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Transforming Agro-Industrial Wastes into Nutrient-Rich Media for Actinomycetes Cultivation

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ABSTRACT

Background: Agro-industrial wastes represent a sustainable and cost-effective alternative for microbial culture media.. **Objective**: This study explores the potential of common agrowastes (rice husk, corn cob, sugarcane bagasse and cassava starch) generated in Ado and Ikere Ekiti, as nutrient-rich media for cultivating actinomycetes. **Methods:** These agrowastes were pre-treated and soaked in distilled water for 24 hours to extract soluble nutrients. The mixture was filtered to remove residues, and filtrate was concentrated. Media were formulated using 2 g of each agrowaste supplemented with essential nutrients and agar, maintaining pH 7. The morphological characteristics of actinomycetes grown on these media were observed and compared with those cultivated on conventional starch-casein agar. Proximate and mineral analyses were conducted to determine the nutritional composition of each agrowaste. A cost analysis was also performed. **Results:** Actinomycetes thrive on all agrowaste-formulated media, exhibiting colony morphologies comparable to those on standard media. Corn cob and starch supported the largest colonies, while sugarcane bagasse and rice husk produced varied pigmentation and textures. Proximate analysis revealed high carbohydrate content in starch (81.7%) and sugarcane (74.1%), and high fibre in corn cob (28.6%) and rice husk (18.9%). Mineral analysis showed corn cob to be richest in iron (373.8 mg) and zinc (5.6 mg), while sugarcane had the highest phosphorus content (1007.3 mg). Media cost using corn cob was ₦206.40, significantly lower than ₦62,000.00 for commercial media. **Conclusion:** Agrowastes, particularly corn cob and cassava starch, offer nutrient-rich and economically viable alternatives for cultivating actinomycetes, supporting sustainable biotechnology and waste valorization initiatives.

Keywords. Agro-waste, Actinomycetes, Formulated media, Proximate analysis, Nutritional analysis

1. Introduction

Agricultural industries generate large amounts of waste residues every year. When these residues are disposed of improperly, they can lead to environmental pollution and pose health risks to humans and animals (Babu et al., 2022). Much of this agro-industrial waste remains untreated and underutilized; commonly, it is disposed of by burning, dumping, or unplanned landfilling, contributing to greenhouse gas emissions and exacerbating climate change (Singh et al., 2021). Ikere-Ekiti, where BOUESTI is located, is primarily an agricultural area, producing significant amounts of agro-industrial waste. Common wastes in this environment include cassava peels, maize husks, rice bran, and fruit peels, among others. These by-products, often rich in organic matter, carbohydrates, proteins, and micronutrients, are typically underutilized or discarded, contributing to pollution and loss of potentially valuable biomass. This situation presents an opportunity to repurpose these wastes as nutrient-rich media for cultivating beneficial microorganisms like actinomycetes. In addition, the demand for cost-effective and sustainable microbial cultivation methods is growing, particularly in the field of industrial microbiology, where microorganisms such as actinomycetes are of great importance.

Actinomycetes, a diverse group of Gram-positive, filamentous bacteria predominantly belonging to the genus *Streptomyces*, are well-known for their prolific production of bioactive compounds, such as antibiotics, enzymes, immunosuppressants, as well as anticancer agents (Helmi, 2025). However, their cultivation on conventional synthetic media can be expensive and environmentally challenging due to the use of refined components like glucose and peptone. In this study, the transformation of agro-industrial wastes into nutrient-rich media

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offers a dual benefit as it supports a circular bioeconomy by enhancing the value of wastes and provides a cost-effective alternative to conventional culture media for actinomycetes. Various substrates such as fruit and vegetable peels, sugarcane bagasse, wheat bran, rice husk, and soybean meal have been investigated for their potential to support microbial growth (Astudillo et al., 2023; SANTOS et al., 2021; Singh & Singh, 2022). These substrates not only supply essential carbon and nitrogen sources but also create an opportunity for tailoring specific nutrient conditions that can trigger the expression of silent biosynthetic gene clusters in actinomycetes, potentially leading to the discovery of novel metabolites (Dinesh et al., 2017).

Furthermore, integration of such bioconversion strategies into microbial biotechnology aligns with the United Nations Sustainable Development Goals (SDGs), particularly goals related to responsible consumption and production (SDG 12) and industry innovation (SDG 9). Thus, the utilization of agro-industrial residues as culture media is emerging as a promising biotechnological innovation, capable of reducing production costs, mitigating waste-related issues, and enhancing the bioactive potential of industrially relevant microorganisms such as actinomycetes. This study, therefore, aimed to transform agro-industrial wastes into nutrient-rich media for actinomycetes.

2. Materials and Methods

2.1. Sample Collection

The agro-industrial wastes collected for this study included sugarcane bagasse, rice husks, corn cobs and cassava starch.

2.2. Test microorganism

Actinomycetes isolate recovered from soil samples from a previous study was used for this study.

Formulation of media using agro-wastes

The agro-wastes were processed by grinding with a blender to increase their surface area, which facilitated better nutrient extraction. They were then pre-treated by autoclaving at 121°C for 15–20 minutes to eliminate contaminants, making them a sterile medium suitable for actinomycetes' growth. The pre-treated agrowastes were soaked in sterile distilled water and incubated for a specific period of 24-48 hours to extract soluble nutrients. The mixture was filtered to remove solid residues and concentrate the filtrate. The extract of each agrowaste was supplemented with additional nutrients which included CaCO3, CaSO4, zinc, sulfate, iron (Fe), yeast extract and Agar gar for solid media preparation to meet the nutritional needs of actinomycetes (Table 1). Finally, the pH of the media was adjusted to pH 7.0 the optimal range for actinomycete growth and each formulated media was autoclaved at 121^0C for 15-20 minutes to ensure sterility before inoculation.

2.3. Inoculation and Cultivation of Actinomycetes

A fresh inoculum of actinomycetes was prepared by culturing on a standard medium (starch-casein agar) at 28 ^{0}C for 7 days and then transferred to the prepared agro-waste media. The inoculated media was incubated under optimal conditions 28°C for a specified duration of 7days. Actinomycetes growth on each formulated media was characterized.

2.4. Evaluation of media efficiency

The growth of actinomycetes on agro-industrial wastes media was compared with their growth on standard synthetic media (Starch Casein Agar).

2.5. Cost-effectiveness Analysis

The cost-effectiveness of the formulated media was evaluated and compared to commercial media.

2.6. Nutritional Analyses of agrowaste samples

Proximate analysis was performed on each of the agro-wastes used to formulate media to determine their nutritional content. Moisture content was determined using the air-oven method, Ash content was determined by using a

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Table 1: Formulation of media

	Media Composition (g)			
	Sugarcane bagasse	Rice husk	Corn cob	Cassava starch
Agro wastes	2.0	2.0	2.0	2.0
Fe	0.6	0.6	0.6	0.6
CaCO3	0.6	0.6	0.6	0.6
CaSO4	0.6	0.6	0.6	0.6
Yeast extract	0.6	0.6	0.6	0.6
Agar-agar	2.4	2.4	2.4	2.4
Zinc sulphate	0.6	0.6	0.6	0.6
pH	7	7	7	7

standard gravimetric procedure (dry ashing), and determination of crude protein was performed by using micro-Kjeldahl method as described by the Association of Official Analytical Chemists (Chemist, 2000). Crude fat was determined using the standard Soxhlet method, the standard Weende procedure was used to determine crude fibre, while Total Carbohydrate was determined by difference by summing up the percentages of moisture, ash, crude protein, fat (ether extract) and subtracting from 100% CHO

2.7. Mineral Composition Analyses of agrowaste samples

The composition of iron (Fe), zinc (Zn), magnesium (Mg), phosphorus (P), and calcium (Ca) in the sample were determined by the standard Association of Official Analytical Chemists (AOAC) method.

3. Results

The cultural characteristics of the actinomycetes inoculated on each formulated medium are shown in Table 2. The Table reveals that the agrowaste-grown actinomycetes had sizes ranging from small to big; consistency such as powdery, leathery and chalky; pigmentation such as green, white and cream; elevation of low and high and surface characteristics which included rough, irregular and round. These observed characteristics were consistent with the conventional-grown actinomycetes. Table 3 shows the cost analysis for each of the agrowaste-formulated medium. In the Table 3, each estimated cost compared to the conventional (starch-casein agar) bought at ₦62,000:00K was found to be extremely low in price. The table also reveals that formulated media with corn cob have the least amount, followed by starch-formulated media. While sugarcane bagasse and rice husk are of the same amount.

3.1. Cost of casein starch agar: ₦62,000: 00k

Table 4 reveals the analysis of the proximate composition of Rice Husk, Starch, Sugarcane, and Corn Cob, which shows notable differences in their moisture, fat, protein, ash, crude fiber, and carbohydrate contents. Rice husk has a moderate moisture content ranging between 12.13 % and 12.19 %, with a high carbohydrate content of approximately 54.19 % to 54.27 %. Its crude fibre content, around 18.90 % to 18.97 %, is relatively high, indicating a significant amount of indigestible material. The protein and fat contents are low, ranging between 2.92 % to 2.98 % and 3.27 % to 3.33 %, respectively, while the ash content is moderately high at 8.40 % to 8.45 %, reflecting the presence of mineral components. This composition suggests that rice husk has limited nutritional value for dietary purposes but is suitable for industrial applications such as bio-fuel production or fibre-related uses. Starch, on the other hand, exhibits a high carbohydrate

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Table 2: Cultural characteristics of the agrowaste-grown actinomycetes

Sample with Actinomycetes ID	Size	Consistency	Pigment	Elevation	Surface
Rice husk	Small	Powdery	Green	Low	Round
Rice husk	Small	Leathery	Cream	High	Irregular
Rice husk	Small	Powdery	green	low	Rough
Starch DB[3]	Big	Powdery	Green	Low	irregular
Corn Cob DB[3]	Big	Leathery	White surrounded with green	High	round
Sugar Cane Bagasse LB[2]	Small	Leathery	Green	Low	irrregular
Sugar cane Bagasse DB[3]	Small	Leathery	White	High	round
Sugar cane bagasse DE[2]	Big	Chalky	Green	Low	round
Corn Cob DE[2]	Small	Powdery	White surrounded with brown	Low	irregular

Table 3. Cost analysis of formulated media from each agrowaste

Composition		Amount (₦: K)			
		Sugar-cane bag-	Rice husk	Corn cob	Cassava starch
Agro wastes	Waste	500:00	500:00	0	200:00
Supplements	(Fe) Iron	20:40	20:40	20:40	20:40
	($CaCO_3$)	2:40	2:40	2:40	2:40
	($CaSO_4$)	8:40	8:40	8:40	8:40
	Yeast Extract	48:00	48:00	48:00	48:00
	Agar Agar	115:20	115:20	115:20	115:20
	($ZnSO_4$)	12:00	12:00	12:00	12:00
Total		₦686:00	₦686:00	₦206:40	₦406:40

content of 81.73 % to 81.77 %, making it a pure energy source. Its moisture content is slightly higher, ranging between 14.82 % and 14.95 %, which could impact its storage stability over time. The fat and fibre contents are minimal, both close to 0.1 % to 0.2 %, confirming its purity as a carbohydrate source. The protein content is low, ranging between 2.64 % and 2.79 %, while ash content remains very low at 0.26 % to 0.33 %, indicating minimal mineral presence. This composition makes starch ideal for applications where high carbohydrate content is required, such as in the food, pharmaceutical, or industrial sectors.

The sugar cane sample reveals a moderate carbohydrate content of 74.05 % to 74.13 %, with moisture levels ranging between 13.33 % and 13.53 %. The crude fibre content is notable at 9.93 % to 9.94 %, highlighting its fibrous nature, which could be useful for non-food applications such as animal feed or bio-fuel production. Protein and fat contents are very low, ranging from 1.80 % to 1.88 % and 0.12 % to 0.14 %, respectively, while the ash content is around 0.52 % to 0.56 %, indicating a small mineral presence. Overall, sugar cane is best suited for sugar extraction and other energy-related uses. Corn cob demonstrates the highest crude fibre content among the samples, ranging between 28.54 % and 28.58 %, which makes it particularly useful for industrial purposes like bio-fuel production, paper manufacturing, or animal feed as a dietary fibre source. The carbohydrate content, between 48.76 % and 48.83 %, is moderate compared to the other samples. The protein and fat contents are relatively higher than those in rice husk and sugar cane, ranging between 3.60 % and 3.80 % for protein, and 1.20% to 1.30% for fat. The ash content is moderate, ranging between 4.33 % and 4.50 %, suggesting a reasonable mineral presence. The moisture content remains moderate, between 13.10 % and 13.30 %.

Table 4: Proximate Analysis (%) of each Agrowastes material used in the Formulation of Media

Sample	Mois-ture (%)	Fat (%)	Protein (%)	Ash (%)	Crude fiber (%)	Carbo-hydrate (%)
Rice husk	12.19	3.27	2.98	8.40	18.97	54.19
	12.13	3.33	2.92	8.45	18.90	54.27
	12.13	3.33	2.92	8.45	18.90	54.27
Starch	14.95	0.12	2.64	0.33	0.23	81.73
	14.82	0.10	2.69	0.26	0.22	81.76
	14.92	0.10	2.79	0.30	0.22	81.77
Sugar cane	13.42	0.12	1.88	0.52	9.94	74.12
	13.53	0.14	1.80	0.56	9.93	74.05
	13.33	0.12	1.80	0.55	9.93	74.13
Corn cob	13.24	1.24	3.78	4.33	28.58	48.83
	13.30	1.30	3.60	4.40	28.54	48.76
	13.10	1.20	3.80	4.50	28.54	48.76

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Table 5 shows the analysis of the mineral content in Rice Husk, Starch, Sugar Cane, and Corn Cob. This highlights significant variations in their calcium, magnesium, zinc, iron, and phosphorus levels. Rice husk has a moderate calcium content of 204.50 mg and a high phosphorus level of 330.75 mg, making it a good source of these essential minerals. The magnesium content is relatively high at 125.40 mg, and iron is abundant at 238.13 mg. Zinc content is moderate at 3.60 mg. This composition suggests that rice husk could be utilized for applications requiring a balance of minerals, such as soil amendments or animal feed supplements. Starch has the highest calcium content at 485.13 mg, indicating its potential use in calcium-enrichment applications. However, its magnesium (84.30 mg), zinc (2.71 mg), and iron (64.50 mg) levels are comparatively low. Phosphorus content is minimal at 93.13 mg, making starch less suitable for applications requiring phosphorus. Its overall profile aligns with its use in energy-related or food applications where calcium is a priority. Sugar cane demonstrates a high phosphorus content of 1007.25 mg, the highest among the samples, making it an excellent source of this mineral. Its calcium content is also significant at 412.80 mg, and it has a moderate magnesium level of 95.13 mg. Iron is abundant at 219.63 mg, while zinc is the lowest among the samples at 1.62 mg. This composition highlights sugar cane's potential for use in applications emphasizing phosphorus and calcium, such as fertilizers or mineral-rich supplements. Corn cob has a unique profile, featuring the highest zinc content at 5.62 mg and the highest iron content at 373.75 mg, making it valuable for iron and zinc supplementation. Its phosphorus content is also substantial at 668.25 mg, while calcium and magnesium are relatively lower at 182.57 mg and 91.40 mg, respectively. This composition suggests corn cob's suitability for applications requiring high levels of trace elements like iron and zinc, such as in animal feeds or industrial mineral extraction.

4. Discussion

The transformation of agro-industrial wastes into nutrient-rich media for cultivating actinomycetes presents a sustainable and cost-effective alternative to conventional synthetic media. The findings from this study strongly support that agrowaste-derived media can support the growth and morphological diversity of actinomycetes, offering substantial economic and environmental benefits.

The proximate and mineral analyses of the tested agrowastes, rice husk, cassava starch, sugarcane bagasse, and corn cob, revealed distinct nutritional profiles that influenced actinomycete growth. Starch exhibited the highest carbohydrate content (81.73 % – 81.77 %), affirming its role as a potent energy source (Table 4). This aligns with the robust growth of actinomycetes (e.g big size, irregular surface) on starch-formulated media, indicating that a high carbohydrate content can enhance biomass production. Similar observations were made by Shirling and Gottlieb (1966) and Hamilton & Ellwood (1983) who demonstrated that readily metabolizable carbohydrates support rapid actinomycete proliferation. Furthermore, it strengthens a similar studies titled "Waste to wealth: Production of oxytetracycline using *Streptomyces* species from household kitchen wastes of agricultural produce". The study reported proximate analyses of agricultural wastes that substantial amount of agricultural wastes still contain several reusable substances of high value such as soluble sugars, protein, moisture, ash and fibre, all of which are of

Table 5: Mineral Analysis (mg) of each Agrowastes material used in the Formulation of Media

Sample	Calcium (mg)	Magnesium (mg)	Zinc (mg)	Iron (mg)	Phosphorus (mg)
Rice hub	204.50	125.40	3.60	238.13	330.75
Starch	485.13	84.30	2.71	64.50	93.13
Sugar cane	412,80	95.13	1.62	219.63	1007.25
Corn cob	182.57	91.40	5.62	373.75	668.25

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variable concentrations (Tobias et al. 2012).

Corn cob media, on the other hand, resulted in the cultivation of large, leathery colonies with distinct pigmentation and surface elevation (Table 2), which may be attributed to its elevated fiber (28.54 % – 28.58 %) and mineral contents—particularly iron (373.75 mg) and zinc (5.62 mg) (Table 5). Fibre may influence the structural matrix of the media, while the high mineral content likely enhances sporulation and pigmentation, critical traits for actinomycetes identification and industrial viability (Williams et al., 1993). Sugarcane bagasse and rice husk also supported notable actinomycete growth, producing colonies with varying morphologies, pigmentations (e.g. green, white, cream), and elevations. Rice husk demonstrated high carbohydrate (54.19 % – 54.27 %) and moderate ash content (8.40 % – 8.45 %), reflecting a considerable mineral presence that includes iron (238.13 mg) and phosphorus (330.75 mg). These findings corroborate earlier studies indicating that iron and phosphorus play significant roles in secondary metabolite production in actinomycetes (Demain & Sanchez, 2009). Sugarcane bagasse, with its high phosphorus content (1007.25 mg) and moderate carbohydrate levels (~74.1 %), produced both low- and high-elevation colonies with leathery and chalky textures, suggesting its supportive nature for diverse actinomycete phenotypes.

Cultural characteristics of actinomycetes grown on all agrowaste-based media closely mirrored those observed on conventional starch-casein agar (SCA), suggesting comparable effectiveness in supporting actinomycete growth. Morphologies observed such as powdery, leathery, and chalky textures; pigmentation in green, white, and cream; and varied elevations and surfaces (Table 2) align with typical Streptomyces traits (Hopwood, 2007). The ability of all four waste types to support these traits indicates their adequacy in sustaining actinomycete physiology and possibly antibiotic biosynthesis pathways.

Cost analysis (Table 3) further strengthens the case for agrowaste utilization. The formulated media from corn cob and starch cost ₦206.40 and ₦406.40, respectively, significantly lower than the ₦62,000 required for conventional media. This drastic reduction (over 99 %) underscores the economic viability of agrowaste substrates, especially in low-resource settings. Notably, the corn cob medium was the cheapest and also produced rich morphological diversity, making it a highly promising candidate for scale -up and industrial applications. The mineral analysis (Table 5) offers further insights into how specific micro-nutrients may influence actinomycete development. For example, zinc and iron, which were highest in corn cob, have been reported to play regulatory roles in enzyme activation and secondary metabolite gene clusters (Lyu et al., 2022; Weinberg, 2020). This could explain the intense pigmentation and elevated structures observed in corn cob-grown colonies.

From a broader perspective, this study contributes to circular bio-economy practices by enhancing the value into high-value biotechnological inputs. By integrating waste management with microbial biotechnology, this approach aligns with sustainable development goals (SDGs 12 and 13) and the global push toward green innovation in bio-production systems (FAO, 2013).

5. Conclusion

The bio-transformation of agro-industrial wastes into nutrient-rich media for actinomycetes cultivation represents a transformative shift in microbial biotechnology, offering both environmental and economic benefits. While actinomycetes are renowned for their ability to synthesize a wide array of bioactive compounds—including antibiotics, antitumor agents, and industrial enzymes—the cost and sustainability of their cultivation remain critical limitations. This research contributes to knowledge by advancing a low-cost, eco-friendly strategy to optimize actinomycetes growth, productivity, and metabolite expression through the utilization of agricultural wastes.

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