

# By-Product and Residues of Tropical Crops as a Feed Source for Ruminants

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## ABSTRACT

**Objective:** To analyze the available information on the use and nutritional characteristics of tropical agro-industrial by-products with potential application in ruminant feeding.

**Design/Methodology/Approach:** A literature review was conducted on agricultural by-products of tropical origin used in ruminant diets, identifying nine residues commonly produced in the tropical region of southeastern Mexico.

**Results:** The review was performed using databases such as Google Scholar and Redalyc, with the search term “tropical agricultural residues with nutritional potential for ruminants.” The results were extensive and subsequently refined to include updated publications focused on agricultural by-products.

**Limitations/Implications:** No limitations or specific implications were identified.

**Findings/Conclusions:** Incorporating agro-industrial by-products and agricultural residues available in the region into ruminant diets offers a viable alternative for enhancing livestock production. This approach reduces dependence on conventional feed resources while minimizing animal feeding costs.

**Keywords:** By-products, livestock, agricultural waste, tropical, ruminants.

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## INTRODUCTION

According to the Servicio de Información Agroalimentaria y Pesquera (SIAP), national live cattle production in 2023 reached 4,002,013.02 t, with the main producing states being Veracruz (525,610.59 t), Jalisco (472,346.45 t), Chiapas (210,282.60 t), San Luis Potosí (231,832.14 t), and Sinaloa (197,460.16 t). In sheep farming, live sheep production was 132,328.71 t, with the highest contributions from Estado de México (18,139.97 t), Hidalgo (13,484.40 t), Veracruz (11,751.08 t), Jalisco (10,186.33 t), and Zacatecas (8,660.80 t) (SIAPa, 2023). In Mexico and other Latin American countries, livestock production is of great importance both as a source of economic income and



to meet the nutritional needs of the population (Martínez González *et al.*, 2017). For fattening purposes, the use of concentrates under confinement systems is a viable option when pasture is of poor quality or during the dry season when forage production and nutritional value decline (Desdémone Martínez, 2023). However, feeding animals with concentrates is often not economically viable for producers, especially in Latin America (Ramírez de la Ribera *et al.*, 2017). Therefore, the use of agricultural residues for ruminant feeding has proven to be an excellent alternative as feed ingredients (Guerra Italo, 2020). The use of agro-industrial and agricultural by-products from local production represents a cost-effective strategy, while also providing essential nutrients to meet the nutritional requirements of animals at different productive stages (García Ceballos, 2021). In tropical regions of Mexico, several crops are particularly relevant. According to SIAP (2023), their production included: oil palm (1,392,671.63 t), banana (2,642,338.39 t), mango (2,299,983.41 t), sugarcane (55,589,515.48 t), coffee (1,058,862.35 t), cacao (29,047.40 t), maize (27,549,917.53 t), soybean (199,162.60 t), and sorghum (4,815,930.91 t), among others (SIAPb, 2023). These crops generate agro-industrial by-products and agricultural residues such as bagasse, seeds, pulp, husks, green material residues, and stubble, which, when properly managed, can be used as alternative ingredients in ruminant diets (Vargas Corredor & Pérez Pérez, 2018).

## MATERIALS AND METHODS

The initial search was conducted using the criterion “tropical agricultural residues with nutritional potential for ruminants” in the Google Scholar and Redalyc databases, which yielded a large number of scientific articles and publications from various journals. The search was then refined to focus on the most relevant by-products produced in southeastern Mexico. Each by-product was described in terms of its nutritional composition, highlighting its production significance and use in ruminant feeding.

### Agro-industrial by-products of tropical crops

#### Banana

From banana bunch harvests, only 20-30% of the biomass is used, while 70-80% remains underutilized (Table 1), consisting mainly of the plant stem with its leaves, the floral bud, the rachis, and the peel, which represents 35-40% of the fruit (Rojas *et al.*, 2019). Proximate chemical analysis of ripe, fresh banana peel reported the following composition:

**Table 1.** Chemical composition of different parts of the banana plant.

Bromatological analysis	Leaf	Stem	Spine
Crude protein (%)	7.62	4.38	4.52
Crude energy (Mcal/kg)	4.49	4.17	4.6
Ether extract (%)	5.01	3.96	3.92
Ash (%)	11.14	16.15	17.65
Neutral detergent fiber (%)	45.34	39.04	54.46
Total dry matter (%)	13.79	3.3	7.07

Source: Vera Rodríguez *et al.*, 2021.

crude protein (CP) 5.93%, ether extract (EE) 40.28%, crude fiber (CF) 6.92%, ash 11.57%, moisture 87.22%, nitrogen-free extract (NFE) 25.30%, and gross energy (GE) 14,371.74 kJ/kg (Benítez Meza *et al.*, 2020). From an energy standpoint, its nutritional value is noteworthy, given the high dry matter content, elevated concentration of non-fibrous carbohydrates, and its potential as a source of antioxidants and antimicrobial compounds, including anthocyanins and carotenoids (Cornejo-Cornejo *et al.*, 2020). Banana peel contains a high concentration of reducing sugars, making it a valuable source of soluble carbohydrates for ruminant feeding, suitable for use either fresh or ensiled (Valverde Lucio *et al.*, 2024). In another study, banana rachis was used for silage to assess its bromatological quality. The silage mixture included 95% rachis, 5% molasses, and lactic acid bacteria (commercially known as Silobacter) to enhance its nutritional profile. The results showed: CP 5%, EE 3.7%, ash 11.39%, CF 18.07%, and NFE 23.74%. The study concluded that banana rachis silage is viable for ruminant feeding, with lactic acid bacteria improving silage quality (Macay Anchundia *et al.*, 2023). The nutritional characteristics of banana by-products represent a valuable alternative for animal feeding, particularly for ruminants due to their ability to efficiently utilize fiber, while also providing protein and energy. Banana leaves, suckers, and rachis contain adequate levels of crude protein, gross energy, ether extract, ash, and dry matter, making them suitable primarily as forage in ruminant diets (Vera Rodríguez *et al.*, 2021).

### **Sugarcane**

Agricultural residues generated from sugarcane cultivations such as tops and green leaves along with by-products from processing, including bagasse, filter cake, molasses, and vinasse, represent valuable alternatives for animal feeding, particularly during drought periods when pasture availability is reduced. These residues become essential supplements in ruminant diets (Salazar Ortiz *et al.*, 2017). Sugarcane stalks, tops, green leaves, and shoots contain on average: dry matter (DM) 19.3%, crude protein (CP) 4.3%, ash 7.4%, neutral detergent fiber (NDF) 61.2%, and acid detergent fiber (ADF) 38.3%. These characteristics highlight their potential as feed resources for animal nutrition (Hurtado *et al.*, 2021). Bagasse, obtained after juice extraction, can be used as ruminant feed because it retains about 50% of the sugars and provides a significant fiber source (Lagos Burbano & Castro Rincón, 2019). Its composition includes: DM 89.90%  $\pm$  4.6; CP 3.81%  $\pm$  0.07; crude fiber (CF) 37.89%  $\pm$  3.6; NDF 75.6%  $\pm$  3.7; ADF 58.8%  $\pm$  4.9; ether extract (EE) 0.50%  $\pm$  0.1; ash 4.87%  $\pm$  0.07; cellulose 38.4%; hemicellulose 23.2%; and lignin 25%. The fiber fractions (CF, NDF, and ADF) provide a source of energy for ruminant diets, while the protein content, though modest, can contribute to improved milk and meat production when properly supplemented (Jácome-Pilco *et al.*, 2023).

### **African or oil palm**

Three commercial products are obtained from the industrial processing of the oil palm fruit: crude palm oil, which results from the extraction of the fruit's mesocarp; palm kernel oil, which results from the extraction of the fruit's kernel; and palm kernel flour, which is a residual byproduct obtained from extracting the oil from the endocarp

(Torres Mejía, 2023). Palm kernel flour contains a high fiber content, its protein content is 14-15%, and its digestibility is between 50-60%. These characteristics make it viable for use in the production of feed for broiler chickens, ruminants, and pigs, coupled with its low economic cost and abundance in the region (Da Silva Rosa & Castillo Vargas, 2022). Among the main nutritional values provided by palm kernel meal are: DM (92.23%), CP (10.55%), ME (3000 kcal), NDF (76.56%), EE (7.27%) (Escobar-España *et al.*, 2022). In a study on lambs, the inclusion of palm kernel meal at 0, 15, 30, and 45% in the diet was evaluated. According to the results, using 20% inclusion levels in the diet did not affect production yields or meat quality (Escobar España *et al.*, 2023). Nutritional blocks were evaluated as feeding alternatives. The treatments were: T0 or control (Grazing with *Brachiaria* grass and mineral salts), T1, T2 and T3, supplemented with multinutritional blocks, which included ingredients such as molasses, urea, mineral salts, common salt, lime, cement and palm oil, varying in their content in coconut flour at 30% and palm kernel flour at 30% in treatments 2 and 3 respectively, based on the results it was concluded that the use of multinutritional blocks improves milk production, attributable to the higher consumption of energy and nitrogen, highlighting treatment 3 with 30% palm kernel flour and showing significant differences compared to treatment 1 and 2 which were similar (Villanueva Pedraza *et al.*, 2023).

### **Mango**

During mango fruit processing, waste generation ranges from approximately 32% to 50%. Additionally, the loss of fresh fruit due to postharvest handling and marketing issues constitutes a significant source of environmental contamination, particularly from the peel, seed, and pulp residues (Pacheco Jiménez *et al.*, 2022). In one study, mango waste samples (peel, pulp, and seed) were collected to perform a proximate chemical analysis. Five parameters were evaluated: Dry Matter (DM) (27.33%), Crude Protein (CP) (7.19%), Crude Fiber (CF) (12.70%), Ether Extract (EE) (3.11%), and Ash (1.99%). The study concluded that mango waste can be used as an alternative feed source for animals, provided either in the form of silage or combined with other ingredients such as vegetable or fruit residues, with additions of molasses and urea in proportions of 2% to 2.5% to enhance protein content and accelerate fermentation (Gómez Peña, 2019). In another experiment, mature discarded mangoes were used to produce silage combined with pangola grass hay in a ratio of 86% mango and 14% grass. Bromatological analysis of the silage revealed the following composition: CP (4.29%), Organic Matter (OM) (94.4%), Neutral Detergent Fiber (NDF) (64.74%), Acid Detergent Fiber (ADF) (36.14%), Hemicellulose (28.6%), and Ash (5.6%). The Metabolizable Energy (ME) was obtained through an *in vitro* fermentation process and yielded 1.86 Mcal kg<sup>-1</sup> DM. The study concluded that producing silage with 86% mature mango and 14% pangola hay could be considered a non-conventional feeding alternative for ruminants in tropical regions (Cañaveral Martínez *et al.*, 2020). Nutritional Blocks (NBs) represent an alternative feeding strategy in goat production and can incorporate regional ingredients such as mango. In one study, NBs were formulated using mango pulp (MP) and sugarcane molasses at 0%, 10%, 20%, and 30%. The NB ingredients included urea, salt, mineral mix, cement, pangola hay, coconut meal, ground corn cob, sugarcane

molasses, and MP. Bromatological analysis of the NB with 30% mango pulp showed the following composition: DM (91.89%), CP (36.16%), NDF (16.58%), ADF (13.32%), and Ash (28.79%). Additionally, animals were provided with 1 kg of pangola hay. The experiment concluded that supplementation with nutritional blocks containing varying levels of mango pulp did not affect productive performance, and thus, their use is recommended for animal supplementation (Manuel Luviano *et al.*, 2017).

### Coffee

During the processing of coffee beans and consumption of the beverage, a substantial number of by-products is generated (peel, pulp, husk, and coffee pulp residue). The coffee fruit contains two beans covered by a thin husk and surrounded by pulp. During the roasting process, a silver-colored husk (the bean's tegument) is produced. Once roasted and ground, the beans undergo heat or steam treatment to extract coffee essence, leaving behind a residue known as coffee pulp (Terán Rivera *et al.*, 2023).

Coffee pulp represents a viable alternative feed for animals, enabling producers to reduce feeding costs (Fernández Navarro *et al.*, 2024). Its nutritional value is comparable to high-quality tropical forages and can be provided to animals either dehydrated or ensiled, with ensiling being the most suitable preservation method (Table 2). In dairy-producing animals, coffee pulp can be included at levels of 20% to 40% in balanced diets or 10% to 20% of the dry base ration without affecting productive performance (Flórez Delgado & Rosales Asensio, 2017). In dairy cattle, it can replace up to 20% of commercial concentrates without compromising yields (Encalada *et al.*, 2018). In intensive beef cattle fattening systems, inclusion levels can reach 20% to 30% of the diet (Cárdenas Solano *et al.*, 2024). It has been demonstrated that dietary antioxidants benefit semen quality. Coffee pulp contains antioxidants that may reduce oxidative damage during semen cryopreservation. Therefore, a study evaluated the antioxidant properties of coffee pulp in a diet for rams, with a 5% inclusion rate. Semen was collected regularly during the experiment for analysis. The study concluded that the inclusion of coffee pulp did not significantly affect the evaluated variables; however, further research with inclusion rates above 5% is recommended (Nieto Aquino *et al.*, 2021).

**Table 2.** Nutrient results of ensiled coffee pulp at different fermentation times.

Nutrients (%)	0 (days)	90 (days)	120 (days)	240 (days)	Means
DM	87.30	95.53	86.16	88.10	89.27
Ash	9.12	12.46	22.12	23.80	16.87
OM	90.88	87.53	77.91	76.93	83.31
EE	3.86	3.27	3.24	3.02	3.34
CP	3.87	25.18	30.52	25.82	21.35
CF	22.86	22.53	35.88	36.42	29.42
NFE	60.29	26.55	8.21	10.93	26.50
Tan	0.06	0.23	0.30	0.34	0.23

0, 90, 120, 240 d, days; DM, Dry Matter; MO, Organic Matter; EE, Ether Extract; CP, Crude Protein; CF, Crude Fiber; NFE, Nitrogen-Free Extract and Tan, Tanin. Fuente: Flórez Delgado & Rosales Asensio, 2017.

In another study, the nutritional composition of coffee pulp silage was evaluated at different fermentation durations (30, 45, and 90 days), concluding that fermentation time does not significantly affect the nutritional parameters of the silage (Flórez Delgado, 2020).

### **Cocoa**

In cocoa production, only the sedes which account for approximately 20-23% of the pod are utilized, primarily for chocolate manufacturing. The remaining biomass, including the pod husk composed of endocarp, mesocarp, and exocarp (67-76% of the fruit), along with mucilage, leachate, and hull, is discarded as waste (Vega González *et al.*, 2024). A proximate chemical analysis and *in vitro* digestibility (based on dry matter) of various cocoa residues revealed the following composition for cocoa hulls: Dry Matter (DM) (91.1%), Crude Protein (CP) (23.6%), Total Digestible Nutrients (TDN) (66.35%), Net Energy (NE) (1.51 Mcal/kg), Neutral Detergent Fiber (NDF) (28.7%), Crude Fiber (CF) (32.3%), Ether Extract (EE) (10.6%), and Ash (8.9%). The study concluded that cocoa hulls exhibit considerable protein potential and represent a viable alternative for cattle feeding in tropical regions (Godoy Padilla *et al.*, 2020). The nutritional value of the “Arriba” variety cocoa husk, according to a proximate analysis on a dry matter basis, was as follows: DM (48.91%), CP (8.15%), Gross Energy (GE) (4.61 Mcal/kg), Acid Detergent Fiber (ADF) (32.22%), NDF (41.45%), Nitrogen-Free Extract (NFE) (49.94%), Fat (6.20%), and Ash (9.80%). García Villoslada *et al.* (2022) note that cocoa harvest by-products offer potential as ingredients in multi-nutritional blocks due to their protein and fiber content, as well as their high palatability for livestock, without negatively impacting weight gain or milk production. In a separate study, a balanced feed was formulated by incorporating 0%, 20%, 30%, and 40% cocoa husk flour and nacedero leaf meal, aimed at potential use in beef cattle. Bromatological analysis of the concentrate showed that the 40% inclusion met the nutritional requirements established by the NRC, and the nutritional profile of cocoa husk supports its feasibility as an ingredient in animal feed (Molina Pinza *et al.*, 2024).

### **Citrus By-products**

Citrus production in Mexico is a vital agricultural activity for both domestic consumption and export markets. The principal crops include orange, lime, mandarin, and grapefruit (Valencia Sandoval & Duana Ávila, 2019). According to SIAP (2023), the leading citrus-producing states are Veracruz, Michoacán, Tamaulipas, Puebla, San Luis Potosí, Nuevo León, Oaxaca, and Yucatán. Nationally, orange production reached 4,942,658.65 tons, lime 3,239,914.70 tons, mandarin 309,740.49 tons, and grapefruit 488,140.72 tons (SIAPc, 2023). Fermenting citrus by-products through the addition or inoculation of fungal strains specifically *Aspergillus niger* presents a promising method for biodegrading these residues and converting them into feed for large livestock, particularly cattle (Marin Machuca *et al.*, 2021). In one study, orange silage was included in dairy cattle feed, replacing 20% of commercial concentrate. The results indicated that orange silage not only enhanced milk composition but also reduced production costs (Flórez Delgado *et al.*, 2020). In another research trial, a concentrate for fattening steers was developed by incorporating citrus by-products across four treatments: T1 (control), T2 (with orange bagasse), T3 (with orange

peel), and T4 (based on orange silage). The findings demonstrated that the inclusion of citrus by-products improved weight gain, enhanced palatability, and promoted ruminal microflora activity by increasing the production of beneficial biochemical compounds, thereby enriching the substrate (Cabrera Núñez *et al.*, 2020).

### **Pineapple**

Pineapple cultivation generates a substantial volume of by-products, such as stubble, which are traditionally reincorporated into the soil as fertilizer. However, this practice may contribute to pest proliferation in agricultural zones. These residues, nonetheless, can be repurposed as forage for ruminants, either fresh or ensiled, thereby preserving their nutritional properties under optimal conditions. Additionally, the inclusion of complementary ingredients can enhance their physical and nutritional characteristics (Viveros Torres *et al.*, 2022). In Mexico, the primary pineapple-producing state is Veracruz, contributing 66% of the national total, equivalent to 840,317.47 tons. Other key producers include Oaxaca, Nayarit, Tabasco, and Quintana Roo. These five states collectively account for 93% of national production, totaling 1,193,630.43 tons out of 1,272,559.15 tons cultivated across 46,954.27 hectares (SIAPd, 2023). One study evaluated pineapple crown silage with varying inclusion levels (0%, 15%, 30%, and 45%) of musaceous fruits. Bromatological analysis was conducted on both the pineapple crown and the musaceous fruit. The pineapple crown showed the following composition: Crude Protein (CP) (12.09%), Neutral Detergent Fiber (NDF) (57.5%), Dry Matter (DM) (9.1%), Ash (8.79%), Ether Extract (EE) (2.86%), and Lignin (2.5%). The study concluded that pineapple crown is an acceptable feed resource for ruminants, whether fresh or ensiled; however, supplementing with starch-rich sources like musaceous fruits can enhance its nutritional value (Lazo Salas *et al.*, 2018). In another investigation, six treatments were formulated using different by-products: fish waste, corn stubble, molasses, and pineapple peel (PP) at inclusion levels of 15%, 30%, and 45%, with various fermentation durations. Additionally, inoculants such as *Lactobacillus* sp. or *Lactobacillus* B2 were added at 4%. It was concluded that inclusion of 15% and 30% PP resulted in better acidification at 7 days of fermentation. By day 14, all silages were stable and showed high nutrient content. Therefore, silage production using these by-products represents a simple, cost-effective, and environmentally friendly alternative for ruminant nutrition (Ramírez Ramírez *et al.*, 2020). A separate study evaluated intake, milk yield, and composition in lactating goats fed diets supplemented with fresh pineapple processing residues at inclusion levels of 0%, 10%, 20%, and 30%. It was concluded that using fresh pineapple by-products is a viable feeding strategy at 10% and 30% inclusion on a fresh matter basis (Alpízar Solís & Elizondo Salazar, 2019).

### **Crop residues**

Agricultural residues commonly referred to as stubble, straw, hay, or forage play a crucial role in agricultural and livestock systems, particularly in ruminant nutrition. These by-products are primarily derived from cereal crops such as maize and sorghum, and to a lesser extent from legumes like soybean. The volume of crop residues is directly proportional to grain production (Macías Rodríguez *et al.*, 2021). In 2023, maize

**Table 3.** Nutritional value of orange by-products.

Nutrients	OB	OP	OS
CP (%)	10	10	16
EE (%)	3.2	4.96	9.22
Ash (%)	3.3	7.92	9.22
CF (%)	14.92	30.8	33.4
NFE (%)	64.51	67.18	77.58
GE <sub>p</sub> (Mcal)	22.6	26.87	27.89
TDN (Mcal)	60.39	63.78	64.56

OB: Orange Bagasse, OP: Orange Peel, OS: Orange Silage, CP: Crude Protein, EE: ether extract, CF: Crude Fiber, NFE, Nitrogen-Free Extract, ENP: Gross Energy Production and TDN: Total Nutrient Digestible. Fuente: Cabrera Núñez *et al.*, 2020.

production in Mexico reached 27,549,917.53 tons across 6,941,031.12 hectares. The leading producing states include Sinaloa, Jalisco, Michoacán, the State of Mexico, and Guanajuato. Soybean production was 199,162.60 tons on an equivalent cultivated area, with Campeche, Yucatán, and Chiapas as the main producers. Sorghum production totaled 4,815,930.91 tons across 1,359,920.57 hectares, with Tamaulipas, Guanajuato, Michoacán, Sinaloa, and Nayarit as the top-producing states (SIAPe, 2023). Although crop residues are essential in ruminant feeding, their limited nutritional value has prompted research into strategies to enhance their composition and digestibility (Macías Rodríguez *et al.*, 2021). One study assessed the mineral content of corn stubble silage supplemented with three non-protein nitrogen sources (urea, poultry litter, and fresh pig manure) and two carbohydrate sources (molasses and bakery by-products). After 30 days of fermentation, results showed that silage enriched with poultry litter and molasses provided both macro- and microminerals suitable for ruminant diets (Domínguez Vara *et al.*, 2023). In another experiment, the productive response of dairy cows was evaluated when fed *ad libitum* corn stubble treated with 26 and 40 grams of urea in treatments one and two, respectively. Treatment three used untreated corn stubble supplemented with 760 grams of soybean meal. The results indicated that urea supplementation improved nutritional quality and reduced structural carbohydrate content. However, no statistically significant differences were observed among the treatments (García Martínez *et al.*, 2020).

## CONCLUSIONS

Formulating ruminant diets with the inclusion of agro-industrial by-products and regionally available agricultural residues represents a viable alternative to enhance livestock production, reduce dependence on conventional feed ingredients, and minimize feed costs. Additionally, the proper management of residual materials from agro-industrial processes fosters more efficient waste handling and contributes to mitigating environmental impact.

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## REFERENCES

- Alpízar-Solís, C., & Elizondo-Salazar, J. A. (2019). Utilización de residuos de piña para alimentación de cabras: efecto sobre la producción y composición láctea. *Agronomía Costarricense*. Vol. 43(núm. 1), pp. 113-124. ISSN:0377-9424.
- Benítez Meza, J. A., Borrayo-González, J.J.F., Hernández-Ballesteros, J. A., & De La Cruz-Moreno, C. O. (2020). Evaluación nutricional de la cáscara de plátano Tabasco y su efecto productivo en la alimentación de conejos Nueva Zelanda. *Revista EDUCATECONCIENCIA*. Volumen 27, No. 28, Pp. 55-65, ISSN: 2007-6347. Tepic, Nayarit. México. DOI: <https://doi.org/10.58299/edu.v27i28.256>
- Cabrera-Núñez A., Lammoglia-Villagómez M., Martínez-Sánchez C., Rojas-Ronquillo R., & Montero-Solís F. (2020). Utilización de subproductos de naranja (*Citrus sinensis* variedad valencia) en la alimentación para rumiantes. *REV. ABANICO VETERINARIO* ISSN 2448-6132. DOI: <http://dx.doi.org/10.21929/abavet2020.6>
- Cárdenas-Solano, L. J., Contreras Pedraza, C. A., Báez Daza, E. Y., Rodríguez Silva, L.G., Zambrano Ortiz, J. R. & Cardona Iglesias, J. L. (2024). Escaneo científico sobre tendencias en usos y agregación de valor de los residuos de café. Corporación Colombiana de Investigación Agropecuaria (AGROSAVIA). DOI: [10.21930/agrosavia.escaneocientifico.2023.2](https://doi.org/10.21930/agrosavia.escaneocientifico.2023.2)
- Cañaverl-Martínez, U. R., Sánchez-Santillán, P., Torres-Salado, N., Sánchez-Hernández, D., Herrera-Pérez, J., & Rojas-García, A. R. (2020). Características de calidad, bromatológicas y fermentativas in vitro de ensilado de mango maduro. Artículo Científico ISSN:2007-9559. *Revista Mexicana de Agroecosistemas* Vol. 8 (Núm.1), Pp. 11-13.
- Cornejo-Cornejo, R., Azúm-González, J. L., Gorozabel-Muñoz, W., Vargas-Zambrano, P., Mendoza-Rivadeneira, F., & Macías-Barberan, R. (2020). Valor nutritivo in vitro de la cáscara *Musa paradisiaca* L., pretratada con enzima exógena xilanasa. *Pastos y Forrajes*, vol. 43, núm. 1, pp. 11-17. Facultad de Ciencias Zootécnicas, Universidad Técnica de Manabí, Ecuador.
- Da Silva-Rosa, J. J., & Castillo-Vargas, J. A. (2022). Efectos de la inclusión de la torta de palmiste en la dieta de bovinos sobre el metabolismo ruminal y la composición química de la leche y la carne producidas por esta especie: un breve panorama. *Agrícola & Hábitat*, vol. 5(núm. 2), pp. 63-87. <https://doi.org/10.22490/26653176.6145>
- Desdémona-Martínez, E. (2023). Implicaciones que influyen en el desempeño productivo, características de la canal y de la carne de ganado bovino engordado en corral. Prestador de Servicios Profesionales en Producción Animal, Oaxaca, México. Artículo de revisión. DOI: <https://doi.org/10.15381/rirep.v34i3.24517>
- Domínguez-Vara I., Bórquez-Gastelum J., Lugo-de-la-Fuente J., & Trujillo- Gutiérrez D. (2023). Contenido mineral y de nutrientes de ensilados de rastrojo de maíz con excretas pecuarias y subproductos ricos en carbohidratos. *Revista Abanico Veterinario*. Vol. 13: pp. 1-19. DOI: <http://dx.doi.org/10.21929/abavet2023.17>
- Encalada, M., Fernández, P., Jumbo, N., & Quichimbo, A. (2018). Ensilaje de pulpa de café con la aplicación de aditivos en el cantón Loja. *Bosques Latitud Cero*. Vol. 7(núm. 2): pp. 71-82.
- Escobar-España, J. C., Bárcena-Gama, J. R., Ley-De Coss, A., y Crosby- Galván, M. M. (2022). Nutrient content and in vitro degradability of the palm kernel meal produced in the state of Chiapas, México, as feed for ruminants. *Agro Productividad* 15(5). DOI: <https://doi.org/10.32854/agrop.v15i5.2235>
- Escobar-España, J. C., Ley-de-Coss, A., Valencia-Núñez, K. N., & Bárcena-Gama, J. R. (2023). Comportamiento productivo, características de la canal y de la carne de corderos suplementados con harina de palmiste (*Elaeis guineensis*). *NACAMEH* Vol. 17, No. 2, pp. 67-84, ISSN 2007-0373. DOI: <https://doi.org/10.24275/uam/izt/dcb/PENDIENTE>
- Fernández-Navarro, A. L., Rojas-Bourrillon, A., & Campos-Granados, C. M. (2024). Suplementación con pulpa de café deshidratada en vacas lecheras y su efecto en el desempeño productivo. *Nutrición Animal Tropical* Vol.18 (núm.1). ISSN: 2215-3527. DOI: [10.15517/nat.v18i1.58614](https://doi.org/10.15517/nat.v18i1.58614)
- Flórez-Delgado, D. F., & Rosales-Asensio, E. (2017). Uso del ensilaje de pulpa de café en alimentación animal. *Revista científica Mundo Fesc*. Vol. 15, Núm. 1, pp. 73-82.

- Florez-Delgado, D. F., Capacho-Mogollón, A. E., & Quintero Muiño, S. M. (2020). Efecto de la suplementación con ensilaje de naranja sobre la composición de la leche bovina. *Revista de investigación agraria y ambiental*. Vol. 11, num. 2. DOI: <https://doi.org/10.22490/21456453.2974>
- Flórez-Delgado, D. F. (2020). Efecto del tiempo de fermentación sobre la calidad nutricional del ensilaje de pulpa de *Coffea arabica* L. *Cienc. Tecnol. Agropecuaria*, vol.21 (núm. 3). DOI: DOI: [https://doi.org/10.21930/rcta.vol21\\_num3\\_art:1423](https://doi.org/10.21930/rcta.vol21_num3_art:1423)
- García-Cevallos, C. A., Mancilla-Montelongo, M. G., Sandoval-Castro, C. A., & Torres-Acosta, J. F. (2021). Subproductos agroindustriales: alimentos nutracéuticos para cabras y borregos. *Bioagrociencias*, Volumen 14, Número 2. DOI: <https://doi.org/10.56369/BAC.3916>
- García-Martínez, A., López-González, F., Prospero-Bernal, F., Albarrán- Portillo, B., Arriaga-Jordán, C. M. (2020). Evaluación de rastrojo de maíz (*Zea mays* L.) tratado con urea como una alternativa en la suplementación de vacas lecheras en sistemas de producción de leche en pequeña escala. *Agroproductividad*: Vol. 13, Núm. 2, pp. 11-17. <https://doi.org/10.32854/agrop.vi.1628>
- García-Villoslada, A. E., Acosta-Núñez, Y. N., Terrones-Campos, H. G., Carrasco-Pacheco, R. E., & Autukai-Biktuk, J. L. (2022). Subproductos del cacao (*Theobroma cacao*) como alternativa para la mejora de la dieta balanceada en rumiantes. *Revista de Investigación Científica DEKAMU AGROPEC*. Vol. 3(núm. 1), pp. 42-57. DOI: DOI: <https://doi.org/10.55996/dekamuagropec.v3i1.72>
- Godoy-Padilla, D. J., Daza-La-Plata, R., Fernández-Curi, L. M., Layza- Mendiola, A. E., Roque-Alcarraz, R. E., Hidalgo-Lozano, V., Gamarra- Carrillo, S. G., & Gómez-Bravo, C. A. (2020). Caracterización del valor nutricional de los residuos agroindustriales para la alimentación de ganado vacuno en la región de San Martín, Perú. *Ciencia y Tecnología Agropecuaria*. vol.21(núm. 2). DOI: [https://doi.org/10.21930/rcta.vol21\\_num2\\_art:1374](https://doi.org/10.21930/rcta.vol21_num2_art:1374)
- Gómez-Peña, G. R., Guzmán-Nariño, O. F., & Urbano-Caicedo, I. (2019). Alternativa biotecnológica para suplementación bovina mediante ensilado de mango en el departamento del Atlántico, Colombia. *Revista Colombiana de Investigaciones Agroindustriales*. Volumen 7 (1), pp. 42-57, DOI: <https://doi.org/10.23850/24220582.2326>
- Guerra-Italo, E., Villacis-Marlene, M., Álvarez-Alexandra, B., Villamar, R., & Vivas-León, M. (2020). Efecto de inclusión de cáscara de plátano en la degradabilidad *in situ* de ensilaje de maíz forrajero. *Revista Ingeniería e Innovación* ISSN: 2346-0474. Universidad Técnica Estatal de Quevedo, Ecuador.
- Hurtado, E. A., Vélez-Saeteros, R. D., Bravo-Vargas, A. R., & Macías- Rodríguez, E. G. (2021). Efectos de la amonificación y tiempo de fermentación sobre la composición bromatológica del bagazo de caña de azúcar. *Zootecnia Tropical*. Vol. 39. DOI: 10.5281/zenodo.5092156
- Jácome-Pilco, C., García-Culqui, R., Guevara-Narváez, L., & Moreta- Guangasi T., (2023). Revalorización del bagazo de caña de azúcar (*Saccharum officinarum*) como residuo importante para la agroindustria. *593 Digital Publisher CEIT*, 8(3), 134-148. Universidad Estatal de Bolívar, Ecuador. DOI: <https://doi.org/10.33386/593dp.2023.3.1661>
- Lagos-Burbano, E., & Castro-Rincón, E. (2019). Caña de azúcar y subproductos de la agroindustria azucarera en la alimentación de rumiantes. *Agronomía Mesoamericana*, vol. 30, núm. 3. Universidad de Costa Rica. DOI: <https://doi.org/10.15517/am.v30i3.34668>
- Lazo-Salas, G. J., Rojas-Bourrillon, A., Campos-Granados, C. M., Zumbado-Ramírez, C., & López-Herrera, M. (2018). Caracterización fermentativa y nutricional de mezclas ensiladas de corona de piña con guineo cuadrado musa (ABB) I. Parámetros fermentativos, análisis bromatológico y digestibilidad *in vitro*. *Nutrición Animal Tropical*. Vol.12(núm. 1): pp.59-79 DOI: <https://doi.org/10.15517/nat.v12i1.33847>
- Macay-Anchundia, M. A., Zambrano-Mendoza, M. E., Cedeño-Moreira, A. A., & Intriago-Vera, J. V. (2023). Uso de Raquis de Plátano (*Musa AAB*) para la Producción de Ensilaje Como Estrategia de Economía Circular. *Ciencia Latina Revista Científica Multidisciplinar*, Volumen 7, Número 5, Universidad Laica Eloy Alfaro de Manabí, Ecuador. DOI: [https://doi.org/10.37811/cl\\_rcm.v7i5.8074](https://doi.org/10.37811/cl_rcm.v7i5.8074)
- Macías-Rodríguez, N. A., Armenta-Valenzuela, B., Peláez-Estrada, U. V., Norzagaray-Cervantes, G. A., & Camargo-Luque, A. (2021). Obtención de celulosa a partir de rastrojo y olote de Maíz, *Zea mays* L. *Innovación y desarrollo tecnológico revista digital*. Vol. 13, núm. 4. ISSN: 2007-4786.
- Manuel-Luviano, D., Torres-Salado, N., Ávila-Nájera, D.M., Peláez-Acero, A., Herrera-Pérez, J., Rojas-García, A. R., Bottini-Luzardo, M. B., & Sánchez-Santillán, P. (2017). Conducta de cabras (*Capra aegagrus hircus*) estabuladas en corraletas alimentadas con bloques nutricionales elaborados con pulpa de mango. *Agroproductividad*: Vol. 11, Núm. 2. Pp: 135-139.
- Martinez-Gonzalez, J. K., Castillo-Rodríguez, S. P., Villalobos-Cortés, A., & Hernández-Meléndez, J. (2017). Sistemas de producción con rumiantes en México (revisión bibliográfica). *Ciencia agropecuaria* no. 26:132-152.

- Marín-Machuca, O., Iannacone, J., Porras-Lavalle, R. E., Alvarado- Zambrano, F. A., Vásquez-Aranda, A. O., & Alvarado-Zambrano, R. A. (2021). Aprovechamiento de subproductos cítricos: fermentación de la corteza de naranja por *Aspergillus niger* van tieghem. *Revista de investigación (The Biologist)*. Vol. 19 (núm. 1), pp. 57-64. DOI:10.24039/rtb2021191882
- Molina-Pinza, M. S., Salgado-Tello, I. P., Usca-Mendez, J. E., & Mancheno-Neira, P. A. (2024). Valoración bromatológica de la harina de cascara de cacao y nacedero en la formulación de un balanceado. *Revista Científica Agropecuaria*. Vol.4 (Núm.2), pp. 78-87. DOI: <https://reciena.espoeh.edu.ec/index.php/reciena/index>
- Nieto-Aquino, R., Saldaña-Campos, p., Hernández-Rodríguez, B., & Giménez-San Juan, R. (2021). Adición de la pulpa de café en la dieta de ovinos y su efecto en las características seminales. *Revista Académica Científica (TECTZAPIC)*. Vol. 7, núm. 2.
- Pacheco-Jiménez, A. A. Basilio-Heredia, J., Gutiérrez-Grijalva, E. P., Quintana-Obregón, E. A., & Muiy-Rangel, M. D. (2022). Potencial industrial de la cáscara de mango (*Mangifera indica* L.) para la obtención de pectina en México. *Revista Especializada en Ciencias Químico-Biológicas*, 25: 1-13. DOI: <https://doi.org/10.22201/fesz.23958723e.2022.419>
- Ramírez-Ramírez, J., Loya-Olguín, J., Ulloa, J., Rosas-Ulloa, P., Gutiérrez- Leyva, R., & Silva-Carrillo Y. (2020). Aprovechamiento de desechos de pescado y cáscara de piña para producir ensilado biológico. *Revista Abanico Veterinario*. Vol.10. pp.1-12. DOI: <http://dx.doi.org/10.21929/abavet2020.29>
- Ramírez-Ribera, J. L., Zambrano-Burgos, D. A., Campuzano, J., Verdecia- Acosta, D. M., Chacón-Marcheco, E., Arceo-Benítez, Y., Labrada-Ching, J., & Uvidia-Cabadiana, H. (2017). El clima y su influencia en la producción de los pastos. *Revista Electrónica de Veterinaria* ISSN 1695-7504, vol. 18, núm. 6, pp 1-12. Malanga España.
- Rojas, A. F., Rodríguez-Barona, S., & Montoya, J. (2019). Evaluación de Alternativas de Aprovechamiento Energético y Bioactivo de la Cáscara de Plátano. *Información Tecnológica* Vol. 30(5), 11-24. Universidad Nacional de Colombia. DOI: <http://dx.doi.org/10.4067/S0718-07642019000500011>
- Sanchez, A., Perea, J., Montenegro, L., Espinoza, I., Avellaneda, J., & Barba, C. (2020). Cinética de degradación ruminal *in situ* de ensilado de rastrojo de maíz (*Zea mays*) con niveles crecientes de urea. *Revista Científica Archivos de Zootecnia*. Vol. 69 (núm.267): pp. 320-326.
- Salazar-Ortiz, J., Trejo-Téllez, L. I., Valdez-Balero, A., Sentíes-Herrera, H. E., Rosas-Rodríguez, M., Gallegos-Sánchez, J., Crosby-Galván, M. M., & Gómez-Merino, F. C. (2017). Caña de azúcar (*Saccharum* spp.) en la alimentación de rumiantes: experiencias generadas con cañas forrajeras. *Agroproductividad*: Vol. 10, Núm. 11.
- [SIAPa] Servicio de Información Agroalimentaria y Pesquera. 2023. Producción de ganado bovino y ovino a nivel nacional. Recuperado de: <https://nube.siap.gob.mx/cierrepecuario/>
- [SIAPb] Servicio de Información Agroalimentaria y Pesquera. 2023. Principales cultivos en las regiones tropicales de México. Recuperado de: <https://nube.siap.gob.mx/cierreagricola/>
- [SIAPc] Servicio de Información Agroalimentaria y Pesquera. 2023. Principales cultivos de cítricos en México. recuperado de: <https://nube.siap.gob.mx/cierreagricola/>
- [SIAPd] Servicio de Información Agroalimentaria y Pesquera. 2023. Principales estados productores de piña en México. Recuperado de: <https://nube.siap.gob.mx/cierreagricola/>
- [SIAPe] Servicio de Información Agroalimentaria y Pesquera. 2023. Principales estados productores de maíz, soya y sorgo. Recuperado de: <https://nube.siap.gob.mx/cierreagricola/>
- Terán-Rivera, S. C., Torres-Martínez, B. M., Torrescano-Urrutia, G. R., Esqueda, M., Sánchez-Escalante, A., & Vargas-Sánchez, R. D. (2023). Residuos del procesamiento del fruto de café como fuente natural de antioxidantes para la industria cárnica. *Revista Especializada en Ciencias Químico-Biológicas*. Vol. 26: pp.1-12. DOI: <https://doi.org/10.22201/fesz.23958723e.2023.540>
- Torres-Mejía, F., Torres-Mejía, J. A., & Cantarero-Reyes, L. M. (2023). Análisis del proceso agroindustrial y valoración energética de la palma africana (*Elaeis guineensis* Jacq) en Honduras. *Revista científica*, Vol. 36, No. 03, pp. 439-457, ISSN-E 1995-9516. DOI: <https://doi.org/10.5377/nexo.v36i03.16466>
- Valencia-Sandoval, K., & Duana-Ávila, D. (2019). Los cítricos en México: Análisis de eficiencia técnica. *Revista Análisis Económico*, vol. XXXIV, núm. 87, pp. 269-283, ISSN: 0185-3937.
- Valverde-Lucio, Y. A., Orlando-Tóala, G., Gabriel-Ortega, J., Merchán- García, W. A., & Orlando-Indacochea, F. (2024). Efecto de microorganismos eficientes en el ensilaje de cáscara de banana maduras (*Musa paradisiaca*) para alimento de ganado bovino. *Revista UNESUM- Ciencias*, Volumen 8, Número 3. Universidad Estatal del Sur de Manabí, Ecuador. DOI: <https://doi.org/10.47230/unesum-ciencias.v8.n3.2024.60-68>
- Vargas-Corredor, Y. A., & Pérez-Pérez, L. I. (2018). Aprovechamiento de residuos agroindustriales para el mejoramiento de la calidad del ambiente. *Revista Facultad de Ciencias Básicas*. Universidad Militar

- Nueva Granada, Colombia. ISSN 1900-4699. Vol. 14 (1). DOI: <http://dx.doi.org/10.18359/rfcb.3108>
- Vega-González, R. J., Castro-Salinas, D., Pajuelo-Risco, F. M., Honorio-Javes, C. E., & Hernández-Valdez, J. E. (2024). Subproductos de cacao (*Theobroma cacao*) en la alimentación animal: Una alternativa viable y sostenible. Artículo de revisión “Manglar” vol. 21(núm. 1): pp127-134. DOI: <http://doi.org/10.57188/manglar.2024.013>
- Vera-Rodríguez, J., Torres-Sánchez, S., Macías-Rojas, H., Galarza-Cabrera, J., Piña-Reinoso, L., Morán-Cabrera, W., Rivera-Vivar, L., & Cabrera-Guaraca, O. (2021). Valoración nutricional de los residuos orgánicos de banano en el cantón La Troncal, Ecuador. *Revista Universitaria Del Caribe*, vol. 26(núm. 01), pp. 78-86. <https://doi.org/10.5377/ruc.v26i01.11882>
- Villanueva-Pedraza, E., Villanueva-Guerrero, J. A., Cueva-Valdivia, J., Ticona-Chayña, E., Calsin-Turpo, J. R., & Piñarreta-Neira, W. V. (2023). Alternativa de bloques multinutricionales a base de subproductos agroindustriales para la suplementación de ganado lechero en pastoreo en la provincia del Alto Amazonas, Loreto. *Journal of the Selva Andina Anim. Sci.* Vol. 10(Núm. 2): PP. 88-95. ISSN 2311-2581.
- Viveros-Torres, I., Muñoz-Delgado, J., & Lagunes-Gómez, I. (2022). Diseño de sistemas tecnificados para el aprovechamiento de subproductos de la piña. International Conference on Innovation, Documentation and Education (INNODOCT). <https://doi.org/10.4995/INN2022.2022.15744>

