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SYSTEMATIC REVIEW
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Alternative Feed Ingredients for Sustainable Rabbit Production in Sub-Saharan Africa: Systematic Review

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ABSTRACT

This systematic review aims to assess the potential alternative feed ingredients promoting sustainable rabbit production by minimizing feed costs. These unconventional feedstuffs offer essential nutrients while reducing dependence on traditional feed sources, thereby enhancing cost efficiency. A structured literature search was conducted using major academic databases, including Scopus, Web of Science, ScienceDirect and Google Scholar. Studies were included based on the following criteria: focus on rabbits, evaluation of at least one alternative feed ingredient, and reporting of performance or health-related outcomes. Only articles published in English between 2010 and 2025 were considered. The final analysis comprised seven studies, all of which were conducted in sub-Saharan Africa and exclusively focused on the application of alternative feed ingredients in rabbit nutrition. This review demonstrates that ingredients such as false yam tuber, sweet potato peel meal, and rumen-filtrate fermented rice offal have shown promising results as maize substitutes, enhancing growth performance, improving nutrient digestibility, and reducing production costs. Similarly, mulberry leaf meal, maggot meal, and MOLM demonstrated potential as adequate replacements for SBM. It can be concluded through this systematic review that various alternative feed ingredients can successfully replace maize or soybean meal in rabbit diets without compromising the growth, health, or economic viability of rabbit production in sub-Saharan Africa.

Keywords: Alternative feed, Sustainable, Rabbit, Sub-Saharan Africa

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INTRODUCTION

Sub-Saharan Africa (SSA) continues to grapple with persistent challenges related to food security, poverty, and limited access to affordable animal-source protein (FAO, 2023; Assan, 2023; Ntsongota et al., 2025). The region's rapidly growing population has increased the demand for sustainable and cost-effective livestock production systems (FAO, 2021). In this context, rabbit farming has emerged as a promising solution, and this advantage is primarily due to the species' high reproductive capacity, rapid growth rate, and efficient feed conversion efficiency (Gidenne et al., 2017; Oseni and Lukefahr, 2014). These attributes make rabbits particularly well-suited for smallholder and resource-constrained farming systems that are prevalent throughout Sub-Saharan Africa (Lebas et al., 1997; Biobaku & Oguntona, 2014). Despite these advantages, the sustainability of rabbit production is constrained by an overreliance on conventional feed ingredients such as cereal grains, legumes, and protein meals (Lukefahr and Cheeke, 1990; Jones et al., 2024). These feed resources are often costly and seasonally scarce, posing significant challenges for many rabbit producers in sustaining profitability and consistent production (Gidenne, 2015). This frequently leads to compromised animal health, diminished productivity, and increased mortality rates (Maertens and Gidenne, 2016; Pinheiro and Gidenne, 2024).

To address these constraints, growing attention is being directed toward the utilization of alternative feed ingredients as a practical and sustainable strategy (Ogbuewu et al., 2017).

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These alternatives, such as agro-industrial byproducts, crop residues, tropical plant foliage, and seeds, are widely available across sub-Saharan Africa but remain largely underutilized (Ikusika et al., 2024). Incorporating non-conventional feedstuffs can substantially reduce feed costs, minimize waste, and lessen dependence on imported or commercially processed feed inputs (Jones et al., 2024). Rabbits possess a unique digestive physiology, notably their capacity for cecal fermentation of fibrous materials, which enables them to efficiently utilize many non-conventional feed sources (Carabano et al., 2020; van der Sluis et al., 2024). According to Johnson et al. (2024), promotion and adoption of alternative feed ingredients in rabbit production have the potential to contribute meaningfully to several United Nations Sustainable Development Goals (SDGs), including SDG 1 (No Poverty), SDG 2 (Zero Hunger), and SDG 12 (Responsible Consumption and Production). Therefore, by lowering feed costs, improving access to affordable animal protein, and promoting the reutilization of agricultural and household waste, this approach supports the development of more resilient and environmentally sustainable food systems within the SSA region.

This review explores the potential of alternative feed ingredients that can support sustainable rabbit production by reducing costs. These feedstuffs can provide essential nutrients while reducing reliance on conventional feed sources, thereby lowering costs. Incorporating these alternative feed ingredients into rabbit diets, farmers can not only improve the economic viability of their operations but also contribute to a more sustainable food production system.

MATERIALS & METHODS

The literature search was conducted in accordance with the systematic reviews PRISMA guidelines (Rethlefsen et al., 2021). A systematic search strategy was conducted across multiple academic databases, including Scopus, Web of Science, and Google Scholar. All retrieved articles were exported and subsequently imported into an EndNote reference management library, where duplicate records were identified and removed. The remaining unique records were consolidated into a single group within EndNote. Thereafter, the articles were imported into Covidence for title and abstract screening, as well as full-text review. Full-text articles of studies that were deemed relevant were then retrieved and assessed against the inclusion and exclusion criteria to ascertain their eligibility for final inclusion in the review.

Inclusion and Exclusion Criteria

Studies were Considered Eligible for Inclusion if they met the Following Criteria:

This review considered peer-reviewed research articles published in English between 2010 and 2025. Eligible studies exclusively involved domestic rabbits (*Oryctolagus cuniculus*) reared for meat production, encompassing various growth stages, including weaners, growers, and finishers, and representing both sexes. Studies were required to have been conducted under controlled experimental conditions or in farm-like environments, and to evaluate the use of alternative feed ingredients. These ingredients included agro-industrial by-products, insect meals, forage or leaf meals, aquatic plants, and other novel protein or carbohydrate sources aimed at improving production sustainability, reducing feed costs, or enhancing nutritional quality. Inclusion was restricted to studies incorporating either a control or standard diet for comparison, or those assessing different inclusion levels of the alternative feed ingredients. Furthermore, the production systems investigated were required to reflect agricultural or semi-intensive contexts representative of practical rabbit farming conditions.

Studies were excluded based on the Following Criteria:

Studies were excluded if they involved wild rabbits, non-domestic breeds, or rabbits kept for laboratory, pet, or if they were not conducted in Sub-Saharan Africa. Research focusing on other livestock species or studies with an unclear or mixed-species focus was also not considered. Moreover, studies using only conventional feed ingredients such as maize-soybean diets without any alternative ingredients were excluded, as were those examining pharmaceutical, genetic, or breeding interventions without dietary changes. Feed additives that did not function as ingredient replacements, such as vitamins, enzymes, or probiotics, were also outside the scope of this review. Studies lacking a comparator or control group were not included. Furthermore, non-primary sources such as review articles, conference abstracts, editorials, book chapters, and non-English publications were excluded. Finally, non-comparative case reports and purely descriptive studies without measurable outcomes were also excluded.

RESULTS

Characteristics of the Included Studies

Fig. 1 illustrates the process of literature identification across selected databases, which initially yielded 796 records. After eliminating 16 duplicate entries, 780 unique studies proceeded to title and abstract screening, during which 517 were removed. Full-text reviews were conducted on the remaining 263 articles, and 256 were excluded based on the predetermined eligibility criteria. Ultimately, inclusion criteria were met by seven studies, which were incorporated into the final review. All included studies originated from Sub-Saharan Africa, with six conducted in Nigeria (Ibrahim & Olaniyi, 2018; Olajide & Garus-Alaka, 2018; Abubakar et al., 2021; Kpehe et al., 2020; Orayaga et al., 2024; Mafimidiwo & Williams, 2024) and one from Ghana (Azupio et al., 2023). Four of these studies investigated alternatives to maize (Ibrahim & Olaniyi, 2018; Kpehe et al., 2020; Orayaga et al., 2024; Azupio et al., 2023), while the other three studies explored substitutes for SBM (Olajide & Garus-Alaka, 2018; Abubakar et al., 2021; Mafimidiwo & Williams, 2024). Table 2 provides a comprehensive overview of the studies included. All studies assessed non-conventional feed ingredients in

Table 1: Specific search terms for all databases

Databases	Search terms
Scopus Web of Science Science Direct Google scholar	("rabbit production") AND ("alternative feed" OR "non-conventional feed" OR "agro-industrial byproducts" OR "non-conventional feedstuffs")

Table 2: Summary of alternative ingredients in included studies

Study	Country	Study Design	Total number of rabbits	Feed ingredient & Dose	Comparator	Duration
Azupio et al. (2023)	Ghana	CRBD	16	Soaked false yam (Icacina oliviformis) *Inclusion levels:* 0, 10, 15, and 20 %	Maise	8 weeks
Ibrahim and Olaniyi (2018)	Nigeria	CRD	36	Sweet potato (Ipomoea batatas lam.) Peel meal *Inclusion levels:* 0, 5, 10, 15 %	Maise	8 weeks
Kpehe et al. (2020)	Nigeria	CRD	25	Fermented rice offal *Inclusion levels: 0,* 5, 10, 15 and 20%	Maise	10 weeks
Orayaga et al. (2024)	Nigeria	CRD	20	Mango Fruit Rejects *Inclusion levels*:0, 22, 28, 34 and 40%	Maise	10 weeks
Mafimidiwo and Williams (2024)	Nigeria	CRD	60	Maggot meal *Inclusion levels:* 0, 25, 50, 75 and 100%	Soybean	8 weeks
Abubakar et al. (2021)	Nigeria	CRD	60	Moringa oleifera leaf meal *Inclusion levels:* 0, 5, 10, 15 and 20%	Soybean	7 weeks
Olajide and Garus-Alaka (2018)	Nigeria	CRD	40	Mulberry leaf meal *Inclusion levels:* 0, 25, 50, 75 and 100 %	Soybean	8 weeks

CRD: Completely randomized design; CRBD Randomized Complete Block Design

Table 3: Alternative feed ingredients: Recommended inclusion levels, comparators, and reported effects

Alternative ingredients	Comparator	Recommended inclusion level	Effect	References
Soaked false yam (Icacina oliviformis)	Maise	Up to 20% replacement of maize	No detrimental effects on haematological and biochemical indices	Azupio et al. (2023)
Sweet potato (Ipomoea batatas lam.) Peel meal		15% maize replacement	Improved growth and reduced feed cost without adverse effect	Ibrahim and Olaniyi (2018)
Fermented rice offal		Up to 20% inclusion	Good performance, economic benefit	Kpehe et al. (2020)
Mango Fruit Rejects		Up to 40% inclusion	No significant adverse effect on performance	Orayaga et al. (2024)
Maggot meal	Soyabean meal	Up to 100% replacement	Improved performance, nutrient digestibility, and carcass characteristics	Mafimidiwo and Williams (2024)
Moringa oleifera leaf meal		Up to 20% inclusion	Enhanced performance; safe for weaner rabbits	Abubakar et al. (2021)
Mulberry leaf meal		25 % replacement	No adverse effects on performance, haematology, or serum biochemistry	Olajide and Garus-Alaka (2018)

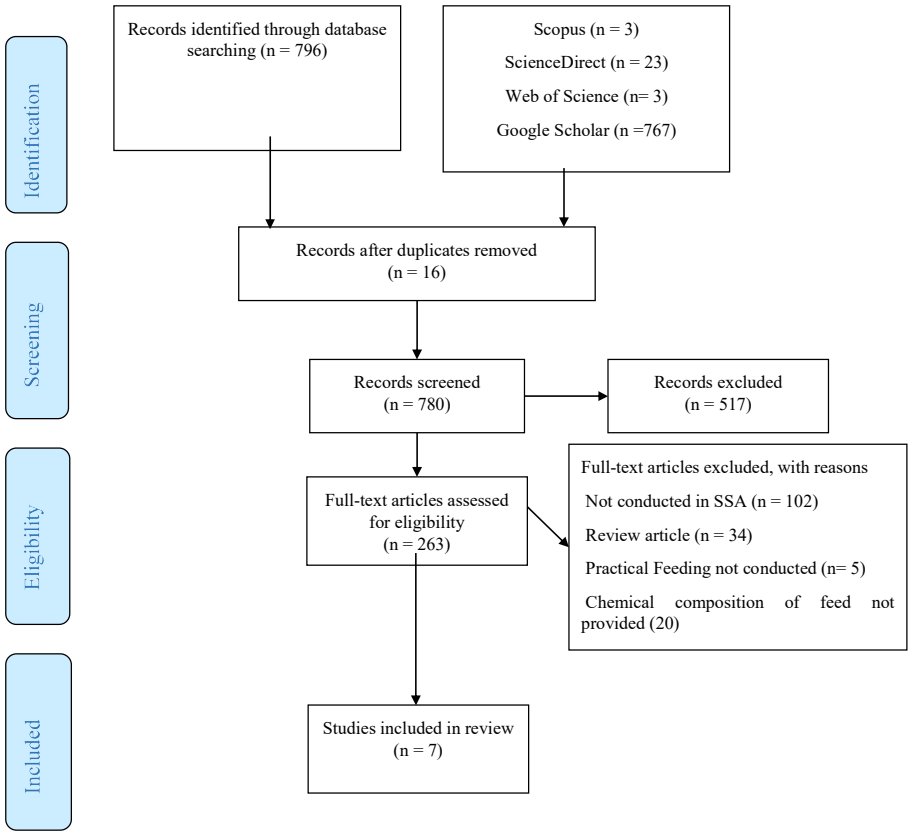

Fig. 1: PRISMA Flowchart Illustrating the Process of Study Selection and Inclusion.

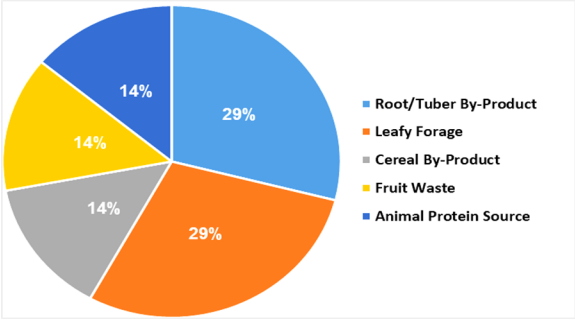

Fig. 2: Categorical distributions of alternative feed ingredients evaluated in selected rabbit nutrition studies.

rabbit diets, though they differed in design and methodology. One employed a Completely Randomized Block Design (CRBD), while the remaining six used a Completely Randomized Design (CRD). Experimental durations ranged from 8 to 10 weeks, and variations existed in group allocation methods, housing conditions, and the performance parameters evaluated.

Fig. 2 illustrates the classification of seven alternative feed ingredients into five categories based on their origin and nutritional type: leafy forage (29%), including *Moringa oleifera* and mulberry leaf meals; fruit waste (29%), represented by mango fruit rejects and sweet potato peel meal; animal protein source (14%), represented by maggot meal; root/tuber (14.%), represented by soaked false yam (*Icacina oliviformis*); and cereal byproduct (14.%), represented by fermented rice offal. The distribution reflects the emphasis on plant-derived and agro-industrial waste materials in recent efforts to develop cost-effective and sustainable rabbit feeding strategies.

DISCUSSION

Out of the seven studies reviewed on alternative feed ingredients in rabbit diets, four studies focused on the substitution of maize. These studies varied in terms of experimental duration, parameters measured, and methodological approaches, offering a diverse insight into the effects of maize replacement on rabbit performance, health, and production economics. Ibrahim and Olaniyi (2018) investigated the effect of replacing maize with sweet potato (Ipomoea batatas Lam.) on the growth performance and cost of feeding weaner rabbits (Oryctolagus cuniculus). The diets were incorporated with varying levels of sweet potato peel meal (SPPM) at 0, 5, 10, and 15% to evaluate its efficacy as a maize substitute, each containing 18% crude protein. Similarly, Kpehe et al. (2020) evaluated rice offal meal improved by rumen filtrate fermentation on the performance and economics of producing table rabbits and maize was utilized as the primary energy source and replaced it in experimental diets with rumen-fermented rice offal meal (RF-FROM) at inclusion levels of 5, 10, 15, and 20%. Orayaga et al. (2024) formulated diets with mango fruit reject meal (MFRM) replacing maize at levels of 0, 22, 28, 34, and 40%. This study aimed to assess the impacts on growth performance, carcass yield, internal organ characteristics, and the economic viability of rabbit production. Lastly, Azupio et al. (2023) substituted maize with soaked *Icacina oliviformis* (false yam) tuber meal at 5, 10, 15, and 20%, investigating its effect on haematological and serum biochemical parameters (Table 3).

Ibrahim and Olaniyi (2018) primarily examined growth performance and economic metrics, whereas Azupio et al. (2023) focused on haematological indices and serum biochemistry. Kpehe et al. (2020) assessed daily weight gain (DWG), feed intake (FI), feed conversion efficiency (FCE), and final live weight, along with feed cost and profitability. Orayaga et al. (2024) extended their assessment to include growth, carcass traits, internal organ weights, and cost-benefit analysis. The outcomes of maize substitution varied by ingredient and inclusion level. Ibrahim and Olaniyi (2018) reported no significant differences in growth performance among the groups fed with SPPM. However, economic evaluation showed that the diet with 10% SPPM (Treatment 3) had the lowest feed cost per kilogram, and 15% inclusion (Treatment 4) achieved the lowest cost per gram of weight gain. This suggests a cost advantage at moderate to high inclusion levels without compromising growth performance.

Kpehe et al. (2020) observed that RF-FROM significantly improved DWG, FI, FCE, and final live weight. Notably, as RF-FROM inclusion increased, feed costs decreased, and both revenue per rabbit and overall profit improved, indicating enhanced economic efficiency alongside improved performance. Orayaga et al. (2024) found no significant differences in growth, feed intake, or carcass traits among rabbits fed MFRM. However, a significant reduction in the weights of the large intestine and caecum was observed with increased MFRM inclusion. Economically, higher inclusion levels of MFRM led to a marked decrease in feed cost per kilogram and per gram of weight gain, with total feed cost also declining, highlighting the potential of MFRM to reduce production costs. Azupio et al. (2023) provided a more health-focused assessment. The study reported significant differences ($P < 0.05$) across treatments in red blood cell (RBC) count, total white blood cell count (TWBC), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), and monocyte levels. Conversely, no significant differences ($P>0.05$) were observed in haemoglobin (Hb), mean corpuscular volume (MCV), packed cell volume (PCV), platelet count, neutrophils, lymphocytes, eosinophils, and basophils.

Biochemical analysis showed elevated levels of alkaline phosphatase (ALP), alanine aminotransferase (ALT), aspartate aminotransferase (AST), and sodium in treatment groups compared to the control. However, all values remained within physiological norms, indicating no adverse health effects.

Soybean Meal Substitutes in Rabbit Diets: Nutritional and Economic Perspectives

Soybean meal (SBM) remains a widely used protein source in monogastric animal nutrition, including rabbit production, due to its high protein content and balanced amino acid profile. However, increasing cost, competition with human consumption, and environmental concerns have prompted researchers to explore alternative protein sources. Three recent studies, Olajide and Garus-Alaka (2018), Abubakar et al. (2021) and Mafimidiwo and Williams (2024), investigated the efficacy of different plant-based meals as substitutes for SBM in rabbit diets. These studies examined a variety of biological and economic performance indicators, including growth performance, nutrient digestibility, haematological profiles, carcass characteristics, and cost efficiency.

Olajide and Garus-Alaka (2018) evaluated the nutritional value of Mulberry leaf meal (MLM) as a replacement for SBM in rabbit diets. The experiment involved forty crossbred young rabbits over eight weeks, using diets with MLM inclusion levels of 0, 25, 50, 75, and 100%. All diets were formulated to contain metabolizable energy levels ranging from 2617 to 2661 kcal/kg and crude protein levels between 15.01 and 16.00%, ensuring relative nutritional uniformity across treatments. While detailed performance metrics, such as weight gain or feed efficiency, were not specified in the summary, the study's design indicates a comprehensive approach to understanding the viability of MLM as a sustainable alternative. The graded inclusion of MLM would provide insight into the optimal replacement level that balances performance with cost and availability, especially given *Moringa*'s known nutritional and phytochemical properties. This study likely established a foundational basis for incorporating MLM into practical feeding programs in areas where SBM is either costly or scarce. The findings from Olajide and Garus-Alaka (2018) were confirmed by Mohammed et al. (2023), who used graded levels of locally and commercially produced groundnut cake to feed weaner rabbits.

Abubakar et al. (2021) extended the investigation into *Moringa* species by evaluating the effects of *Moringa oleifera* leaf meal (MOLM) as a partial substitute for SBM in diets of weaner rabbits. Sixty New Zealand White rabbits were assigned to diets containing 0, 5, 10, 15, and 20% MOLM and fed over 8 weeks. The results demonstrated that the 20% MOLM inclusion level yielded the highest final body weight (1800g), total weight gain, and average daily weight gain, suggesting a strong positive correlation between MOLM inclusion and growth performance. Carcass and organ weights showed significant variation among the dietary treatments, indicating a potential influence of MOLM on nutrient partitioning and metabolic activity. Furthermore, nutrient digestibility was significantly affected across the treatments, emphasizing the nutritional relevance of MOLM beyond its protein contribution. Haematological indices such as packed cell volume, haemoglobin concentration, and red blood cell count varied significantly with increasing MOLM levels. These results suggest MOLM may enhance physiological and immune function in rabbits. However, the mean corpuscular haemoglobin remained statistically unaffected, indicating some haematological parameters may be less responsive to dietary changes. Overall, this study supports the strategic inclusion of MOLM in rabbit diets to enhance both performance and health parameters.

Mafimidiwo and Williams (2024) investigated the replacement of SBM with mango meal (MM) at 0, 25, 50, 75, and 100% inclusion levels over a 56-day trial in growing rabbits. This study presented one of the most comprehensive assessments, incorporating growth performance, feed conversion ratio (FCR), digestibility metrics, economic evaluation, and carcass characteristics.

The findings revealed a clear trend of performance improvement with increasing MM inclusion and corroborate the result obtained by Njidda & Isidahomen (2010). The MM100 diet resulted in the highest final body weight, most efficient FCR, and superior crude protein digestibility (74.05%). Notably, feed cost per kilogram of live weight and per unit weight gain was lowest for MM100, highlighting its strong economic advantage. Digestibility of dry matter, nitrogen-free extract, and neutral detergent fibre significantly increased in MM75 and MM100 diets, suggesting better nutrient utilization. Dressing percentage peaked in the MM100 group (71.01%), underscoring MM's potential to enhance meat yield. Organ weights also varied with treatment; notably, the gastrointestinal tract weight was highest in the control group (MM0), while liver weight was significantly increased in the MM100 group, possibly reflecting enhanced metabolic processing associated with MM inclusion.

Limitations of the Study

Although this systematic review provides valuable insights into the alternative feed ingredients for sustainable rabbit production in sub-Saharan Africa from 2010 to 2025, nevertheless it is subject to some limitations. Firstly, only four databases were used in this systematic review: Scopus, ScienceDirect, Web of Science, and Google scholar. Even though these are the largest databases, other databases that may contain relevant information for this field of study haven't been included. Secondly, only articles written in the English language were considered. Articles written in other languages, such as French and Portuguese, used in some Africa nations were not included. Lastly, studies from places other than sub-Saharan Africa and before the year 2010 were not included in this present study. However, despite these limitations, this study provides a foundational overview of alternative feed ingredients for sustainable rabbit production. Therefore, future reviews should include more regions, use a greater variety of databases, and incorporate qualitative methods for a more comprehensive understanding and global relevance of the study area.

Conclusion

In conclusion, various alternative feed ingredients have shown promise as adequate replacements for maize and SBM in rabbit feed without negatively impacting growth, health, or cost-effectiveness. False yam tuber, sweet potato peel meal, and fermented rice offal, supplemented with rumen filtrate, all proved to be viable substitutes for maize, improving growth performance, nutrient digestibility, and reducing production costs. Specifically, up to 20% bovine rumen-fermented rice offal meal can be included in rabbit diets without compromising performance. Likewise, Moringa oleifera leaf meal and maggot meal can replace up to 20 and 100% of soybean meal, respectively, enhancing growth, carcass characteristics, and nutrient utilization. Moreover, Mulberry leaf meal can substitute up to 75% of soybean meal in growing rabbit diets, with the 25% inclusion level offering optimal cost-effectiveness. These alternative feed ingredients present opportunities for more sustainable and economically viable rabbit farming, increasing profitability while improving the nutritional quality of rabbit meat.

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