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Benefit-Cost Analysis of Tomato Processing Enterprises in Nigeria

[version 1]

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Abstract

Tomato processing has been promoted as a pathway for reducing post-harvest losses and strengthening domestic value addition in Nigeria's agri-food system. This study evaluates the economic viability of tomato processing enterprises in Kaduna and Oyo States using a 10-year Benefit–Cost Analysis framework. Primary data were collected from all identified processors within wholesale markets and processing clusters in the two states. Investment indicators—including Benefit–Cost Ratio (BCR), Net Present Value (NPV), and Internal Rate of Return (IRR)—were estimated to assess long-term profitability. Results indicate that tomato processing is economically viable for MSMEs. BCRs exceed unity across all categories: pooled sample (2.37), custom millers (15.31), regular processors (1.89), Kaduna (2.20), and Oyo (2.98), with positive NPVs confirming financial feasibility. However, IRRs (2.36–8.17%) fall below the assumed 10% discount rate, suggesting that, while profitable, returns may be insufficient to attract large-scale private investment without policy support. Important cross-state differences also emerge, with start-up costs and revenues are in Kaduna, and stronger relative returns (higher BCR) seen in Oyo. Custom millers (who process customers' tomatoes for a fee without owning the product) outperform regular processors in terms of capital efficiency. Overall, tomato processing is viable but constrained by scale, cost structure, and modest returns, indicating the need for supportive investment and market-stabilization policies.

Keywords
Tomato processing, Benefit-cost analysis, Kaduna, Oyo, Economic viability, MSMEs

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1. Introduction

Globally, approximately one-third of tomato production is said to be lost after harvest, with only about a quarter being processed.[1,2,3,4,5] Factors that explain this low rate of processing include inadequate logistics, poorly performing processing industries, substandard packaging, insufficient storage facilities, and underdeveloped marketing channels. In countries that rely partly on tomato imports, a high level of post-harvest loss widens the gap between supply and demand.[6,7,8]

Developing the processing capabilities within the agrifood value chain can plausibly reduce post-harvest losses in quantity and quality, thereby enhancing the benefits of increased production. The significance of processing as a critical node in the tomato value chain cannot be overstated. The processing node also has implications for a country's import dependency. Nigeria is the second-largest producer of fresh tomatoes in Africa.[9] At the same time, it ranks as the 13th largest importer of tomato paste globally and the third in Africa.[10] A robust processing sector can improve domestic supply and reduce the country's reliance on imported processed tomatoes. This strategy could therefore help Nigeria fully leverage its comparative advantage in tomato production.

However, the establishment of a tomato processing plant requires significant capital investment. Processors often make substantial investments in fixed capital, including processing plants and storage facilities, which are essential for handling perishable products like tomatoes.[11,12,13,14] For micro, small, or medium-sized enterprises (MSMEs) in Nigeria[1], this cost burden may be prohibitive.

To promote the growth of Nigeria's tomato processing industry, it is essential to understand the costs and revenues associated with MSMEs engaged in this industry. A detailed benefit-cost analysis can provide insight into the profitability and risks of tomato processing, helping policymakers identify key areas for support. This benefit-cost analysis of tomato processing enterprises in Nigeria fills a gap in the literature to inform policy design and support for this crucial segment of the tomato value chain.

This study examines the cost structure (both variable and fixed costs), revenue, and profitability of a typical tomato processor; evaluates the long-term investment performance of a representative 10-year enterprise using the Net Present Value (NPV), Benefit–Cost Ratio (BCR), and Internal Rate of Return (IRR); and analyzes how these metrics vary across processor types (regular processors versus custom millers; nano-scale versus micro/small-scale; men versus women) and across Oyo and Kaduna States.

2. Literature review

Processing is a crucial component of the development of the tomato value chain, particularly in countries like Nigeria with high production potential and a need to reduce post-harvest losses.[15] In areas where fresh tomatoes may be challenging to access or require considerable effort to obtain and preserve, processed tomato products such as tomato paste present a convenient alternative. These products can be easily purchased from stores, offering greater convenience to consumers—especially as more women enter the labour force and have limited time to source and preserve fresh foods.[16] Processed tomatoes, therefore, offer the utility of form, place, and time, catering to the evolving needs of urban households.

The COVID-19 pandemic has further exposed vulnerabilities in countries heavily reliant on food and agricultural imports, underscoring a need for shorter value chains that emphasize market flexibility and predictability and help producers minimize losses.[17] Addressing these challenges involves introducing new technologies and innovative solutions to improve infrastructure for fresh food markets and processing facilities, as well as enhancing post-harvest management and cold chain capacity.[17] This is in line with the World Bank 2030 agenda, in which processing is among the approaches recommended to transform food systems in order to reduce post-harvest losses.[18]

Food systems encompass all activities involved in the production and consumption of food, from farm to fork to landfill. This includes activities that produce, aggregate, process, distribute, consume, and dispose of food.[19] Unfortunately, one-third of all food produced globally is either lost or wasted, representing a significant economic loss and contributing to global greenhouse gas emissions.[20,21] In the absence of cold storage, surplus tomatoes will spoil unless they are preserved. However, processing allows fresh tomato to be kept for longer periods. Well-preserved tomato products can be kept for up to a year or more, depending on processing techniques and storage conditions.[22] Enhancing the

[1]According to the 2021–2025 National Policy, MSMEs are categorised based on employee numbers and investment amounts: Nano/Homestead enterprises, with 1–2 employees and a turnover of less than N3 million; micro enterprises: 3–9 employees and a turnover of N3–25 million; small enterprises: 10–49 employees and a turnover of 25+ but less than N100 million; and medium enterprises: 50–199 employees and a turnover of N100+ but less than N1 billion.

efficiency of food systems, particularly in the processing and distribution segments, is critical to reducing food loss and waste and ensuring sustainable food security.[18,23,24]

There are different types, levels, and forms of tomato processing/preservation being done in Nigeria.[15] Tomatoes have very high moisture content; without removing this moisture, they spoil rapidly, especially in tropical climates. To address this, tomatoes are sometimes dried, usually in slices laid out on the ground. This introduces a risk to food safety as the tomato product sometimes mixes with sand and other dirt. The process is weather-dependent and slow. In addition, this drying process can be laborious if done at the local level. Manual labour associated with drying tomatoes includes placing and rearranging the tomato slices, turning them to dry evenly, and protecting them from rain, night humidity, insects, and contamination from dust or dirt. These tasks are time-consuming and require ongoing hands-on attention.[25] Further value can also be added by grinding the dried tomato into powder. While costs are minimal when this is done at the household level, these activities require considerable capital investments in machinery if they are undertaken at a larger scale. Another popular type of processing in Nigeria is the production of tomato paste, which can be packaged in a sachet or a tin and is broadly accepted in the Nigerian market.[26]

There is a wide variety of tomatoes cultivated in Nigeria, but only a few are considered suitable for processing.[27] (When there is a limited supply of suitable tomatoes, processing may not be profitable because the use of unsuitable varieties undercuts the quality of the processed products. Quality traits in tomato varieties chosen for processing include taste, colour, flavour, nutrient content, and other industrial usefulness.[28]

Many authors have noted the importance of vertical coordination in the agri-food supply chain as a cost minimisation strategy.[29,30,31,32,33] Productive partnerships among tomato producers and processors are a kind of vertical integration characterised by collaboration among independent firms. The partners share interests as well as knowledge and resources to improve the outcomes of supply chain activity. This can take different organizational forms such as stable, long-term, and trust-based cooperation or contracts.[34] Vertical coordination in the tomato supply chain can take the form of tomato producers who produce only for a particular processing company for the sole aim of processing, and this is aimed at sustaining the flow of supply and quality.[35,36]

One of the main reasons that processors enter into contracts is the ability to control input supplies. Processors use contracts to achieve uniformity and predictability to suit consumers, but they also benefit from reduced costs in processing, packaging, and grading.[37,38,39,40] Theoretically, vertical coordination is more likely to favour large-scale farming. However, processors in many developing economies depend on many small-scale farmers for their tomato supply, thus incurring high costs to assemble the needed quantity to support production. Some studies have shown that wholesale traders most often bridge the gap by purchasing from small-scale farmers and supplying the processors with the needed quantity and quality.[41]

The global literature has established that the processing of tomatoes is capital-intensive because it involves various types of equipment and, like other enterprises in the food and beverage sector, it can sometimes consume a high amount of energy and water for various processes.[42] However, there is a dearth of focused assessments to ascertain whether tomato processing is worth the heavy investment, either on a small or large scale, especially in a developing economy like Nigeria. Notably, tomato production is seasonal, especially in many developing countries, including Nigeria. Coupled with small-scale production, as earlier highlighted, this may affect the profitability of a tomato processing firm.

Much of the existing literature on the tomato value chain in developing countries has focused on production and marketing. Research has predominantly examined production efficiency,[43] post-harvest losses,[44] and marketing strategies, with limited attention to the processing sector, and few studies address the profitability of processing.[45] A few studies have analysed the activities of the tomato processor by studying the importance of water use efficiency in tomato processing,[42] though this did not take the form of a comprehensive benefit-cost analysis. This study aims to fill this gap by conducting a rigorous assessment of the profitability of tomato processing enterprises in Nigeria. The general objective is to measure the overall profitability of tomato processing enterprises, with attention to start-up costs and durable investments in addition to variable costs.

A comparison among scale of production can help determine whether it is worthwhile to produce at a nano scale or micro/small scale, depending on the return on every N1 spent on investment. It is expected that the NPV, BCR, and IRR of micro/small scale processors will be far higher than at the nano scale level of production.

A comparison across geographies can indicate whether becoming a tomato processor is relatively more worthwhile (or even not worthwhile) in Kaduna and Oyo State. Processing investment in Kaduna benefits from abundant and cheaper raw

materials, making large-scale or semi-industrial processing more economically viable. On the other hand, raw material costs are typically higher in Oyo, which may reduce processing margins unless compensated by higher product prices.

A comparison across genders can shed light on whether becoming a tomato processor is more worthwhile for men or for women. A comparison across different types of processors can indicate whether it is preferable to become a custom miller (a processor that sells their processing services for a fee but does not ever own the product) or a regular processor (one that purchases and takes ownership of the tomato before processing and reselling it as processed product).

3. Materials and methods

3.1 The study area

The study area for this research was Oyo and Kaduna States in Nigeria (Figure 1). Oyo State is in southwestern Nigeria, with the capital city of Ibadan. It is the sixth most populated state in Nigeria, with a projected population of 7,976,100 in 2022. Oyo State has an equatorial climate with distinct wet and dry seasons. The dry season lasts from November to March, and the wet season lasts from April to October. It is 28,454 square kilometers in area, making it the 14th largest state in Nigeria. It is bordered by Kwara State to the north, Osun State to the east, Ogun State to the south, and the Republic of Benin to the west. The economy of Oyo State is primarily based on agriculture and handicrafts, and the main agricultural products include tomato, yams, corn, cassava, beans, millet, plantains, tobacco, cacao, palm oil, palm kernels, cotton, kola nuts, indigo, and fruits.

Kaduna State is located in northwest Nigeria and is one of the country's most prominent states in terms of landmass and population. It is the fourth largest state by area and the third most populous in Nigeria, with an estimated population of about 8.9 million people as of 2021. The state is widely recognized as a major hub for agriculture and trade and is often referred to as a "Centre of Learning" due to the presence of numerous educational institutions. Geographically, Kaduna State lies within the Guinea Savannah ecological zone and experiences a tropical climate characterized by distinct wet and

Figure 1. Study sites.

dry seasons. It shares boundaries with Niger, Zamfara, Katsina, Kano, Bauchi, and Plateau States, as well as the Federal Capital Territory, Abuja. The state is traversed by the Kaduna River, which supports agricultural activities, including tomato production and processing.

Both states were selected because of their important role in tomato production in their respective regions (APS, 2020) and to other regions (such as Kaduna supplying tomatoes to the South including Oyo State; and Oyo State farmers supplying the South, including major cities in the state such as Ibadan).

3.2 Sampling and data collection

This study is based on the universe of tomato processors identified in the two study states, Oyo and Kaduna. In each state, we listed all processors found in wholesale markets, as well as in processing clusters. This listing of tomato processors was supplemented by data from the Small and Medium Enterprise Development Association of Nigeria (SMEDAN) and the National Association of SMES (NASME) in each state, as well as various donor projects operating in the horticultural sector in each state. A snowball sampling method (applied to identified processors) was used to identify additional processors. The universe of identified tomato processors was included in the study, with a total sample of 317 (156 in Oyo, 161 in Kaduna). Questionnaire administration was done between June 2024 and February 2025 to each processor identified. The questionnaires collected detailed data on the tomato processors' business operations over the November 2023 to October 2024 reference period, making it possible to calculate their annual costs and revenues.

The sampling exercise revealed two distinct types of processors: regular processors (196 out of 317) and custom millers (121 out of 317). Regular processors procure raw tomato and transform the produce into various value-added forms such as dried tomatoes, paste, and chopped products for onward sale. In contrast, custom millers function as service providers. Equipped with milling and blending machinery, they process tomatoes on behalf of clients who supply their own raw produce. Their revenue is fee-based and confined strictly to processing services, without engagement in raw material procurement or product marketing.

3.3 Benefit-Cost analysis

Benefit-cost analysis (BCA) is a decision-making tool that aids in evaluating the economic feasibility of an investment by assessing the costs and comparing them to the benefits.[46] BCA is used in investigating and evaluating a project or investment to maximise allocative efficiency,[47] and the BCA process entails producing a discounted stream of costs and benefits over a certain time period. These values can be combined to calculate the Net Present Value (NPV) and the benefit-cost ratio (BCR) of a project or investment.[48] The NPV can also be used to determine which investment (or variation of an investment) performs better among several alternatives when they all have positive NPV. The investment with the largest NPV is considered to be the best.[47]

The data on tomato processors in Oyo and Kaduna States are analysed using BCA. Three decision metrics of profitability were used, namely NPV, BCR, and Internal Rate of Return (IRR).

The NPV is the value of the discounted future net benefits.[47] A project or adaptation practice with an NPV > 0 is deemed viable and should be adopted. A project is rejected if otherwise (i.e., NPV < 0). The functional model is given as:

$$\text{NPV} = \sum_{t=0}^{n} \frac{CF_t}{(1+i)^t}$$

where CF_t= Cash flow in year t.

i = Discount rate

The discount rate is an important parameter used in BCA. It captures the time value of a reward—in other words, how much reward at hand would equal a promised reward at a future time.[49] Analysts discount future costs and benefits so that all costs and benefits are in a common metric—the present value.[47] The discount rate is generally higher in lower-income settings, where people need to prioritize their current needs over a future reward. These relatively high discount rates capture liquidity constraints and stronger preferences for present consumption over future gains.[47] In Nigeria, private investment discount rates commonly range between 15% and 30%, reflecting high lending rates, inflation volatility, and macroeconomic risk. Public-sector appraisals, however, typically apply lower social discount rates between 8% and 15%.

The IRR is the discount rate which gives the project an NPV of zero. The IRR can then be compared with the predetermined discount rate. The decision rule is to consider implementing a project (or establishing an enterprise) if the calculated IRR is greater than the predetermined discount rate (IRR>i).

The Benefit Cost Ratio (BCR) measures the viability of a business venture. BCR will be estimated as in the equation below:

$$BCR = \frac{\sum_{t=0}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t=0}^{n} \frac{C_t}{(1+i)^t}} = \frac{\text{Discounted Revenues}}{\text{Discounted Costs}}$$

The decision rule, in this case, is similar to that of NPV, where an enterprise is deemed worthwhile if the ratio is positive and greater than 1. This implies that the benefits realised can completely offset the costs incurred, with some residual benefits.

3.4 Model structure

The BCA in this paper is based on a 10-year time horizon for a typical tomato processor in our study site. Key parameters include start-up costs, variable costs (including the cost of tomato inputs), and revenues (income from the sale of processed tomato products). In each case, the mean value was used to generate parameters that characterize a "typical" tomato processor enterprise.

Noting that tomato processors seem to operate on a smaller scale when they are very young (as will be demonstrated in section 5), the model assumes that the processor incurs one-third of the average annual costs and receives one-third of the average annual benefits in the first year of the enterprise's lifespan. For year 2, the processor incurs two-thirds of the average annual costs and sees two-thirds of the average annual benefits. For years 3 through 10, the full values of these two parameters are used.

Respondents reported their fixed costs as of the year each cost was incurred. To undertake a BCA, all historical expenditures were inflated to 2024 naira such that year 0 of the modelled enterprise was 2024, and the model extends from 2024 to 2034. At the 5-year mark, halfway through the enterprise's modelled lifespan, the enterprise replaces 50% of its purchased equipment (i.e., it incurs a cost in this year that is 50% of the value of any start-up costs).

As noted, in estimating the cash flow of an enterprise, there are fixed costs associated with long-term operation. All purchased processor equipment/vehicles are depreciated using a rule-of-thumb that 10% of the remaining value is lost each year. In year 10 (the final year of the enterprise's modelled operations), a "salvage value" is calculated for all purchased equipment and vehicles. This is the value of the item that remains after 10 years, and it enters the model as a benefit in the final year.

As noted, a key parameter in any BCA is the discount rate, or the rate at which future streams of income are discounted in the eyes of the business owner. We follow the example of Akinyi et al.[46] and use a discount rate of 10% for Nigeria. This value reflects an appropriate social opportunity cost of capital in a developing-country context. In development economics, discount rates used for project appraisal typically range between 8% and 15%, particularly where the analysis evaluates medium-term productive investments with broader economic and social implications rather than purely private commercial returns. A 10% rate balances the need to account for time preferences and capital scarcity while avoiding the distortion that excessively high market lending rates may introduce in smallholder and MSME-level agrifood investments. It is widely applied in cost–benefit analysis of agricultural and rural development projects, especially in low- and middle-income countries, where it approximates the social opportunity cost of capital rather than short-term commercial borrowing costs.[47,50,51] Using 10% therefore ensures comparability with established development appraisal standards while providing a conservative yet realistic benchmark for evaluating the long-term viability of tomato processing enterprises over the 10-year investment horizon.

4. Results

4.1 Descriptive analysis

4.1.1 Characteristics of processors and enterprises

The descriptive results indicate a clear gender and spatial pattern in tomato processing activities across the study areas (Table 1). Overall, male processors dominate the sector, with a higher concentration observed in Kaduna State (94% male). In contrast, Oyo State records a higher proportion of female processors (62% female). Custom millers also show a higher concentration of female processors (55% female) compared to regular processors (20% female). In Kaduna, it is very rare to find any female regular processors (1%), whereas in Oyo, about half (52%) of the regular processors are female. In Kaduna, custom millers are 21% female, whereas this value is 71% for custom millers in Oyo. This distribution reflects regional and cultural differences in processing roles within the tomato value chain.

Table 1. Basic characteristics of tomato processors.

	All	Processor type		State		Gender		Scale of enterprise	
		Regular processors	Custom millers	Kaduna	Oyo	Male	Female	Nano	Micro/ small
Gender of ownership (%)									
Male only	66	80	43	94	38	100	0	64	71
Female only	33	20	55	5.6	62	0	98	35	29
Male and female[a]	0.63	0	1.7	0.62	0.64	0	1.9	0.96	0
Age (mean)									
Age of owner (years)	43	43	43	40	46	41	47	42	45
Education (%)									
Completed primary school	89	87	92	83	95	86	93	89	88
Completed secondary school	50	46	58	42	60	48	55	51	50
State (%)									
Kaduna	51	63	31	100	0	72	9.3	53	46
Oyo	49	37	69	0	100	28	91	47	54

[a]Jointly (male and female) owned businesses are classified as female-owned when the sample is disaggregated by gender. This is because, in both cases, a female was the respondent for the survey.

The mean age of processors across all categories is approximately 43 years, placing them within Nigeria's economically active population. This suggests that tomato processing is largely undertaken by individuals in their productive years, who are capable of making meaningful contributions to the agro-processing subsector and the broader economy.

In terms of educational attainment, the majority of processors possess basic formal education: about 89% have completed primary education, while approximately 50% have attained secondary education. Female processors were found to be relatively more educated than their male counterparts, a factor that may influence enterprise management decisions, technology use, and processing choices.

Multiple tomato processing methods were identified in the study (Table 2), with sun-dried tomato processing undertaken by the largest share of processors in the sample (56%). Dried tomato products are more commonly produced in Kaduna State in northern Nigeria; this is due to a surplus of fresh tomato supply and favourable climatic conditions characterized by abundant sunshine and lower humidity, which facilitates sun-drying. Conversely, blended or ground tomato processing, largely undertaken through custom milling, was more prominent among female processors in Oyo State. This pattern may be attributed to prevailing socio-cultural norms in southern Nigeria, where tomato blending is commonly perceived as a market- and neighbourhood-based activity traditionally carried out by women.

The scale distribution reveals that more than half of the processors operate at the nano level, with some in the micro category and very few in the small-scale category. This underscores the predominantly small-scale and informal nature of tomato processing enterprises in the study area.

4.1.2 Start-up cost analysis

Start-up costs for a tomato processing enterprise include the costs associated with license and registration, as well as any equipment or other assets that are purchased. The average start-up costs of tomato processors are presented in Table 3. These results reveal notable variation across processor types, locations, gender, and scale of operation. Regular processors require higher start-up capital compared to custom millers, with start-up costs generally higher in Kaduna

Table 2. **Characteristics of tomato processing business.**

	All	Processor type		State		Gender		Scale of enterprise	
		Regular processors	Custom millers	Kaduna	Oyo	Male	Female	Nano	Micro/small
Type of processor (%):									
Regular processor (purchases and sells)	62	98	0	76	47	74	37	56	72
Custom miller	37	0	100	22	53	24	63	43	26
Both regular processor and custom miller[a]	0.95	1.5	0	1.2	0.64	1.4	0	0.48	1.9
Products produced (%):									
Blended/Ground tomato	38	3	96	24	52	25	62	43	28
Pureed tomato	1.6	2.5	0	1.9	1.3	0.48	3.7	0.96	2.8
Oven-dried tomato	3.2	4.5	0.85	5	1.3	4.3	0.93	4.3	0.93
Sun-dried tomato	56	87	2.5	65	46	67	34	49	69
Chopped tomato	3.2	4.5	0.85	6.2	0	4.8	0	4.3	0.93
Other forms of tomato	2.2	3	0.85	3.7	0.64	2.9	0.93	2.4	1.9
Scale of processor (%):									
Nano (1–2 permanent workers)	66	60	76	69	63	63	71	100	0
Micro (3–9 workers)	32	37	24	28	37	34	28	0	94
Small (10–49 workers)	1.9	3	0	3.1	0.64	2.4	0.93	0	5.6
Seasonality (mean values):									
Months operational in "peak season"	4.7	4.8	4.5	4.9	4.4	4.9	4.3	4.7	4.5
Months operational in "lean season"	3.8	4.1	3.4	4.2	3.5	4.0	3.5	4.0	3.6

[a]Businesses that are both regular and custom millers are classified as regular processors when the sample is disaggregated by processor type.

Table 3. Start-up costs (mean values, naira).

	All	Processor type		State		Gender		Scale of enterprise	
		Regular processors	Custom millers	Kaduna	Oyo	Male	Female	Nano	Micro/ small
License and registration	25,687	17,172	40,048	22,415	29,065	29,801	17,613	26,307	24,488
Assets (purchased)									
Scales	5,869	9,348	0	3,223	8,599	1,887	13,683	1,822	13,700
Blenders (grinder/milling machine)	156,210	28,650	371,331	86,483	228,171	126,986	213,563	137,349	192,708
Racks (and tarpaulin)	5,411	8,462	266	4,062	6,803	7,390	1,528	3,496	9,119
Furniture	42,158	48,055	32,213	54,796	29,115	44,048	38,450	34,188	57,582
Baskets/crates/sacks	74,447	97,459	35,637	105,500	42,398	92,667	38,687	63,155	96,298
Phones	51,763	56,395	43,952	36,344	67,677	45,899	63,272	53,355	48,684
Other electronics	5,670	9,032	0	11,101	65	93	16,616	8,469	253
Ovens	105	167	0	0	213	0	310	0	308
Generators	873	1,390	0	0	1,774	1,318	0	0	2,562
Other tools/equipment	30,471	43,914	7,800	50,580	9,717	5,117	80,231	36,286	19,218
Other assets (excl. vehicles)	2,348	3,640	170	3,273	1,394	959	5,074	2,310	2,421
Vehicles	340,403	538,481	6,356	570,138	103,304	238,859	539,695	325,853	368,560
TOTAL	**741,415**	**862,165**	**537,773**	**947,915**	**528,295**	**595,024**	**1,028,722**	**692,590**	**835,901**

Table 4. Distribution of start-up costs (%).

	All	Processor type		State		Gender		Scale of enterprise	
		Regular processors	Custom millers	Kaduna	Oyo	Male	Female	Nano	Micro/ small
License and registration	3.5	2.0	7.4	2.4	5.5	5.0	1.7	3.8	2.9
Assets (purchased)									
Scales	0.8	1.1	0.0	0.3	1.6	0.3	1.3	0.3	1.6
Blenders (grinder/milling machine)	21.1	3.3	69.0	9.1	43.2	21.3	20.8	19.8	23.1
Racks (and tarpaulin)	0.7	1.0	0.0	0.4	1.3	1.2	0.1	0.5	1.1
Furniture	5.7	5.6	6.0	5.8	5.5	7.4	3.7	4.9	6.9
Baskets/crates/ sacks	10.0	11.3	6.6	11.1	8.0	15.6	3.8	9.1	11.5
Phones	7.0	6.5	8.2	3.8	12.8	7.7	6.2	7.7	5.8
Other electronics	0.8	1.0	0.0	1.2	0.0	0.0	1.6	1.2	0.0
Ovens	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Generators	0.1	0.2	0.0	0.0	0.3	0.2	0.0	0.0	0.3
Other tools/ equipment	4.1	5.1	1.5	5.3	1.8	0.9	7.8	5.2	2.3
Other assets (excl. vehicles)	0.3	0.4	0.0	0.3	0.3	0.2	0.5	0.3	0.3
Vehicles	45.9	62.5	1.2	60.1	19.6	40.1	52.5	47.0	44.1

State than in Oyo State. Start-up investment is also higher among women than men and among micro/small-scale processors compared to nano-scale operators.

Across all categories, expenditure on vehicles constitutes the largest proportion of start-up costs, followed by the purchase of grinders/blenders and baskets (Table 4). Regular processors incur higher vehicle-related costs due to the need to transport fresh tomatoes from farms or markets, whereas custom millers allocate a greater share of their start-up capital to grinders and blenders, which are central to their operations.

In Kaduna State, a larger proportion of start-up costs is devoted to vehicles, reflecting the dominance of regular processors in the state. Both male and female processors allocate substantial portions of their start-up capital to vehicles and grinding equipment. Notably, no expenditures on ovens were recorded across all categories, indicating minimal reliance on mechanized drying technologies.

4.1.3 Variable cost analysis

The variable cost structure also differs significantly across processor categories (Table 5). Regular processors incur, on average, 19 times the variable costs of custom millers, primarily due to expenditures on tomato purchase and vehicle rental. Variable costs are also higher in Kaduna State than in Oyo State, reflecting the larger number of regular processors in Kaduna. Additionally, male processors incur higher variable costs than female processors, largely because men are more engaged in regular processing activities that involve tomato procurement.

Micro and small-scale processors record higher variable costs than nano-scale operators, consistent with their larger scale of operation. Custom millers spend relatively more on packaging materials, electricity or fuel, and labour, while regular processors incur higher costs for vehicle rental after tomato inputs.

An examination of the annual variable cost composition shows that tomato inputs, labour, and vehicle rental are the major cost components for most processors (Table 6). However, for custom millers, packaging materials and energy costs are more prominent. This reflects the need for appropriate packaging to deliver blended tomato products and the energy requirements of milling and blending machines.

Table 5. Annual variable costs (mean values, naira).

	All	Processor type		State		Gender		Scale of enterprise	
		Regular processors	Custom millers	Kaduna	Oyo	Male	Female	Nano	Micro/ small
Labor (casual)	627,415	943,430	94,474	783,947	465,865	679,016	526,140	584,107	711,222
Labor (long-term)	317,648	462,078	74,075	540,909	87,231	145,345	655,813	16,077	901,244
Vehicle rental	1,404,266	2,196,585	68,068	2,498,350	275,116	2,048,445	139,989	1,302,427	1,601,344
Other recurring costs									
Taxes and license renewal	17,785	26,642	2,848	32,381	2,721	25,487	2,670	13,065	26,919
Workspace rental	105,597	140,115	47,385	165,158	44,128	131,714	54,340	41,213	230,193
Electricity, water, diesel	79,376	40,705	144,592	47,779	111,985	48,240	140,483	79,378	79,371
Ingredients (besides tomato_	516	702	203	979	38	750	56	714	133
Maintenance	49,481	38,055	68,750	37,211	62,144	37,307	73,375	48,144	52,069
Other bills (insurance, telephone)	30,405	42,241	10,446	38,784	21,758	25,482	40,067	32,554	26,248
Packaging materials, ice, and other	278,864	391,669	88,624	437,991	114,636	130,886	569,288	328,680	182,459
Tomato inputs	4,437,478	7,068,747	0	6,831,098	1,967,140	5,777,079	1,808,355	3,870,189	5,535,287
TOTAL	7,348,831	11,350,969	599,464	11,414,588	3,152,761	9,049,751	4,010,576	6,316,548	9,346,490

Table 6. **Distribution of annual variable costs (%).**

	All	Processor type		State		Gender		Scale of enterprise	
		Regular processors	Custom millers	Kaduna	Oyo	Male	Female	Nano	Micro/ small
Labor (casual)	8.5	8.3	15.8	6.9	14.8	7.5	13.1	9.2	7.6
Labor (long-term)	4.3	4.1	12.4	4.7	2.8	1.6	16.4	0.3	9.6
Vehicle rental	19.1	19.4	11.4	21.9	8.7	22.6	3.5	20.6	17.1
Other recurring costs									
Taxes and license renewal	0.2	0.2	0.5	0.3	0.1	0.3	0.1	0.2	0.3
Workspace rental	1.4	1.2	7.9	1.4	1.4	1.5	1.4	0.7	2.5
Electricity, water, diesel	1.1	0.4	24.1	0.4	3.6	0.5	3.5	1.3	0.8
Ingredients (besides tomato_	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maintenance	0.7	0.3	11.5	0.3	2.0	0.4	1.8	0.8	0.6
Other bills (insurance, telephone)	0.4	0.4	1.7	0.3	0.7	0.3	1.0	0.5	0.3
Packaging materials, ice, and other	3.8	3.5	14.8	3.8	3.6	1.4	14.2	5.2	2.0
Tomato inputs	60.4	62.3	0.0	59.8	62.4	63.8	45.1	61.3	59.2

Table 7. **Average quantities produced and prices received, by product.**

		Mean values	
	Number of observations	Quantity produced (kg)	Price or fee per kg (naira)
Blended/Ground tomato	119	25,702	618
Pureed tomato	5	2,926	2,000
Oven-dried tomato	10	27,720	2,662
Sun-dried tomato	176	15,849	3,204
Chopped tomato	10	9,690	2,626
Other forms of tomato	7	38,616	1,249

Note: Some processors produced multiple products.

4.1.4 Revenue analysis

Production output varies considerably across processing types (Table 7). Sun-dried tomato processors record the highest average output, producing approximately 15,849 kg per processor at an average price of ₦3,204 per kilogram.[2] In contrast, blended or ground tomato processors produce an average of 25,702 kg per processor at ₦618 per kilogram. These differences likely reflect consumer preferences across northern and southern markets, as well as differences in product form, shelf life, and pricing.

Despite differences in production processes and costs, net revenues (exclusive of fixed costs) for regular processors and custom millers are broadly comparable (Table 8), indicating that custom milling is not an inferior or less profitable

[2]The exchange rate in 2024 was ₦1,478.97 = $1.

enterprise option. Processors in Kaduna State record over two times higher revenues than in Oyo State, attributable to higher levels of investment and larger-scale operations. Male processors earn higher revenues than female processors, consistent with their higher variable costs and greater involvement in regular processing activities. Net revenues for nano and micro/small-scale processors are also similar, even though micro/small-scale processors incur higher variable costs. A calculation of net revenue as a percent of total revenue indicates that, for all processors, this value is 59.6%. However, for custom millers, this value is considerably higher at 94.6%.

Average net revenues vary according to the age of the enterprise, as illustrated in Figure 2. While the pattern fluctuates (especially after ten years), this figure shows that very young enterprises tend to see smaller net revenues than those that are more established. This justifies our modelling decision to have the "typical" tomato processing enterprise incur one

Table 8. Average annual revenues and net revenues.

		Mean values (naira)			
		Variable costs	Total Revenue	Net revenue (exclusive of fixed costs)	Net revenue relative to total revenue (%)
All		7,348,831	17,840,870	10,638,297	59.6
Processor type	Regular processors	11,350,969	21,789,330	10,438,362	47.9
	Custom millers	599,464	11,182,026	10,582,562	94.6
State	Kaduna	11,414,588	25,657,654	14,243,066	55.5
	Oyo	3,152,761	9,773,548	6,620,787	67.7
Gender	Male	9,049,751	22,186,866	13,137,114	59.2
	Female	4,010,576	9,311,346	5,300,770	56.9
Scale of enterprise	Nano	6,316,548	16,733,008	10,416,461	62.3
	Micro/small	9,346,490	19,984,788	10,638,297	53.2

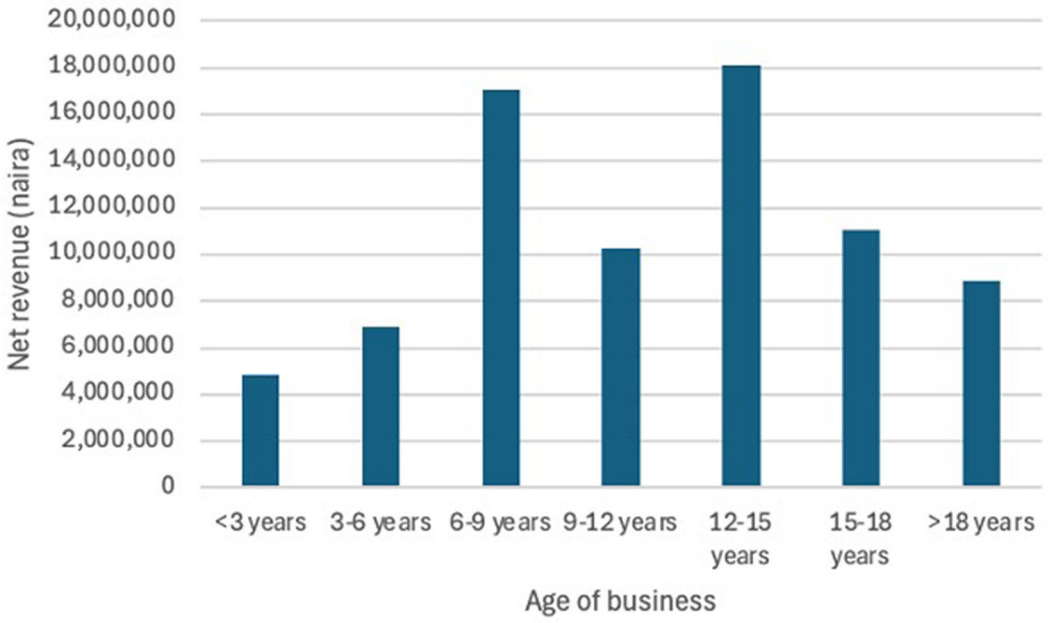

Figure 2. Average annual net revenue by age of business.

Table 9. Net present value and internal rate of return for a typical 10-year tomato processing enterprise.

		Net present value	Benefit-cost ratio	Internal rate of return (IRR)
All		54,262,853	2.37	5.50
Processor type	Regular processors	53,819,919	1.89	4.81
	Custom millers	54,980,522	15.31	7.37
State	Kaduna	73,729,1332.58	2.20	5.80
	Oyo	34,172,650	2.98	4.95
Gender	Male	68,334,249	2.41	8.17
	Female	26,646,102	2.19	2.36
Scale of enterprise	Nano	53,923,254	2.58	5.80
	Micro/small	54,920,036	2.09	5.02

third of the average costs and one third of the average benefits in year 1 of the enterprise's lifespan and two thirds of these values in year 2, while the complete average values are used for years 3–10.

4.2 Benefit-Cost analysis

The average values for startup costs in year 0, variable costs in years 1–10, and revenues in years 1–10 are used as parameters in a benefit-cost analysis. As noted earlier, startup costs are incurred in year 0 before the enterprise begins operating. The enterprise operates at a reduced level in years 1 and 2 before building up to full operation in years 3–10. At year 5, the enterprise replaces half of its purchased assets, and at year 10, the ownership of the enterprise retains a depreciated value of its purchased assets, which is counted as a benefit in the final year. The discount rate used is 10%.

As shown in Table 9, the net present value (NPV) of a 10-year tomato processing enterprise in our study sites is ₦54.3 million. That this is a positive value indicates that tomato processing is profitable in Nigeria, even when accounting for fixed costs. The internal rate of return (IRR) for the "typical" processor is 5.5. In settings where capital can readily be redirected towards its most profitable use, a standard rule-of-thumb is to pursue an investment if the IRR exceeds the weighted cost of capital, which is about 10% in Nigeria.[52] By this rule, tomato processing is not a preferable investment. However, we observe that tomato processors rarely draw on bank loans to fund their startup costs and do not generally engage with capital markets. In this setting, the IRR can be another metric to decide between different investments or different business structures, with a higher IRR being preferable.

The benefit-cost analysis results further reveal that male processors, custom millers, processors in Kaduna State, and nano-scale operators record higher IRRs, in that order. The NPV estimates are positive across categories, and a comparison by subgroup suggests that custom milling outperforms regular processing, micro-scale operations outperform nano-scale operations, Kaduna State outperforms Oyo State, and male processors outperform female processors in terms of investment returns. Across all categories investigated, the NPV is lowest for women processors and for those operating in Oyo State.

The Benefit–Cost Ratio (BCR) estimates in Table 9 indicate that tomato processing enterprises in the study area are economically viable across all categories examined, as all BCR values exceed one. A BCR greater than one implies that the discounted benefits of tomato processing outweigh the associated costs, confirming profitability and investment attractiveness. For all processors, the BCR of 2.37 indicates that every ₦1.00 invested in tomato processing yields an average return of ₦2.37, reflecting strong overall investment performance within the sector. Regular processors recorded a BCR of 1.89, while custom millers exhibited a substantially higher BCR of 15.31, suggesting higher benefit–cost efficiency for custom milling operations. Across the geography, processors in Kaduna state recorded a BCR of 2.20, whereas those in Oyo state achieved a higher BCR of 2.98, indicating that tomato processing is profitable in both locations, with relatively stronger benefit–cost performance observed in Oyo State. Gender-disaggregated results show that male processors recorded a BCR of 2.41, while female processors achieved a BCR of 2.19. Both values exceed one, indicating economic viability for both genders, with a marginally higher benefit–cost ratio among male processors. Looking at the scale of operation, nano-scale processors recorded a BCR of 2.58, compared to 2.09 for micro/small-scale processors. This suggests that smaller-scale processors derive relatively higher returns per unit of cost than their micro/small-scale counterparts. Overall, the BCR results demonstrate that tomato processing is a profitable enterprise across processing types, geographic locations, gender groups, and enterprise scales within the study area.

5. Discussion

The analysis of tomato processing enterprises in the study area reveals several important insights into the economic dynamics and investment potential of small- and medium-scale processing. These findings have implications for policy, market development, and technology adoption in agro-processing value chains in Nigeria.

The relatively low start-up costs identified for tomato processing enterprises in the study area suggest that entry into the business is accessible to a wide range of actors, including, for example, smallholder farmers, youth, and women entrepreneurs. This is in line with FAO,[19] which states that limited capital barriers lower the threshold for participation and expand the pool of potential investors, contributing to inclusive economic growth. However, this is contrary to others,[11,12,13] who suggest that agro-processing enterprises in many parts of Africa face prohibitive capital requirements due to expensive machinery and infrastructure. The observed cost structure in Kaduna indicates that processors can begin operations with minimal equipment and other fixed costs. This accessibility, combined with the positive profit margins seen in this study, supports the notion that tomato processing is not only commercially feasible but also moderately profitable in the current market context.

Electricity-related costs are marginal among the processors surveyed, with energy use largely restricted to custom milling activities. This pattern underscores the reliance on manual and small-scale mechanical operations, rather than intensive, mechanized processing technologies. Notably, none of the processors in the study invested in dryers or ovens, which are necessary to produce higher-value products like sun-dried tomato slices or tomato powders. Previous studies of the Nigerian agro-processing sector have highlighted the challenges of electricity reliability and high energy costs, which discourage investment in mechanized drying technologies.[53] The absence of such investments in this study can be interpreted as a rational response to inconsistent power supply, which would make large-scale mechanized drying economically unattractive in the short term.

The limited adoption of mechanized drying technologies is somewhat contrary to a narrative of rapid transformation in Nigeria's agri-food sector and furthermore has implications for product diversification. While traditional sun drying remains common and cost-effective, it is weather-dependent and yields products with shorter shelf-life compared to oven- or solar dryer-processed products.[54] Future interventions that enhance access to affordable, efficient energy solutions, such as solar dryers or community-shared processing hubs, could significantly enhance product quality.

The cost–benefit analysis reveals that both nano-scale and micro/small-scale tomato processing enterprises showed positive Net Present Value (NPV) and Internal Rate of Return (IRR), indicating financial viability across different scales of operation. Positive NPVs demonstrate that the present value of future net cash inflows surpasses the initial investment cost, while an IRR above the prevailing discount rate would confirm that these enterprises generate returns exceeding the cost of capital.[55] The findings of this study are consistent with evidence from similar agro-processing contexts in sub-Saharan Africa, where even small-scale processing units demonstrate profitability when market linkages are strong and processing costs are contained.[56] The consistency of positive investment indicators across scales supports the tomato processing enterprise as a sustainable livelihood activity and suggests that scaling up when strategically planned can further enhance economic outcomes for processors. At the same time, the rate of return likely needs to increase if tomato processing is to be an attractive investment among agri-food entrepreneurs.

The analysis further highlights that custom millers achieve net revenues comparable to those of regular processors, suggesting that custom milling is a viable and competitive processing option. Custom milling, where processors charge fees to process tomatoes for third parties, allows operators to generate income streams without bearing the full market risk of product marketing and sales. The competitive performance of custom millers in the study area illustrates the viability of diversified enterprises within the tomato value chain and underscores the importance of service-oriented processing.

The observed gender patterns in processing activities indicate greater participation by women in custom milling, which aligns with both economic rationality and existing literature on gender in agro-processing. Women's strong representation in custom milling can be attributed to its relatively lower capital requirements and operational flexibility, which reduce entry barriers for women who may face constraints in accessing finance and productive assets.[57] This pattern is consistent with other authors,[58,59] who reiterate that women in agribusiness tend to engage in segments of value chains that require lower fixed capital and allow for part-time operation alongside household responsibilities. The comparable profitability of custom milling enhances women's economic agency and suggests that targeted support, such as access to micro-credit and business training, could further strengthen women's participation and empowerment in tomato processing.

Although structural cost differences exist between Kaduna and Oyo States, the cost–benefit indicators (Benefit–Cost Ratio, NPV, and IRR) remain positive, and profitability levels are comparable across both states**.** This finding suggests that geographic variations in cost structures, possibly driven by differences in input prices, labour costs, and logistical

factors, may not translate into substantial differences in investment efficiency. Instead, processors in each location appear to adapt their cost allocations to local conditions, enabling them to remain financially viable. The ability of enterprises in both states to maintain a positive performance demonstrates resilience and suggests that broader policy support, such as infrastructure improvement and access to finance, could further enhance investment attractiveness across regions.

6. Conclusion

This study examined the economic viability of tomato processing enterprises in Nigeria using a cost–benefit analysis, with particular attention to enterprise scale, processing type, gender, and geographic location. The findings demonstrate that tomato processing is a profitable and financially viable activity across all categories of processors considered. The consistently positive Net Present Values (NPVs), and Benefit–Cost Ratios (BCRs) above a value of 1 indicate that investments in tomato processing generate returns that exceed their associated costs, regardless of scale or location. However, Internal Rates of Return (IRRs) (2.36–8.17%) fall below the assumed 10% discount rate, suggesting that while profitable, returns may be insufficient to attract large-scale private investment without policy support.

Overall, the study shows that strengthening MSME-level tomato processing in Nigeria can play a critical role in reducing post-harvest losses, improving the domestic supply of processed tomato products, and reducing Nigeria's dependence on imports. Given the scale of post-harvest losses and growing food security concerns, policy interventions that ensure reliable energy and make available appropriate processing technologies particularly for nano and micro-scale enterprises are essential. By supporting the tomato processing enterprise, Nigeria can better leverage its comparative advantage in tomato production, enhance value addition, and realize a future of greater national food security.

Ethical approval and consent statement

All studies in this project involving humans were approved by Michigan State University Institutional Review Board and were conducted in accordance with the local legislation and institutional requirements. This project has the Michigan State University IRB Study ID: STUDY00007403 and was determined exempt Category: Exempt 2ii. The participants provided their written informed consent to participate in this study.

Data availability statement

Data will be made available on request.

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