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CORN COBS AND RUMEN MICROBES FOR COMPLETE GOAT FEED: A ZERO-WASTE CASE STUDY FROM THE TANAH LAUT GOAT FARMERS ASSOCIATION

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ABSTRACT

This community service program addressed high feed costs and the underutilization of crop and slaughter by-products among goat-keeping households in Tanah Laut Regency, Indonesia, by introducing fermented complete feed made from corn cobs and hygienically processed bovine rumen digesta. The program aimed to strengthen farmer self-reliance while reducing open burning and the disposal of residues through a participatory action approach that iteratively combined co-design, hands-on training, on-farm application, evaluation, and refinement. Activities included orientation on feed management and waste-related issues, group mentoring on planning and record-keeping, practical production sessions using locally available inputs, and a thirty-day feeding trial on partner farms. Product quality was supported by simple process control and laboratory proximate analysis, which indicated a semi-dry fermented feed with moderate protein and high carbohydrate content, as is typical of upgraded crop residues. Goats readily consumed the feed, and farmers consistently reported improved appetite and palatability during the trial. Post-training surveys found that seventy-five percent of participants could independently reproduce the fermentation process and integrate it into routine management. Overall, the program demonstrated that converting corn cobs and rumen contents into fermented feed is feasible and acceptable at the farm level, supports skill adoption, and contributes to a zero-waste pathway. Follow-up monitoring will focus on batch consistency, spoilage prevention, feed intake, weight gain, and feed efficiency to document sustained impacts.

Keywords: Corn cobs; rumen digesta; goats; zero-waste; community empowerment

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ABSTRAK

Program pengabdian kepada masyarakat ini menanggapi tingginya biaya pakan dan belum termanfaatkannya limbah pertanian serta hasil samping rumah potong hewan di kalangan peternak kambing sekala rumah tangga di Kabupaten Tanah Laut, Indonesia, melalui penerapan pakan fermentasi berbahan tongkol jagung dan isi rumen sapi yang diproses secara higienis.

Tujuan program adalah meningkatkan kemandirian peternak dalam penyediaan pakan, sekaligus mengurangi praktik pembakaran dan pembuangan limbah dengan mengubahnya menjadi pakan bernilai guna. Metode yang digunakan adalah partisipatif berbasis pemberdayaan yang dijalankan berulang melalui perancangan bersama, pelaksanaan, evaluasi, dan perbaikan. Kegiatan meliputi sosialisasi manajemen pakan dan isu lingkungan, pendampingan perencanaan serta pencatatan, pelatihan praktik produksi pakan fermentasi menggunakan bahan lokal, analisis proksimat produk, dan uji pemberian pakan selama tiga puluh hari pada peternakan mitra. Pakan hasil pelatihan dikonsumsi dengan baik oleh kambing dan peternak melaporkan peningkatan nafsu makan serta palatabilitas selama masa uji. Survei pascapelatihan menunjukkan bahwa tujuh puluh lima persen peserta mampu memproduksi kembali pakan fermentasi secara mandiri dan menerapkannya dalam manajemen rutin. Secara keseluruhan, program menunjukkan bahwa pemanfaatan tongkol jagung dan isi rumen sebagai pakan fermentasi layak diterapkan di tingkat peternak, memperkuat adopsi keterampilan, dan mendukung pendekatan zero-waste; pendampingan lanjutan akan diarahkan pada konsistensi mutu, pencegahan kerusakan, konsumsi pakan, pertambahan bobot, dan efisiensi biaya pakan untuk memastikan keberlanjutan dampak.

Kata Kunci: *Tongkol jagung; isi rumen; kambing; zero-waste; pemberdayaan masyarakat*

INTRODUCTION

Indonesia's small ruminant sector is expanding, with goats serving as a key livelihood and protein source across rural communities improvements in feeding systems are therefore pivotal to productivity and farm income (Baharuddin et al., 2023; Sujarwanta et al., 2024). Feed commonly accounts for the largest share of production costs and constrains performance where quality forages are scarce or purchased concentrates are volatile in price. Recent updates to goat nutritional requirements and sustainable feeding strategies emphasize locally available fibrous resources upgraded through biological processing to improve intake and digestibility (Teixeira et al., 2024).

Corn cobs (maize cobs) are an abundant agricultural residue rich in structural carbohydrates that can be valorized as ruminant feed when appropriately pretreated or fermented. Fermentation or biotreatment enhances fiber degradability, elevates volatile fatty acid production, and supports microbial protein synthesis, thereby improving the nutritive value of low-quality residues. Controlled studies have shown that corn cobs fermented with rumen inoculum or formulated concentrates can improve fermentation profiles and animal performance, underscoring their potential in complete rations (Adeyemi & Familade, 2003; Lee et al., 2023).

Concurrently, slaughterhouse by-products such as rumen digesta (solid and slurry fractions) are often underutilized despite their nutrient content and availability. Within a circular bioeconomy and zero-waste paradigm, these streams can be reprocessed via ensiling, enzymatic/ fermentative treatment, or controlled composting into inputs for feed or soil, reducing pollution loads while closing nutrient loops between crop and livestock subsystems. Recent in vivo work demonstrates that biotreated rumen digesta can enhance growth and health parameters in cattle, supporting its evaluation as a functional component in small ruminant diets when processed safely. Broader reviews of circular crop–livestock integration likewise document the sustainability gains from recycling residues into feed, aligning with zero-waste goals (Sadeghi et al., 2024).

At the rumen ecosystem level, fibrolytic enzymes and fermentative microbes drive the hydrolysis of cellulose and hemicellulose into fermentable sugars, which are converted to short-chain fatty acids (SCFA) that fuel ruminant metabolism. Supplementing low-quality fiber diets with fibrinolytic activities whether via exogenous enzymes or microbially mediated fermentation can increase total tract fiber digestion and improve performance, provided acid load is controlled to avoid subacute ruminal acidosis through balanced ration design. These principles justify using rumen-derived microbial consortia to pre-condition fibrous residues such as corn cobs before inclusion in complete feeds (Ocampos et al., 2025; Swastika et al., 2024).

Optimization of the goat sector in Tanah Laut remains constrained by the paucity of farmer-needs–driven technologies and the incomplete characterization of local breeds (Monau et al., 2020). Strategic remedies include community-based breeding programs (CBBP), cross-institutional research collaborations, and farmer-oriented public policy (Monau et al., 2020; Torres-Hernández et al., 2022), coupled with empowerment through training, education, and access to appropriate technologies.

This community service program targets members of the Tanah Laut Goat Farmers Association (ASPERKAM) to enhance productivity and welfare via hands-on facilitation of complete-feed manufacture from corn cobs. Capacity building focuses on efficient, sustainable feed management and the use of locally available feed resources including agricultural residues and slaughterhouse by-products to reduce dependence on costly commercial feeds. Through a participatory approach, the program aims to strengthen farmer self-reliance, embed environmentally sound practices adapted to local contexts, and ultimately raise animal productivity, farm income, and local economic growth.

METHOD

Design & Approach

This community service program adopts a participatory action design grounded in community empowerment, following an iterative cycle of co-design → implementation → evaluation → refinement (Baum et al., 2006; Leask et al., 2019; Zimmerman, 1995). The approach prioritizes locally available resources, namely corn cobs and bovine rumen contents sourced from local abattoirs, to produce a fermented alternative complete feed that is cost-effective and environmentally sustainable. The program will be implemented in Tanah Laut Regency, South Kalimantan, through the ASPERKAM network, targeting at least 30 goat-keeping households raising Etawa crossbred and local goats.

Materials & Equipment

Materials. Dried corn cobs (≤18% moisture; 82% DM), processed rumen digesta (solid fraction), readily fermentable carbohydrate (molasses), protein source (rice bran), microbial starter (standardized rumen inoculum), and a mineral–vitamin premix.

Equipment. Digital scales, forage chopper, airtight fermentation drums, pH and temperature meters.

Methods of Program Implementation

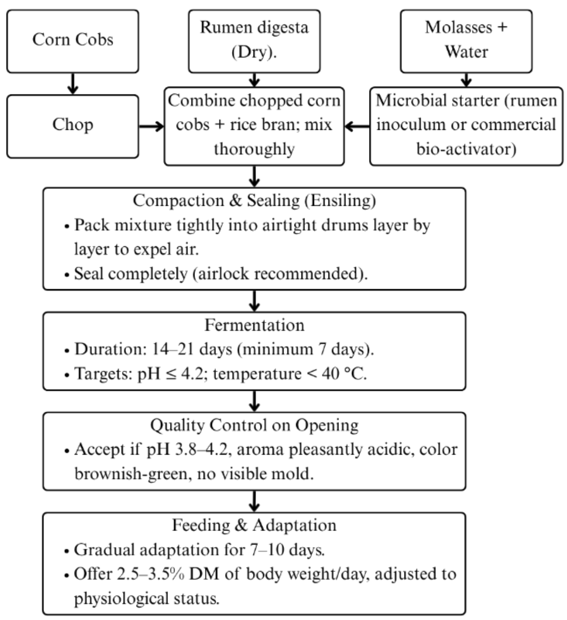

Figure 1. Corn cobs fermented feed workflow
(Source: Processed by the Authors, 2025)

The program is implemented in a participatory, sustained manner grounded in community empowerment and proceeds through five integrated stages. **First**, orientation strengthens farmers' awareness of feed management, agri-livestock waste issues, and the corn cobs fermented feed concept as an appropriate technology via group meetings, interactive discussions, and brief educational media. **Second**, governance coaching mentors producer groups on feed-requirement planning, record-keeping, cost control, and scheduling of fermented-feed delivery, facilitated by lecturers and students. **Third**, technical training delivers hands-on production of fermented feed from corn cobs and rumen digesta, covering raw-material collection and preparation, bio-activator–based fermentation, and storage and feeding techniques (**Figure 1**. Corn cobs fermented feed flow). **Fourth**, product development conducts on-farm trials in goats, documents physiological responses and performance, and standardizes the fermentation process to ensure consistent quality. **Finally**, monitoring and evaluation periodically assess technology adoption and impacts using qualitative (interviews, field observation) and quantitative metrics (productivity, production costs, and waste reduction), feeding results back into iteration and scale-up.

RESULT AND DISCUSSION

Socialization and Outreach Activities

The outreach sessions engaged ASPERKAM members and nearby residents and led to measurable gains in participants' foundational understanding of complete-feed management, the environmental risks of open disposal or burning of residues, and the step-by-step workflow. Participants were able to identify locally available inputs and outline farm-level adoption plans, consistent with evidence that group-based extension approaches, including Farmer Field Schools, improve knowledge and can drive short-term changes in farming practices in low- and middle-income countries (Berg et al., 2020; Waddington et al., 2014).

Figure 2. Implementation of Socialization
(Source: Documentation by the Authors, 2025)

Framed within diffusion of innovations (DOI) theory, the socialization phase emphasized relative advantage (lower feed costs and reduced residue disposal), compatibility with existing labor routines and tools, reduced perceived complexity through clear standard operating procedures (SOPs), and opportunities for trialability and observability; together, these features helped create favorable conditions for subsequent on-farm trials (Oturakci & Yuregir, 2018; Overbye-Thompson & Hamilton, 2025). Positioning the fermented corn-cob complete feed within a circular bioeconomy narrative further supported acceptability by linking residue valorization to environmental co-benefits (McAllister et al., 2025).

Recent reviews indicate that ensiling/fermentation can improve the fermentation quality and feeding value of fibrous or high-moisture by-products and can support animal-performance outcomes, while diverting organic residues away from linear disposal pathways (Nkosi et al., 2024). More broadly, livestock systems are increasingly framed as central to upcycling low-opportunity-cost biomass into nutrient-dense animal-source foods within circular food systems (McAllister et al., 2025; Van Hal, 2020).

Technical Training on Fermented Feed Production

Corn cobs are typically a low-protein, highly fibrous crop residue, while rumen digesta, when collected and processed hygienically, can contribute nitrogenous fractions and functional fiber as a non-conventional ingredient. Because successful ensiling depends on rapid oxygen exclusion and lactic-acid–driven acidification to reach a stable low pH and resist aerobic spoilage during storage and feed-out, the training emphasized particle-size control, tight compaction, and reliable sealing as the primary quality-control levers.

To link this technical basis to field practice, the nutrient characteristics of both inputs were first compiled to guide formulation decisions and define practical QC targets. Table 1 summarizes published nutrient ranges for corn cobs and rumen digesta used to justify ingredient roles in the mix, while Table 2 reports the proximate composition of the fermented corn-cob feed produced and analyzed during the program.

Table 1. Comparison of Nutrient Composition (%DM) between Corn Cobs and Rumen Digesta

Nutrient (%DM)	Corn Cobs (%)	Rumen Digesta (%)
Crude protein	0.5 – 3.9	19 – 22
Crude Fat	0.4 – 1.8	2.3 – 6.1
Ash	2.4 – 7.7	7.5
Crude fibre	31.7	25.4 – 30.3
Neutral Detergent Fiber (NDF)	68.7 – 93.0	42.35
Acid Detergent Fiber (ADF)	48 – 57.3	20.54
Lignin	7.1 – 16.9	

(Source: Garcia et al., 2021; Jovanović & Čuperlović, 1977; Ocampos et al., 2025; Seankamsorn & Cherdthong, 2019)

The nutrient profile of the two core inputs used in the training explains both the selected formulation and the QC targets. Corn cobs are a low-protein, highly fibrous residue (typically 4–5% CP on a DM basis; NDF 80–90%, ADF 40–55%, lignin 4–9%) and thus function primarily as a structural fiber source rather than a protein or energy-dense ingredient. In contrast, rumen digesta provides moderate protein and functional fiber, making it a plausible non-conventional nitrogen source when processed hygienically (Jovanović & Čuperlović, 1977).

During training, these complementary properties were applied as follows: (i) corn cobs supplied effective fiber to support rumen function and physically effective NDF, while (ii) processed rumen digesta contributed degradable nitrogen to support microbial growth during adaptation. The blend was then balanced with rice bran and molasses to increase fermentable carbohydrates and to achieve target DM and pH conditions for stable ensiling (pH $\leq$ 4.2). These compositional differences also guided practical decision-making. Because corn cobs have very high cell-wall fractions, technicians emphasized appropriate particle size and tight compaction to accelerate acidification. Because rumen digesta composition varies with source diet and handling, trainees were taught batch labeling and QC procedures, and to limit inclusion rates initially while monitoring intake and fecal consistency. These practices align with evidence that controlled ensiling of fibrous residues can improve utilization without compromising animal performance, and that dried rumen digesta can be incorporated as a protein-bearing ingredient when hygienic processing and ration balance are maintained (Seankamsorn & Cherdthong, 2019).

Table 2. Proximate composition (as-fed basis) of fermented corn-cob feed analyzed

Parameters	Corn cobs fermented Nutrients	Method
Moisture Content	20.05%	Gravimetry
Ash	3.13%	Gravimetry
Crude protein	10.58%	Kjeldahl
Crude Fat	1.96%	Soxhlet
Crude fibre	11.54%	Gravimetry
Carbohydrate	48.53%	Titrimetry

Note: Proximate analysis (as-fed basis) was conducted at BSPJI Banjarbaru using the methods listed (gravimetry for moisture/ash/crude fibre, Kjeldahl for crude protein, Soxhlet for crude fat, and titrimetry for carbohydrate)

As shown in Table 2, the fermented corn-cob feed contained 20.05% moisture (79.95% dry matter), with 48.53% carbohydrates, 10.58% crude protein, 11.54% crude fibre, 1.96% crude fat, and 3.13% ash. The relatively high DM suggests a semi-dry fermented product, which can reduce effluent losses and ease transport/handling; however, high-DM materials are also more sensitive to oxygen entrapment, so consistent particle sizing, tight compaction, and reliable sealing remain critical to minimize aerobic deterioration and dry-matter losses during storage and feed-out (Borreani et al., 2018). The dominance of carbohydrate indicates that the product still functions primarily as an energy-bearing ingredient and fermentation substrate, while the low crude fat is typical of crop residues and is generally favorable for storage stability and ration formulation.

Nutritionally, the crude protein level (10.58% as-fed; 13.23% on a DM basis) is consistent with the “upgrading” effect often reported when maize cob substrates undergo controlled fermentation/solid-state bioprocessing, where microbial growth and biochemical transformation can increase protein-associated fractions and improve overall feed value (Cheas et al., 2025; Egbune et al., 2024). The crude fibre (11.54% as-fed; 14.43% DM) indicates a moderate structural fraction; nevertheless, for ruminant feeding and QC, crude fibre alone is less informative than detergent fibre fractions, which better characterize cell-wall carbohydrates and predict intake/digestibility so adding NDF/ADF analysis would strengthen interpretation and ration-setting for field use (Hindrichsen et al., 2006).

Figure 3. Technical Training on Fermented Feed Production

(Source: Documentation by the Authors, 2025)

Trial Feeding in Goats

Fermented feed produced during the training was offered to partner-farm goats for 30 days and was readily consumed. Farmers also reported a clear increase in appetite and palatability. This field observation is consistent with controlled studies in goats showing that well-fermented silages, characterized by rapid acidification, low pH, and good aerobic stability, tend to maintain or increase short-term dry matter intake and preference. In contrast, aerobically deteriorated silage depresses intake (Borreani et al., 2018; Gerlach et al., 2014). The literature further indicates that lactic acid bacteria (LAB) inoculation with molasses improves fermentation quality (e.g., lower pH and higher Lactobacillus abundance) and enhances preservation, which plausibly underpins the positive on-farm response observed here. Future cycles will quantify effects on dry matter intake (DMI), average daily gain (ADG), and feed conversion ratio (FCR) to complement these qualitative outcomes (Borreani et al., 2018; Li et al., 2022).

Figure 4. Trial Feeding in Goats
(Source: Documentation by the Authors, 2025)

Knowledge & Skill Gains

Post-training surveys indicated that 75% of participants could independently reproduce the fermentation process and integrate it into routine management. This suggests a shift from "learning" to "behavior" (transfer), consistent with standard training-evaluation frameworks that distinguish learning gains from on-the-job application. To consolidate adoption, we recommend light-touch follow-ups (checklists, pH logs, intake sheets) and periodic mentoring, since follow-up evaluation is a common approach for assessing and strengthening learning transfer after trainees return to their work context. Subsequent monitoring will therefore track both practice indicators (batch quality, material-appropriate target pH such as 3.8 to 4.2 for corn silage, and aerobic stability, often operationalized as the time until silage temperature rises about 2°C above ambient after air exposure) and outcome indicators (DMI, ADG, feed cost per kg gain) at the household level (Sun et al., 2025).

Program Impact

Environmental aspect. The program replaced open disposal/burning of corn cobs and slaughter by-products with valorization through fermented feed, contributing to cleaner farm environments and aligning with circular-bioeconomy principles in livestock systems. Reviews show that crop-residue burning is a major source of particulate pollution in the region, whereas circular approaches reduce waste and environmental externalities (Ocampos et al., 2025; Talang et al., 2024).

Academic and educational aspects. Students gained authentic, technology-enabled service-learning experience in appropriate-technology outreach, documentation, and dissemination (entrepreneurial agriculture). Evidence from agricultural education indicates that service learning improves applied skills, research, and soft-skill development, supporting graduate readiness and community impact. These outcomes are consistent with our field implementation and student deliverables (training materials, basic monitoring records, and brief communications) (Dudi et al., 2022; Ismiraj et al., 2024).

Sustainability Plan

To sustain and scale the initiative, the program will: (i) establish local farmer facilitators for replication and basic QC (batch labeling, pH/odor checks); (ii) diversify substrates (e.g., rice straw, husks) using ensiling with microbial inoculants in line with best practice to stabilize high-moisture by-products; (iii) pursue applied research collaborations with partner universities for nutrient profiling and performance testing.

CONCLUSION

The program successfully converted corn cobs and rumen contents into a viable fermented complete feed that goats readily consumed; 75% of participants were able to reproduce the process, and a 30-day trial indicated improved appetite/palatability. The intervention also reduced waste and strengthened farmer capacity, with follow-up actions focusing on simple quality control, batch record-keeping, and establishing a communal feed unit to support sustainability and scale-up.

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