indicated that the formulated pellet holds promise as animal feed as it meets their nutrient requirement.

Furthermore, Farah et al. research explored the use of Palm Oil Mill Effluent (POME) as animal feed to enhance goat growth performance and body weight gain [6]. The study involved four adults does with an average age of 6 months and a weight of 23.30 ± 2.47 kg. These goats were fed with different dietary treatments for 14 days of adaptation, continuing for 120 days throughout the study. The primary indicators analyzed in the study were the growth performance, body weight gain of goats, and the nutrient requirements for goats. The results revealed that goats on diet consist of 1 kg of Napier grass, 1 kg of coconut waste, 0.5 kg of water lettuce and 0.5 kg of PAO exhibited the highest growth performance and body weight gain.

Palm oil decanter cake presents numerous applications due to its rich nutritional content, particularly in the realms of biodiesel production, animal feed, and organic fertilizers. Palm oil decanter cake is a solid waste byproduct generated during the palm oil extraction process, characterized by its high organic content, moisture, and nutrient-rich composition, making it a valuable resource for various applications [7][8]. Research indicates that palm oil decanter cake can serve as an effective substrate for producing whole-cell lipase through solid-state fermentation, yielding over 95% biodiesel, thus promoting sustainable bioenergy practices [9]. Additionally, palm oil decanter cake enhances the nutritional quality and digestibility of ruminant feed, achieving a significant increase in protein content and digestibility rates [10]. Furthermore, palm oil decanter cake has been successfully utilized as an organic fertilizer, improving the growth and nutrient uptake of crops like edamame and oil palm, demonstrating its potential to enhance agricultural productivity [7][11]. Lastly, palm oil decanter cake can also be incorporated into aquaculture feeds, providing a cost-effective protein source for freshwater fish, with digestibility rates indicating its viability as an alternative feed ingredient [12].

Palm oil mill decanter cake has emerged as a promising feed option for ruminants due to its high protein content and cost-effectiveness [10][13]. Solid-state fermentation (SSF) has been shown to enhance its digestibility, increasing in vitro true dry matter digestibility (IVTDMD) by up to 67.26% [10]. Additionally, palm oil decanter cake supports beneficial rumen bacteria, improves fiber digestion, and reduces methanogenic archaea, contributing to lower methane emissions from ruminants [14]. Studies also indicate that goats fed palm oil decanter cake exhibit improved weight gain and carcass quality [13]. However, challenges such as high fat content, which can affect rumen metabolism, and the need for proper processing techniques remain [10]. Despite its potential, further research is necessary to optimize processing methods and evaluate its long-term impacts on animal

health and farm economics. Hence, this research aims to formulate ruminant feed from palm oil mill decanter cake and assess its effectiveness on ruminant growth performance and nutrient utilization.

By investigating the potential of utilizing palm oil mill decanter cake as animal feed, this study seeks to contribute to sustainable and efficient livestock production practices.

2.0 METHODOLOGY

2.1 Materials

Palm oil mill decanter cake and food additive were used in preparing the goat feed.

2.2 Preparation of Decanter Cake

Decanter cake was sourced from Panji Alam Palm Oil Mill Sdn Bhd and transported to the laboratory for processing. To prevent mold growth, the wet decanter cake was spread out on canvas in an open space. The drying process was conducted in batches, with 30 to 40 kg of wet decanter cake dried per day in a laboratory oven set at 120°C for overnight periods of 12 to 18 hours. Once dried, the decanter cake was finely ground using a stone grinding machine, and the resulting fine powder was stored in an airtight container for future use.

2.3 Preparation of Corn and Crushed Rice

Corn and rice were purchased from a local shop and ground into fine powder using a stone grinding machine. The powdered corn and rice were then stored in an airtight container for later use.

2.4 Nutritional Analysis

The Kjeldahl method was employed to determine the crude protein content of feed samples, a widely recognized and reliable method for quantifying nitrogen in biological materials. The analysis involved three main steps: digestion, distillation, and titration. Initially, feed samples were dried to remove moisture and finely ground for homogeneity. Approximately 0.5 g of each sample was accurately weighed and transferred into a Kjeldahl digestion flask. Concentrated sulfuric acid (H_2SO_4) and a catalyst mixture comprising potassium sulfate (K_2SO_4) and copper(II) sulfate ($CuSO_4$) were added to the flask, and the mixture was heated until a clear solution was obtained, ensuring complete digestion of organic matter and conversion of nitrogen into ammonium sulfate. The digested solution was then cooled, diluted with distilled water, and treated with sodium hydroxide (NaOH) to release ammonia gas, which was distilled into a boric acid solution containing a mixed indicator (methyl red and bromocresol green). The ammonia trapped in the boric acid solution was titrated using standardized hydrochloric acid (HCl) or sulfuric acid (H_2SO_4) until the endpoint, indicated by a color change, was reached. The crude protein content was calculated by determining the nitrogen content from the volume of acid used in titration and multiplying it by the conversion factor of 6.25, assuming protein contains approximately 16% nitrogen.

2.5 Preparation of Goat Feed

The feed formulation for the experiment was based on the Feeding Guide Series note prepared by the Department of Veterinary Services, Ministry of Agriculture and Agro-Based Industry, Malaysia [15]. According to the feeding guide, a goat weighing over 20 kg requires 0.60 kg of dry matter, 7.2 MJ of energy, 67 g of crude protein, 4 g of calcium, and 2.8 g of phosphorus per day. The feed was formulated based on these requirements and the nutrient content of each material. For example, 1 kg of feed was prepared by mixing 0.20 kg of crushed rice, 0.20 kg of corn, and 0.10 kg of dry decanter

cake. Additionally, 0.45 kg of fresh napier grass was added to ensure sufficient fiber intake for healthy digestion. This mixture was further supplemented with 0.025 kg of molasses, 0.02 kg of salt, and 0.05 kg of protein supplement to complete the formulation.

2.6 Field Testing

A healthy goat was selected for testing and housed in a standard cage measuring 8 x 4 ft. The goat was given 14 days to adapt to the new environment before being introduced to the formulated feed. Prior to using the formulated feed, the goat was initially fed commercial feed. Feeding was conducted twice daily, with a daily food allocation of 1 kg. The testing period spanned 23 days, during which the goat's weight was measured every three days. Daily records were kept of the amount of leftover feed and water, as well as the waste generated by the goat. The procedures were repeated using both formulated and commercial feeds, and the effect of the feed on the goat was evaluated based on weight gain.

3.0 RESULTS AND DISCUSSION

3.1 Nutrition Analysis of Decanter Cake

The nutrition analysis of the dry decanter cake yielded the following results as shown in Table 1. The nutritional analysis of dry decanter cake has revealed valuable insights into its potential as an essential component in animal feed formulations. Among the notable findings, the analysis highlighted a significant crude protein composition in the decanter cake, measuring at 16.05%. Crude protein plays a vital role in providing essential amino acids necessary for animal growth, development, and overall health [16]. This high crude protein content suggests that decanter cake could serve as a valuable protein source in animal feed, contributing to improved animal performance and productivity. The elevated crude protein content in decanter cake can be attributed to its composition as a byproduct of the palm oil extraction process, which retains residual protein-rich components from the palm fruit. This cake typically contains a significant amount of crude protein, ranging from 35% to 45%, alongside crude fiber and other nutrients, making it a valuable feed additive [17]. The extraction process itself, which involves cold pressing and subsequent fat extraction, helps preserve these protein components [17]. Additionally, similar extraction techniques applied to other oilseed cakes, such as rapeseed and groundnut, demonstrate that the residual cakes maintain high protein levels due to their initial raw material composition and the efficiency of extraction methods [18][19]. Furthermore, optimizing the extraction process, such as through temperature and moisture adjustments, can enhance the protein yield and quality in these byproducts [19]. Thus, the combination of raw material richness and effective processing contributes to the high protein content in decanter cake.

Table 1: Nutritional analysis of dry decanter cake

Nutrition	Composition (%)
Ash	19.74
Moisture	12.74
Crude Protein (C.P)	16.05
Crude Fiber (C. Fibre)	23.00
Crude Fat (C. Fat)	14.39

Apart from crude protein, other components in decanter cake also play crucial roles in animal feeding. Crude fiber plays a crucial role in promoting digestive health and proper bowel function in animals, as it aids in the regulation of intestinal microorganisms and enhances nutrient absorption, which is vital for overall health [20]. Additionally, dietary fiber can stimulate the production of short-chain fatty acids (SCFAs), which support gut barrier function and immune system homeostasis [20]. Crude fat, on the other hand, is essential for providing energy and essential fatty acids necessary for various metabolic processes, contributing to the overall health of animals [21]. Furthermore, the ash content in animal feed reflects the mineral composition, including vital minerals such as calcium, phosphorus, and magnesium, which are necessary for maintaining optimal mineral nutrition and supporting physiological functions [22]. Together, these components—crude fiber, crude fat, and ash—are integral to ensuring the health and well-being of animals, influencing growth performance and immune function [23].

The significant crude protein composition in decanter cake underscores its potential as a valuable ingredient in animal feed formulations. Understanding and utilizing the nutritional components of decanter cake can lead to sustainable and efficient feed production practices, benefiting both animals and producers in the agricultural sector.

3.2 Weight Gain Analysis

The Figure 1 and Table 2 present the daily weight gain of goats fed with formulated feed and commercial feed over a period of 23 days. The total weight gain and average weight gain per day for each type of feed are also calculated for comparison. From the data, it is shown that goats fed with formulated feed experienced a higher total weight gain of 4.75 kg compared to those fed with commercial feed, which resulted in a total weight gain of 4.15 kg. This indicates that the formulated feed had a more significant impact on promoting weight gain in goats. Meanwhile, when looking at the average weight gain per day, goats fed with formulated feed had an average weight gain of 0.2065 kg/day, whereas goats fed with commercial feed had an average weight gain of 0.1976 kg/day. Although the difference in average weight gain per day between the two groups is relatively small, it still demonstrates a slightly higher weight gain rate in goats fed with formulated feed.

The observed difference in weight gain between the two feeding regimes can be attributed to several factors. Formulated feeds are designed to provide a balanced and optimal combination of nutrients, including proteins, carbohydrates, fats, vitamins, and minerals, which are essential for promoting growth and development in animals. On the other hand, commercial feeds may not always offer the same level of nutritional completeness or quality, leading to potentially lower weight gain rates.

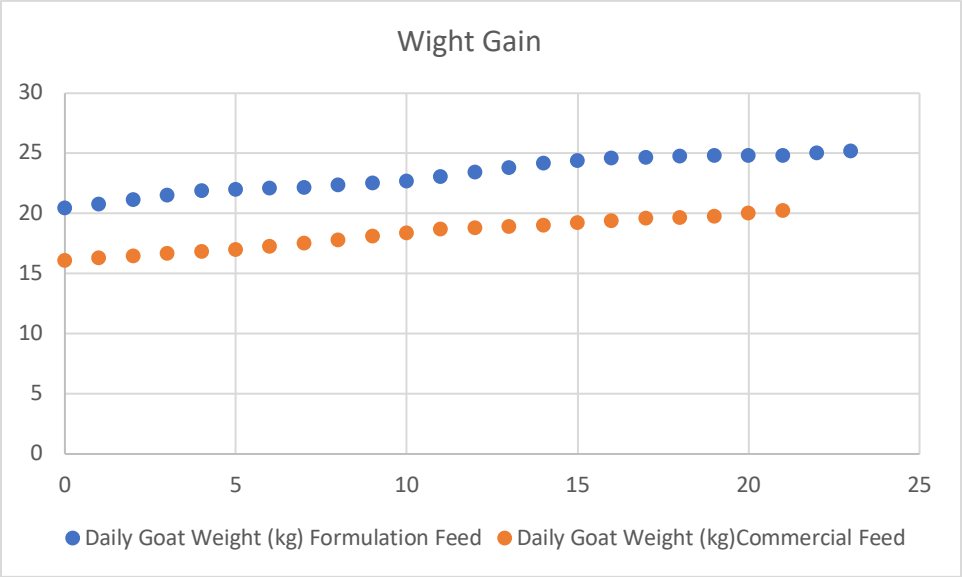

Figure 1: Weight gain of goat fed with formulated feed and commercial feed for 23 days

Table 2: Weight gain

Total weight gain with formulated feed (kg)	4.75
Total weight gain with commercial feed (kg)	4.15
Average weight gain formulated feed (kg/day)	0.207
Average weight gain commercial feed (kg/day)	0.198

Additionally, the quality of ingredients, digestibility, and palatability of the feed can also influence weight gain outcomes. Research indicates that variations in ingredient quality can lead to significant differences in nutrient composition, affecting growth performance [24]. Formulated feeds are often tailored to meet specific nutritional requirements and may use higher quality ingredients compared to some commercial feeds, which can contribute to improved weight gain in animals. Based on the data provided, it can be inferred that formulated feed had a positive effect on promoting weight gain in goats compared to commercial feed. The higher total weight gain and slightly higher average weight gain per day observed in goats fed with formulated feed highlight the importance of using quality, balanced, and tailored feeds to optimize animal growth and performance.

3.3 Suggestion for Commercial production

Based on the findings of this study, it can be concluded that decanter cake presents a viable option as a primary source of crude protein in animal feed formulations. The significant crude protein content observed in decanter cake, as demonstrated in the nutrition analysis, makes it a valuable resource for enhancing the nutritional profile of animal feed. This high protein content can contribute to improved animal growth, development, and overall health, thereby increasing the effectiveness of the feed in promoting optimal livestock performance.

To commercialize the production of animal feed from decanter cake, several key processes need to be considered and implemented. Firstly, the collection of decanter cake from palm oil mills should be carried out efficiently to ensure a consistent and reliable supply of raw material [25]. Proper drying

techniques, such as using a laboratory oven at a specific temperature, should be employed to reduce moisture content and preserve the nutritional integrity of the decanter cake [26]. Subsequently, the dried cake can be ground into a fine powder using a stone grinding machine, facilitating easier mixing and incorporation into feed formulations [27]. Mixing the powdered decanter cake with other feed ingredients in appropriate proportions is crucial to achieve a balanced and nutritionally complete feed product. Finally, pelletization of the mixed feed using a pelletizer machine can enhance feed handling, storage, and consumption by animals, promoting better feed utilization and efficiency[28].

The economic feasibility of producing animal feed from decanter cake hinges on several critical factors, including production costs, market demand, and competition. Studies indicate that alternative feed sources, such as palm oil waste and sago waste, have demonstrated profitability through various financial metrics, including net benefit-cost ratios and payback periods, suggesting that similar analyses for decanter cake could yield positive results [29](Sulistyaningsih et al., 2021)(haedar, 2017). Additionally, the incorporation of by-products like hydrolyzed poultry feathermeal into feed rations has shown enhanced profitability, indicating that innovative feed formulations can be economically viable(Drake et al., 1994). Furthermore, advancements in feed mill technology can significantly reduce production costs, enhancing the overall economic attractiveness of utilizing decanter cake[30](Priporov & Kurasov, 2024). Thus, a comprehensive economic analysis is essential to assess the potential risks and rewards, guiding stakeholders in making informed decisions for sustainable operations.

4.0 CONCLUSIONS

In conclusion, the findings from this study demonstrate the potential of decanter cake as a valuable ingredient in animal feed formulations, particularly as a significant source of crude protein. The high crude protein content observed in decanter cake highlights its suitability for enhancing the nutritional profile of animal feed, leading to improved animal growth, development, and overall health. The study also outlined key processes for commercial production of animal feed from decanter cake, including collection, drying, grinding, mixing, and pelletization, which can be implemented to optimize feed quality and efficiency.

Based on these findings, it is recommended to further explore the commercialization of animal feed production from decanter cake. This could involve conducting a detailed economic analysis to evaluate the feasibility and profitability of large-scale production. Factors such as production costs, market demand, pricing strategies, regulatory compliance, and competition should be carefully considered to develop a comprehensive business plan. Collaboration with industry stakeholders, including palm oil mills and feed manufacturers, can also facilitate the transition to commercial production and ensure the sustainability of the feed supply chain.

Furthermore, future research efforts can focus on optimizing the processing techniques for decanter cake to maximize nutrient retention and feed digestibility. Exploring innovative approaches, such as incorporating enzymes or additives to enhance nutritional value, can also contribute to developing high-quality and cost-effective animal feed formulations. Overall, the utilization of decanter cake in animal feed production presents an opportunity for sustainable agriculture practices, improved livestock performance, and economic growth in the agricultural sector.

Author Contribution

A.H Abdullah, M.H Najwa: Conceptualization, methodology, investigation, visualisation, writing and editing. Z. Najwa, A.R. Kamaruddin: Investigation and writing, and editing.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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