Chapter 40

Innovative Invasive Cactus Management: A Sustainable Solution for Kenya's Rangelands

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Abstract

Invasive plant species are non-native species whose introduction and proliferation threaten biodiversity and ecosystem services. Invasive spiny cactus species are causing severe ecological damage in Kenya's rangelands, particularly in Laikipia North Sub-county. Their uncontrolled spread displaces native flora, disrupts ecosystems, and threatens pastoral livelihoods. The current management strategies, such as physical removal and biological control are costly, labour-intensive, and ineffective at large scales. Our innovative solution tackles this problem by converting invasive cactus into nutritious livestock feed pellets. Preliminary trials show promising results: goats fed cactus pellets gained up to 9 kg in 91 days. This approach not only controls invasive species but also provides pastoralists with a low-cost, sustainable feed alternative through the incorporation of spineless cactus and better use of the perennial grasses. The intervention has a broader potential societal impact that addresses poverty, food security, land degradation, and climate action, which are key UN Sustainable Development Goals (SDGs 1, 2, 13, 15). We aim to scale this research into a large-scale ecological and economic solution by producing cactus pellets for livestock farmers in rangelands. Promoting agro-processing technology could also create jobs and empower communities. The innovation is scalable and cost-effective in that pellet production offers a self-sustaining solution with revenue potential. Cactus pellets production can support community empowerment in agro-processing, creating green jobs (especially for women and youth) and turning an environmental threat into a valuable resource, offering a win-win for ecosystems and farmers.

Keywords: *Ecosystem Services, Sustainable Feed Alternative, Women and Youth Empowerment, Food Security, Improved Livelihoods*

Introduction

Arid and semi-arid lands (ASALs) cover over 65% of the Kenyan land mass[1]. These areas are hotspots of food and nutritional insecurity, and socio-economic marginalisation. The *Cactaceae* family includes several species adapted to ASAL areas due to their high degree of resistance to drought and high temperatures, adaptability to soils with poor fertility, and excellent productivity due to high water-use efficiency.

[1]Vision 2030, Development Strategy for Northern Kenya and other Arid Lands. Strategy of the Government of the Republic of Kenya, 2012 https://faolex.fao.org/docs/pdf/ken179242.pdf.

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Historical records indicate that the spiny *Opuntia stricta* was introduced to Kenya in the 1890s by railway construction workers as fences to shield them from wild animals[2]. Devoid of natural predators in Kenya, the non-native cactus proliferated unchecked into Kenyan rangelands. This invasion was further facilitated by a combination of factors such as prolonged droughts associated with climate change, the sedentarisation of pastoral communities, and subsequent rangeland degradation from overgrazing[3].

The invasive cactus infestation has contributed to a complex socio-ecological challenge that extends beyond rangeland degradation to encompass food security, livelihoods, and human-wildlife conflict. The plants negatively impact biodiversity by outcompeting native grasses and browse species, thereby reducing available forage for both domestic animals and wildlife. Seasons of drought compels both the domestic and wild animals in the rangelands to consume *Opuntia* cladodes and fruits due to lack of alternative forage. This has significant detrimental effects, including mechanical injuries from spines and glochids that cause oral lesions and gastrointestinal distress, a condition known as 'cactus tongue', which can result in mortality. Paradoxically, this foraging behaviour by domestic animals facilitates cactus' dispersal. Secondary dispersal is further aided by birds, elephants, and baboons[4]. Currently, the invasive species *Opuntia* is a critical threat to Kenyan rangelands, occupying 70% of local grazing lands, notably in Laikipia, Baringo, Machakos, Makueni, Narok, and Taita Taveta counties. Its dense thickets impede access to essential resources and have been shown to cause substantial economic losses (US$500–1000/household/year)[5].

Control of invasive cactus has been achieved either by chopping using machetes, manual uprooting and burying, use of herbicides, burning or biological control using the cochineal insects, but with limited success[6,7]. The continued spread of cactus despite these efforts underscores the need for innovative approaches for the management of the invasive cactus. Existing research demonstrates that dietary supplementation with cactus enhances performance in ruminants, including goats[8] and camels[9]. To

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[5]Shackleton, R. T., et al., "Distribution and socio-ecological impacts of the invasive alien cactus Opuntia stricta in eastern Africa," *Biological Invasions,* 19, no. 8 (2017): 2427–41. https://link.springer.com/article/10.1007/s10530-017-1453-x

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[7]Shackleton, R. T., et al., "Distribution and socio-ecological impacts of the invasive alien cactus Opuntia stricta in eastern Africa," 2427–41.

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[9]Ikanya, L. W., et al., "Feed intake, milk yield and milk composition of Somali camels supplemented with Opuntia stricta and urea," Acta Horticulturae, no. 1343 (2022): 207–12 https://www.pubhort.org/members/showdocument?booknrarnr=1343_28

address the dual challenges in the pastoral rangelands of invasive cactus and livestock feed scarcity, especially during drought periods, this project introduced an innovative solution. This was through transforming the invasive *O. stricta* into a valuable resource as livestock feed. The main objective was to pelletize spiny *Opuntia* cladodes, enhancing safety and palatability as a livestock feed. This approach not only helps in managing the invasive cactus in the Kenyan rangelands but also produces a storable product that can minimise livestock losses for pastoralists in the ASALs.

Experimental Design and Treatments

The study was conducted at a selected household in Laikipia County, Kenya from October 2024 to January 2025. Thirty-five weaner castrated male goats of the Galla breed with an initial body weight (BW) of 18 ± 3 kg were used. The animals were arranged in a randomised complete block design. Goats (n = 35) were individually housed in half-shaded stalls fitted with feeding, water, and mineral troughs. Animals were randomly assigned to five different treatments: (1) Hay only (control) (2) Hay + 1.5% pellets based on BW, (3) Hay + 3% pellets based on BW, (4) Hay + 4.5% pellets based on BW, and (5) Grazing (current practice). Pellets were processed from the invasive cactus available in the study area.

Production of Cactus-based Pellets

Cactus cladodes were harvested by cutting the plants at ground level to produce the pellets as indicated in the schematic protocol (Figure **1**). The pads were crushed using an MCTn® machine (Laboremus, Campina Grande, Brazil; Figure **2**). The crushed material was spread in a thin, uniform layer on black tarpaulin sheets under direct sunlight and turned to promote even drying (Figure **3**). Once dried, they are ground using a hammer mill (Figure **4**). The milled cactus was mixed with feed-grade urea and ammonium sulphate based on the cactus dry weight, homogenized and processed through a pelleting machine (Figure **5**). Fresh pellets were sun-dried until completely free of moisture, weighed, packed in airtight bags, and stored in a cool and dry place (Figure **6**).

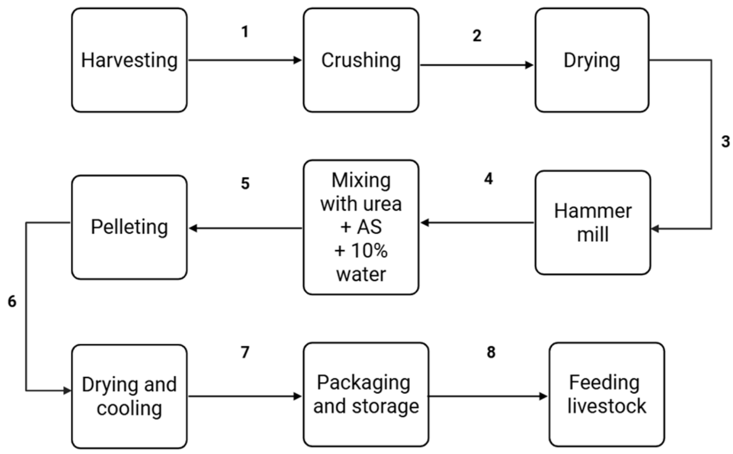

Figure 1: Schematic protocol for producing cactus-based pellets, illustrating sequential steps from harvesting to final feeding.

Machines used for Production of Cactus Pellets

Figure 2: MCTn® machine (Laboremus, Campina Grande, Brazil) used for crushing cactus.

Figure 3: Chopping of the invasive cactus and drying in open field.

Figure 4: Hammer mill used for milling the dried cactus pads.

Figure 5: Pelleting machine used for pelleting the mixture into cactus-based pellets.

Figure 6: The ready to use cactus-based pellets.

Animal Feeding Protocol

a. Goats were provided hay *ad libitum* and a predetermined supplement of cactus pellets for a period of 91 days.
b. Due to presence of urea in the pellets, a 21-day step-up adaptation protocol was used. The pellet supplement was introduced at 20% of the target dose and gradually increased until the full amount was reached.
c. The quantity of pellets offered was adjusted every 14 days based on animal weights. The daily pellet ration was split equally and offered at 8:00 am and 4:00 pm.
d. Hay and pellet orts were collected and weighed daily before the fresh feed was provided. Mineral mix and water were available *ad libitum* throughout the study.

Results and Discussion

Goat Performance

The inclusion of cactus-based pellets in the diet of male Galla goats exerted a significant, positive linear effect on growth performance and body dimensions. Although hay intake decreased, total dry matter intake as a percentage of BW more than doubled, increasing from 2.1% (control) to 5.1% (4.5% group) ($P < 0.0001$). Body condition, visually assessed and quantified through measurements, improved significantly (Figure 7). A pairwise comparison confirmed that pellet-supplemented goats outperformed those grazing on natural rangelands across all measured growth parameters. The linear increase in pellet intake with supplementation rate and concurrent decline in hay intake is a typical substitution effect, suggesting that cactus pellets were accepted and preferred. Increasing levels of supplementation, particularly concentrates, led to a reduction in basal diet intake due to substitution effects in other studies [13, 14]. The key findings demonstrated that goats supplemented with cactus-based pellets achieved nearly double the weight gain compared to goats grazing freely, showing significantly improved average daily gain and overall body condition.

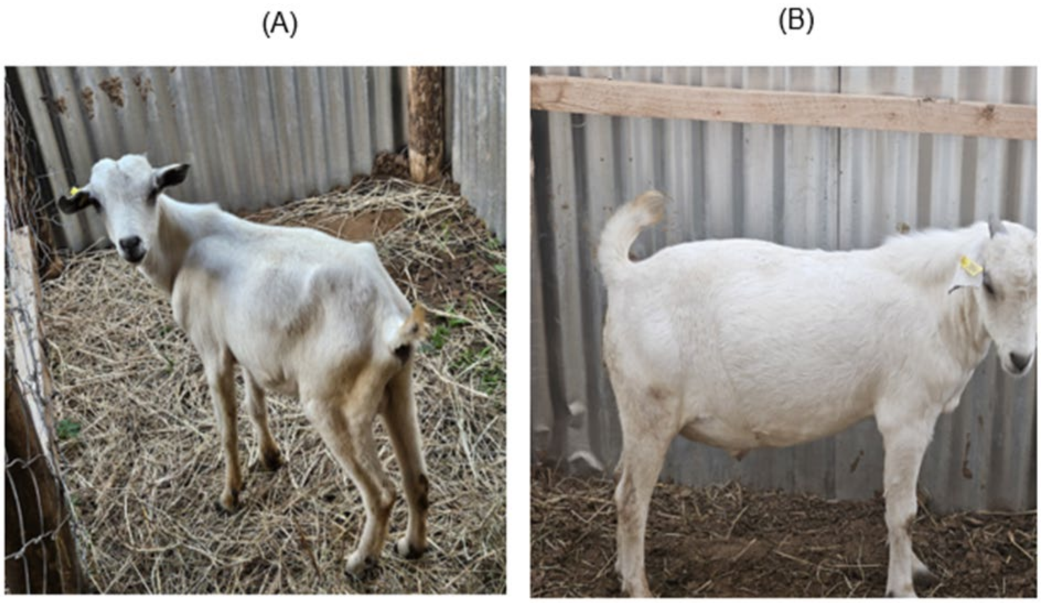

Figure 7: Visual comparison of goat performance under different feeding regimes. (A) Goat fed exclusively on Boma Rhodes hay, exhibiting poor body condition with visible skeletal features. (B) Goat fed Boma Rhodes hay supplemented with cactus-based pellets at 4.5% of body weight, showing improved body condition with fuller musculature and smoother body contours. ()Photo credit: Kenneth Oduor, Doldol, Laikipia county, Kenya.

Conclusion

Building on the established potential for addressing poverty, food security, land degradation, and climate action (SDGs 1, 2, 13, 15), future aspects of the study will focus on

a. mapping and optimizing the entire value chain from harvesting logistics to pellet production, distribution, and end-user sales.

b. Developing low-cost, modular, and off-grid compatible pelletizing machinery suitable for remote, arid regions. Solar-powered or biofuel-driven systems would enhance resilience and reduce operational costs.
c. Conducting extended, multi-species feeding trials (cattle, sheep, camels) to determine optimal inclusion rates of cactus pellets in rations, monitor long-term animal health and assess impacts on meat/milk quality and yield.
d. Long-term ecological studies to quantify the recovery of native rangeland biodiversity following sustained cactus removal and replacement with spineless cactus and native grasses/forages.
e. Translating findings into actionable policy recommendations for rangeland management, invasive species control subsidies, and support for decentralized agro-processing.

Strategy for Scaling the Innovation.

We have put in place a number of steps in upscaling our innovation. These include:

1. Intellectual property protection for the cactus pellets process and products
2. Compliance with regulations from different government agencies
3. Setting up of a pilot processing plant in Laikipia as it is in the heart of the rangelands, close to target market and invasive cactus raw material source. A pilot plant de-risks the full-scale investment.
4. Marketing of the pellets as sustainable, eco-friendly, and cost-effective.
5. Sourcing of the cactus in phases. Phase 1 (invasive cactus harvesting): Through partnerships with county governments (e.g., Laikipia and Baringo) and NGOs (e.g., Northern Rangelands Trust, Laikipia Wildlife Forum), we will engage the community in harvesting the cactus. Phase 2 (cultivation), we will partner with farmers to grow spineless cactus on their land under contract.
6. Sourcing of funding to support the establishment of the pilot plant, including Capital Expenditures (CAPEX) estimated at US$ 250,000 and Operating Expenditure (OPEX for 1st year) estimated at US$ 100,000.

Potential Limitations and Operational Risks

	Factor	Risk	Mitigation
1.	Cactus pads	Nutrient fluctuation between seasons	Storage facilities
2.	Supply chain volatility	Unpredictable harvesting	Transition to spineless cactus
3.	Shelf life	Spoilage due to inadequate drying	Quality control during drying and adequate storage
4.	Cultural resistance	Skepticism of new feed	Establish demo farms and champion farmers

	Factor	Risk	Mitigation
5.	Price sensitivity	Cautious market	Articulate that it is a drought insurance
6.	Competition	Copying of product by competitors	IP protection
7.	Ecological threat of the invasive cactus	Unintentionally incentivise people to propagate	Harvest from pre-approved, mapped areas of infestation and monitor to prevent regrowth
8.	Water use in cultivation of cactus	Competition with other needs	Adopt efficient irrigation systems

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