



PHYTO-NUTRITIONAL EVALUATION OF *Moringa oleifera* LEAF MEAL AND FLAXSEED: IMPACT ON ENTERIC HEALTH AND FECAL CONSISTENCY IN GROWING CROSSBRED GOAT KIDS

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ABSTRACT

Scours (diarrhoea) remains a critical challenge in goat husbandry, leading to high morbidity and economic losses in growing kids. Phytogenic feed supplements offer a promising, sustainable alternative to conventional therapeutics. This study aimed to evaluate the proximate and mineral composition of *Moringa oleifera* leaf meal (MOLM) and flaxseed (FS), and investigate their safety and efficacy as dietary interventions against scours in crossbred goat kids. Proximate analysis and mineral profiling of MOLM and FS were conducted following standard analytical procedures. For the *in vivo* trial, thirty-two crossbred goat kids (aged 03 months) were randomly allocated into four dietary treatment groups. All kids received a basal diet comprising roughage (berseem and wheat straw, 50:50) and a concentrate mixture at a 60:40 ratio. The control group received the basal diet without supplementation; in the T1 and T2 groups, the concentrate mixture was replaced by 20% MOLM and 20% FS, respectively; and in the T3 group, the concentrate was replaced with 10% MOLM plus 10% FS. A weighed quantity of feed was provided daily, and the incidence, duration, and severity of scours were monitored over a 120-day period using a standardized fecal consistency scoring system. Compositional analysis revealed that MOLM is a rich source of crude protein (19.61%) and essential minerals, particularly calcium (1.47%) and iron (352.35 ppm), while FS exhibited high ether extract (39.87%) which is indicative of its energy density along with phosphorus (0.62%) and sodium (0.023%). Throughout the experimental period, all kids across the four treatment groups maintained optimal enteric health with normal fecal consistency (score = 1). No incidence of nutritional or infectious scours was recorded, indicating that the dietary inclusion of MOLM and FS, both individually and in combination up to 20%, is completely safe, highly tolerable and does not adversely alter the gastrointestinal function of growing goat kids. These findings demonstrated that *Moringa oleifera* and flaxseed possess strong phyto-nutritional profiles and their strategic supplementation may serve as a viable dietary intervention to support gut health in goat production.

Key words: *Moringa oleifera*, Flaxseed, Scours, Goat kids.

Introduction

Goat farming plays an indispensable role in the agrarian economy of developing nations, serving as a vital source of livelihood, meat and milk for marginal and landless farmers (Nedumaran and Muthuveni, 2023). However, the profitability of caprine husbandry is frequently compromised by high rates of mortality in young and growing animals. Scours (diarrhoea) is recognized as one of the most prevalent and economically

devastating health challenges in young ruminants (Yadegari *et al.*, 2019; Azmat *et al.*, 2025; Farouk *et al.*, 2021), leading to severe dehydration, electrolyte imbalance, reduced nutrient absorption and impaired growth metrics in crossbred goat kids, ultimately resulting in high morbidity and mortality if left unmanaged (Rajasekaran *et al.*, 2025).

Conventionally, the management of caprine scours has relied heavily on the administration of synthetic

antibiotics and chemotherapeutic agents. The indiscriminate use of these drugs in livestock production has raised global concerns regarding the emergence of antimicrobial resistance (AMR), the disruption of beneficial gut microflora, and the potential for drug residues in the food chain (El-Twab *et al.*, 2016). Consequently, there is an urgent need to explore sustainable, plant-based (phytogenic) alternatives that can effectively manage enteric infections and promote gut health without the adverse effects associated with synthetic antibiotics.

Moringa oleifera (family Moringaceae), often referred to as a “miracle tree,” has gained significant attention in animal nutrition due to its exceptional phyto-nutritional profile. *Moringa* leaves have been recognized as an optimal feed for ruminants (Amad and Zentek, 2023). Out of 13 species, *M. oleifera* is particularly renowned for yielding high amounts of nutrients, including proteins with a quality comparable to that of meat, milk, and eggs (Fuglie, 2005), as well as essential fats, fiber, carbohydrates, vitamins and amino acids (Islam *et al.*, 2021; Peñalver *et al.*, 2022). The leaves are highly palatable and contain numerous bioactive phytochemicals such as flavonoids, saponins and tannins which exhibit potent antioxidant, anti-inflammatory and antimicrobial properties (Abdel-Raheem and Hassan, 2021). Furthermore, Asiedu-Gyekye *et al.*, (2014) reported the presence of 35 elements (14 macroelements and 21 microelements) in the leaf aqueous extract. The leaf powder boasts exceptionally high mineral contents (mg/100 g), including Ca (2787–3307), K (2672–4892), Mg (553–1566), Cl (188–332), Na (14.78–17.76), and Fe (14.11–16.57) (Mulyaningsih & Yusuf, 2018). In comparative terms, *M. oleifera* fresh leaves contain twice the protein of milk (Thurber & Fahey, 2009) and nine times the protein of yogurt. The dry leaf powder delivers four times the calcium of milk, 25 times the iron of spinach (Rockwood *et al.*, 2013), 63 times the potassium of milk, 36 times the magnesium of eggs, four times the vitamin A of carrots, seven times the vitamin C of oranges, and exceptional concentrations of B-complex vitamins and amino acids (Ganatra *et al.*, 2012; Gopalakrishnan *et al.*, 2016). These attributes suggest that *Moringa oleifera* leaf meal (MOLM) could play a crucial role in enhancing intestinal barrier function and mitigating enteric pathogens in young livestock.

Alongside leaf meals, flaxseed (*Linum usitatissimum*) provides an exceptional dietary safeguard, particularly during forage shortages. Flaxseed is made up of 35–45% oil, 24–35% dietary fiber, 20–26% protein, 3–4% ash, and fractions of phytoestrogens (Qin *et al.*,

2022). When incorporated into rations, it delivers concentrated metabolic energy, beneficial dietary fiber, essential minerals, and high-quality protein (Duarte *et al.*, 2025). Flaxseed is recognized as a functional feed ingredient primarily due to its abundant alpha-linolenic acid (an omega-3 polyunsaturated fatty acid) and dietary mucilage (Goyal *et al.*, 2014). This omega-3 content effectively optimizes metabolic functions, stimulates tissue growth, and elevates cellular immune responses across caprine species (Kotsampasi *et al.*, 2024; Yu *et al.*, 2022). Furthermore, the mucilage in flaxseed acts as a demulcent, soothing the inflamed mucosal lining of the gastrointestinal tract during episodes of scours, while the omega-3 fatty acids modulate the inflammatory response, thereby accelerating the recovery of the enteric epithelium (Kaur *et al.*, 2024). In practice, moderate thermal pretreatment such as oven, sand or microwave roasting is commonly utilized to effectively degrade anti-nutritional cyanogenic glycosides and improve the overall oxidative stability of the flaxseed prior to feeding (Hou *et al.*, 2021).

Despite the individual therapeutic potential of *Moringa oleifera* and flaxseed, there is a paucity of literature evaluating their synergistic application in goat kid nutrition. Therefore, the present study was undertaken to evaluate the proximate and mineral composition of *Moringa oleifera* leaf meal and flaxseed, and to investigate their safety and efficacy, both individually and in combination, as dietary interventions to maintain the enteric health of growing crossbred goat kids.

Materials and Methods

Study Location and Ethical Approval

The experiment was conducted over a period of 120 days, from February 2022 to May 2022, at the Livestock Research Centre (LRC) of the ICAR-National Dairy Research Institute (NDRI), Karnal, Haryana. The experiment was duly approved and conducted in strict accordance with the established rules of the Institutional Animal Ethics Committee (IAEC), constituted as per Form No. 13 of the Committee for the Control and Supervision of Experiments on Animals (CCSEA) guidelines laid down by the Government of India.

Procurement and Preparation of Feed Supplements

Fresh *Moringa oleifera* leaves were harvested from the fields of the Integrated Farming System at LRC, NDRI. The leaves were chopped into small pieces (averaging 2 cm in diameter) and dried under shade to preserve their phyto-nutritional integrity. The dried leaves were subsequently ground into a fine powder, weighed and packed for feeding. Clean and graded flaxseed (*Linum usitatissimum*) was procured from the local market in

Karnal. To eliminate the anti-nutritional effects of cyanogenic glycosides, the flaxseed was mildly roasted over a flame at 140 to 145°C with continuous turning for 15–20 minutes on an electric heater. Following roasting, the flaxseed was cooled for approximately one hour and then fed to kids.

Experimental Animals and Housing Management

A total of 32 healthy, post-weaned female Alpine × Beetal crossbred goat kids (aged 3 months) were selected for the *in vivo* trial. Prior to the study, veterinary screening ensured all selected kids were free from anatomical, physiological, and infectious disorders. The kids had an average initial body weight of 12.14 ± 0.03 kg and were randomly allocated into four groups of eight animals each based on their body weights. The kids were housed group-wise in well-ventilated, shielded pens with concrete floors and walls, separate from the main herd. A five-day acclimatization period was provided prior to the commencement of experimental feeding. Strict hygiene was maintained throughout the trial; pens were cleaned twice daily before morning and afternoon feedings, and feeders and waterers were cleaned every morning.

Feeding and Health Management

Feeding was formulated according to ICAR (2013) feeding standards. The kids were fed with a measured quantity of the respective experimental feed every morning with *ad libitum* clean drinking water throughout the day and night. Routine health management protocols of the farm were strictly followed, including pre-trial deworming. Any animal found sick was immediately attended to at the Institute's Animal Health Complex.

Experimental Design and Dietary Treatments

The *in vivo* trial was designed as a Completely Randomized Design (CRD). The basal diet comprised a total mixed ration of roughage (berseem and wheat straw, 50:50 ratio) and a concentrate mixture at a 60:40 ratio, ensuring all diets were isonitrogenous. The four experimental treatments were as follows:

- **T1 (Control):** Basal diet (Roughage + Concentrate) without supplementation.
- **T2:** Basal diet with 20% of the concentrate mixture replaced by *Moringa oleifera* leaf meal (MOLM).
- **T3:** Basal diet with 20% of the concentrate mixture replaced by flaxseed (FS).
- **T4:** Basal diet with 20% of the concentrate mixture replaced by a combination of 10% MOLM and 10% FS.

Feed Sample Analysis

The dry matter (DM) content of the feeds was determined by drying a 100 g sample in a hot air oven at 100°C for 24 hours until a constant weight was achieved. Further feed samples were analyzed for proximate principles following the standard methods of the Association of Official Analytical Chemists (AOAC, 2005). Specifically, crude protein (CP) was estimated using the Kjeldahl method, ether extract (EE) was determined using a Soxhlet apparatus, and total ash was quantified by incinerating the samples in a muffle furnace at 550°C for 2-3 hours. Organic matter (OM) was calculated by subtracting the total ash (TA) percentage from 100. Cell wall constituents (neutral detergent fiber and acid detergent fiber) were determined according to the method described by Van Soest *et al.*, (1991).

For the mineral analysis, the concentrations of macro and micro-minerals (sodium, potassium, zinc, iron, copper, calcium, magnesium, manganese, and phosphorus) were estimated using an Atomic Absorption Spectrophotometer (AAS, Model AA-7000F). To prepare the mineral extract, approximately 1 g of feed sample was digested with 15 mL of a triacid mixture (HNO₃:HClO₄:H₂SO₄ in a 3:2:1 ratio) utilizing a Kelplus KES 12 L R digestion system (Pelican Equipments, Chennai, India). Once the digested samples became clear, they were allowed to cool, diluted with double-distilled water (DDW), and filtered through Whatman No. 42 filter paper to make a final volume of 50 mL. Mineral concentrations were determined against standard calibration curves prepared under identical analytical conditions.

All chemical and mineral analyses of the feed ingredients were performed in triplicate at the TBI Laboratory of the Livestock Production and Management department at LRC, ICAR-NDRI, and the results are reported as descriptive mean values.

Scours Incidence and Fecal Consistency

The incidence and severity of scours were monitored daily by visual observation of the hindquarters and feces of the goat kids. Fecal consistency scores were recorded every day throughout the experimental period by adopting a standard protocol. The details of the 1-4 point fecal consistency scoring system (Larson *et al.*, 1977) are outlined in Table 1.

Statistical Analysis

Data pertaining to the proximate and mineral composition of the experimental feedstuffs were analyzed in triplicate, and the results were expressed using descriptive statistics (means). For the *in vivo* dietary trial, the incidence of scours and fecal consistency scores were

Table 1: Fecal consistency scoring system (Larson *et al.*, 1977).

Score (Code)	Consistency	Visual Description
1.	Normal	Feces are firm but not hard. Original form changes slightly after dropping to the floor.
2.	Soft	Feces do not hold a firm shape; they pile but spread slightly (similar to soft-serve ice cream).
3.	Runny	Feces spread readily to about a 6 mm depth (similar to pancake batter).
4.	Watery	Liquid consistency that splatters upon impact.
The duration of scours (in days) and the number of scouring episodes per kid were recorded for each treatment group to assess overall enteric health.		

recorded daily. However, because no incidence of scours was observed and the fecal consistency score remained uniformly constant (Code 1) across all treatment groups throughout the experimental period, the clinical data lacked mathematical variance. Consequently, inferential statistical analysis was not applicable, and the *in vivo* observations were reported descriptively.

Results

Proximate and Mineral Composition of Experimental Feeds

The proximate and mineral composition of the basal diet ingredients (berseem, wheat straw, and concentrate mixture) and the experimental supplements (*Moringa oleifera* leaf meal and flaxseed) are presented in Table 2 and 3. The basal diet was formulated to provide adequate baseline nutrition for growing crossbred kids in accordance with standard requirements. Among the supplemental ingredients, *Moringa oleifera* leaf meal (MOLM) demonstrated a rich profile of crude protein and essential minerals, particularly iron. Similarly, the roasted flaxseed exhibited high concentrations of ether extract (crude fat) and organic matter, confirming its suitability as an energy-dense dietary intervention.

Fecal Consistency and Dietary Safety

Throughout the entire 120-day experimental period, zero incidences of scours were observed in any of the dietary treatment groups, including the control. Daily visual monitoring confirmed that the fecal consistency score for all 32 crossbred goat kids remained strictly at Code 1 as per the Larson *et al.* (1977) scale. There was no occurrence of soft, runny, or watery feces (Codes 2–4) at any point during the trial.

Discussion

Proximate composition of *Moringa oleifera* leaf meal (MOLM)

The proximate composition of the experimental feeds is presented in Table 1. In the present study, *Moringa oleifera* leaf meal (MOLM) demonstrated a high nutritional density, with a dry matter (DM) content of 91.80%. The composition on a DM basis specifically organic matter (OM), crude protein (CP), ether extract

(EE), total ash (TA), neutral detergent fiber (NDF), and acid detergent fiber (ADF) which fell within normal ranges and was highly consistent with values reported by Meel *et al.*, (2018), Tona *et al.*, (2014), and evaluations by Kholif *et al.*, (2022).

Notably, MOLM exhibited the highest CP and the lowest NDF when compared to the other experimental feedstuffs (flaxseed, basal concentrate, berseem, and wheat straw). While this CP level is substantial and easily supports the rapid tissue growth requirements of young ruminants, it is relatively lower than the values observed by Leitanthem *et al.*, (2022) and Damor *et al.*, (2017). As noted by Kholif *et al.*, (2015), the CP content in *Moringa* foliage can range widely from 13% to 33% depending on maturity and the proportion of leaves and stems utilized. The slightly lower CP observed in the current study is practically attributed to the inclusion of twigs (approximately 1 cm in diameter), which were ground alongside the leaves to prepare the meal. Furthermore, general variations in the nutritive value of *M. oleifera* can also be influenced by harvest age, soil fertility, seasonal changes, and the specific agro-ecological zone of cultivation (Meel *et al.*, 2018). Nevertheless, the overarching chemical composition in *M. oleifera* fundamentally varies with climate, genotype, cultivation practices, harvesting time and drying methods (Dhakad *et al.*, 2019).

Despite the inclusion of twigs, the structural carbohydrates (NDF and ADF) remained exceptionally low, indicating that MOLM is highly digestible, less bulky than conventional roughages, and optimal for the developing gastrointestinal tract of crossbred kids. This aligns with findings that low-fiber *Moringa* supplementation significantly enhances ruminal fermentation and nutrient degradability (Abdel-Raheem & Hassan, 2021). Additionally, the EE provided a valuable source of metabolic energy, while the total ash content reflected a robust inorganic matrix. Overall, these parameters confirm MOLM as a highly digestible and nutrient-dense concentrate replacer.

Proximate composition of Flaxseed

The proximate analysis of the flaxseed utilized in this

Table 2: Proximate analysis of different feeds.

Parameter %	MOLM	Flaxseed	Concentrate	Berseem	Wheat straw
Dry matter	91.80	92.37	91.38	11.24	92.32
Organic matter	91.68	95.51	90.21	89.64	92.14
Crude protein	19.61	19.38	19.26	17.12	2.91
Ether extract	4.27	39.87	3.72	1.81	1.06
Total ash	8.32	4.49	9.79	10.36	7.86
Neutral detergent fibre	24.83	44.68	29.61	44.61	79.24
Acid detergent fibre	16.58	28.94	14.36	28.43	52.41
Values are derived from mean values of multiple replications of each sample					

study demonstrated its exceptional value as an energy-dense dietary supplement. The dry matter (DM) content was recorded at 92.37%, and the overall composition on a DM basis fell within the normal range, remaining highly consistent with the values reported by Ulfina *et al.* (2020) and Ali (2017).

Furthermore, the organic matter (OM) and ether extract (EE) were found to be higher in flaxseed as compared to all other experimental feedstuffs. This high EE directly represents the substantial fatty acid content of the flaxseed. This elevated lipid profile is characteristic of high-quality oilseeds and provides a concentrated source of metabolic energy, which is highly beneficial for meeting the intensive caloric demands of growing crossbred kids.

Simultaneously, the crude protein (CP) was observed at 19.38%, establishing the flaxseed as a robust protein contributor alongside the *Moringa* leaf meal. The structural carbohydrates were While the fiber fractions are naturally higher due to the presence of the seed coat and play a critical role in the ruminant digestive tract by stimulating rumination, maintaining proper gut motility and preventing digestive disturbances. Collectively, this proximate profile highlights the roasted flaxseed as a highly nutrient-dense, fat-rich ingredient perfectly suited for incorporation into the basal concentrate mixture.

Mineral composition of *Moringa oleifera* leaf meal (MOLM)

The mineral composition of the experimental feeds is presented in Table 3. The analysis of *Moringa oleifera* leaf meal (MOLM) underscored its immense potential as a natural mineral supplement in caprine diets. The calcium (Ca) concentration in MOLM was 1.47%, which was slightly lower than observations of Zaher *et al.*, (2020), Leitanthem *et al.*, (2022) and Ajantha *et al.*, (2018), respectively. The magnesium (Mg) content was comparable to the 0.43% reported by Ajantha *et al.*, (2018), falling between the higher value of 4.81% (Leitanthem *et al.*, 2022) and the lower value of 0.22% (Zaher *et al.*, 2020). Additionally, the sodium (Na) and

potassium (K) values (0.018% and 1.31%) were lower than the respective values of 0.07% and 1.63% reported by Zaher *et al.*, (2020), and 0.12% and 1.38% reported by Ajantha *et al.*, (2018). Despite these variations which are likely driven by soil fertility and agro-ecological differences the macro-mineral profile, particularly the Ca: P ratio, remains highly favorable for supporting optimal skeletal development in growing crossbred kids.

Regarding micro-minerals, the concentrations of manganese (Mn), iron (Fe), zinc (Zn), and copper (Cu) in the current study were notably higher than the values of 30.38 ppm, 331 ppm, 26.1 ppm, and 5.7 ppm, respectively, reported by Zaher *et al.*, (2020). The exceptionally high iron concentration (352.35 ppm) is particularly significant. As noted by Kozat (2007), while iron is commonly deficient in many conventional plants, it is found in abundance in *Moringa* leaves, making MOLM a powerful natural source of Fe to prevent anemia and support rapid blood volume expansion in growing animals.

Furthermore, these trace minerals play indispensable roles in overall physiological health. Zinc possesses well-documented antiviral, antibacterial, antifungal, and anticancer properties (Brisibe *et al.*, 2009). MOLM also provides an optimal amount of Cu, which is essential for maintaining the robust immune status of the animals. Importantly, copper works synergistically with zinc to increase superoxide dismutase activity (Guo *et al.*, 2010), thereby enhancing the antioxidant defense mechanisms in the gastrointestinal tract and contributing to the excellent enteric health observed in the supplemented kids.

Mineral composition of Flaxseed

The mineral profile of the roasted flaxseed (Table 2) highlights its role as a complementary dietary component in the basal concentrate mixture. Flaxseed is recognized as a valuable source of essential minerals like Ca, Mg, and P, with even small quantities capable of fulfilling a substantial percentage of established recommended dietary allowances (Singh *et al.*, 2011). In the present study, the flaxseed exhibited a higher phosphorus content (0.62%) relative to its calcium content (0.21%). This

Table 3: Mineral analysis of different feeds.

Minerals	MOLM	Flaxseed	Concentrate	Berseem	Wheat straw
Calcium (%)	1.47	0.21	0.94	1.76	0.62
Phosphorus (%)	0.21	0.62	0.70	0.31	0.71
Magnesium (%)	0.46	0.38	0.77	0.63	0.16
Sodium (%)	0.018	0.023	0.07	0.016	0.011
Potassium (%)	1.31	0.78	0.63	3.31	1.24
Iron (ppm*)	352.35	46.2	341.82	263.31	158.21
Manganese (ppm)	58.60	23.18	54.38	31.42	27.63
Zinc (ppm)	38.61	32.28	78.50	16.22	10.21
Copper (ppm)	18.72	0.0011	28.42	3.82	2.82
*ppm: parts per million. Values are derived from mean values of multiple replications of each sample					

inverted Ca:P ratio is a standard characteristic of oilseeds and is highly advantageous in this experimental design; when flaxseed is fed in combination with the calcium-rich MOLM (as in the T4 treatment group), the ingredients naturally complement one another to help balance the overall dietary macro-mineral ratio. The flaxseed also contributed stable levels of potassium and magnesium, alongside a low sodium concentration. Any observed variability in these mineral concentrations compared to other studies can be attributed to inter-study variations in seed maturity, the impact of environmental and agronomic management practices and the inherent genetic potential of different cultivars (Shih *et al.*, 2011; Olson *et al.*, 2016).

Regarding the micro-mineral matrix, the flaxseed provided a steady supply of essential trace elements, specifically zinc and iron, which further support the immunological and hematological requirements of growing crossbred kids (Suttle, 2022). While the copper concentration in the flaxseed was trace compared to the MOLM, the synergistic inclusion of both supplements ensures a comprehensive and well-rounded mineral supply. Ultimately, the mineral analysis confirms that substituting the basal concentrate with roasted flaxseed provides a wholesome, energy-dense intervention without disrupting the essential ionic balance of the caprine diet.

Dietary Safety and Enteric Health

The absence of scours and the maintenance of a normal fecal consistency score (Code 1) across all treatment groups, including the control, indicating the excellent dietary tolerability of the tested supplements. Frequently, the introduction of novel, unconventional feed ingredients to growing ruminants can disrupt the gastrointestinal microbiome, alter gut motility and induce nutritional scours, particularly when the ingredients possess high lipid profiles or complex phytochemicals (Makkar, 2003; Hess *et al.*, 2008). However, the present study demonstrates that substituting up to 20% of the

basal concentrate mixture with *Moringa oleifera* leaf meal (MOLM) and roasted flaxseed is entirely safe for growing crossbred kids.

The gastrointestinal safety of MOLM observed in this trial can be attributed to optimal inclusion levels. While *Moringa* leaves contain phytochemicals such as tannins and saponins which at excessive concentrations can cause mucosal irritation or depress nutrient absorption (Priyashantha *et al.*, 2026) but the 20% replacement level utilized in this study did not cross the threshold of gastrointestinal toxicity. Instead, the well-documented antibacterial and antioxidant properties of these phytochemicals (Abdel-Raheem & Hassan, 2021) likely contributed to maintaining a stable and healthy enteric environment.

Furthermore, the excellent fecal consistency observed in the flaxseed-supplemented groups (T3 and T4) validates the efficacy of the thermal pretreatment method. Mild roasting (140–145°C) effectively degrades anti-nutritional cyanogenic glycosides that could otherwise compromise animal health (Hou *et al.*, 2021). Additionally, flaxseed is uniquely rich in dietary mucilage, a soluble fiber known for its high water-holding capacity. In the ruminant digestive tract, this mucilage acts as a natural demulcent, soothing the intestinal mucosa, regulating transit time, and ensuring the formation of firm, properly pelleted feces (Kaur *et al.*, 2025). Consequently, the synergistic combination of high-quality fiber from MOLM and mucilage from flaxseed ensures that gut integrity is preserved without any adverse laxative effects.

Conclusion

The phyto-nutritional evaluation of *Moringa oleifera* leaf meal (MOLM) and flaxseed (FS) confirms their substantial value as nutrient-dense feed alternatives for growing crossbred goat kids. MOLM provides a rich source of essential crude protein, calcium, and iron, whereas FS delivers concentrated metabolic energy and complementary phosphorus. Dietary interventions

replacing up to 20% of the concentrate with these supplements, either individually or in combination, maintained optimal enteric health and normal fecal consistency. The inclusion of these phyto-genic ingredients offers a safe, sustainable and highly effective dietary strategy to optimize goat kid nutrition while preserving gastrointestinal integrity.

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