# A case-study approach to profitability assessment in fermented African locust beans (*iru*) production using break-even analysis

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**Abstract:** The significance of a break-even point and sensitivity analyses are much important to the small- scale enterprises in determining profit or loss incurred and input-and-output relationship, respectively. In this study, a case study approach was used to test these concepts on *iru* production using structured oral interviews and visual observation of a production centre in Nigeria. Data analysis was achieved using production cost, the unit quantity and break-even analysis. The results showed that the monthly average cost of ₦32,237 the monthly average variable cost of ₦71,334 Contribution Margin Ratio (CMR) of 47.06% and break-even sales of ₦ 68,502 were obtained using a Traditional *Iru* Production Process (TIPP). In a Mechanized *Iru* Production Process (MIPP), monthly average fixed cost of₦85,887 the monthly average variable cost of ₦55,000, monthly average sales of₦141,500 CMR of 61.13% and break-even sales of₦140,499 were obtained. High CMR value of MIPP to TIPP signifies a higher level of safety in the enterprise. Also, the graphical methods revealed that MIPP is best option to choose by the processor for the large-scale productions since the process took lesser production costs, yields more outputs and gave more profits at any point above BEP compare to TIPP counterpart. Thus, the enterprise earns more profit from *iru* production at any point above the equilibrium point (break-even point) with the use of a processing machine. The results from sensitivity analysis have good agreement with results from break-even point analysis. Hence, the research could serve as a reference point to promote mechanization for improving *iru* production.

**Keywords**: locust bean-processing, traditional, mechanized, break-even analysis, sensitivity analysis, production cost, profitability.

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## 1 Introduction

Break-even point (BEP) analysis is a classical management accounting tool to quantify the amount of product needed to be covered and sold in other to meet the total fixed costs of production in small-scale business (Kucharski and Wywial, 2019). BEP is determined with simple mathematics or using a graphical method (Gutierrez and Dalsted,1990; Kampf *et al.*,2016). The graphical method of analysis BEP gives a better understanding of the concept, faster and more accurate, though, plotting the cost and income lines is tedious and laborious (Gutierrez and Dalsted, 2016). BEP analysis applies to both homogeneous and heterogeneous products. In the case of former products, sale calculations and BEP determination are easy with the use of mathematical formula (Kucharski and Wywial, 2019; Kampf *et al*., 2016):

$$Q = F / (P - C) = F / M \qquad (1)$$

Where, $Q$ stands for BEP, $F$ denotes total fixed costs,

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$P$ denotes unit selling price,$C$ denotes the unit cost of production, and$M$ denotes margin per unit.

Complication set-in with an application of break-even analysis to heterogeneous products as demonstrated using econometric modeling methods (Kucharski and Wywial, 2019). Extensive research works are also required, thus calculations become complex in the scope of later products. However, Garrison *et al.* (2012) presented a most popular approach to determine the overall BEPs in sales revenue as a ratio of the total fixed costs divided by the weighted average value of contribution marginal ratio, and then distribute the break-even sales proportionally to the sales. Syrůček *et al.* (2018) reported profitability and BEPs in Suckler cow herds.

Given the strength and weakness of break-even analysis, BEP is an accepted decision-making tool to consider for the design process of a product in a small-scale industry or energy system modeling in terms of break-even costs (Nasution and Pramana, 2019). In agricultural mechanization, break-even analysis is a useful guide which helps farmers to choose between machinery ownership and conventional hiring through the calculation of BEP units for different types of agricultural field machinery (Kadhim *et al.,* 2018). It is an important step needed to be followed before finalizing the design and production phase to ensure the sustainability of the industry or organization. In the cost analysis, break-even analysis (BEA) serves as a market study for investigating potential risks in a small-scale enterprise (Nasution and Pramana, 2019). Furthermore, Break–even point (BEP) provides information that determines the requirements to achieve more profit in terms of unit price and a corresponding number of units produced, or vice versa. Also, BEP could give information that correlates between cost and revenue in determining business profitability (Nasution and Pramana, 2019). Break-even analysis is conceptually simple and comparatively easy to apply in small-scale business practice (Kucharski and Wywial, 2019). As the analysis revealed the relationship between cost, production volume and returns generated in a business organisation. BEP analysis also indicates the lowest amount of business activity important to prevent losses (Gutierrez and Dalsted, 1990). Conversely, BEP is only best suitable for cost analysis of a product at a time. As arises in the classification of different variable and fixed costs for many products at a time. Since, cost and income functions are not fixed; thus, the result of break-even analysis is subjected to continuous changes.

## 2 Review of related studies

In other works of literature, Niu *et al*. (2016) applied Break-Even Analysis to Poultry Egg Production in Rural Area in South East, Sulawesi. The study acquired research data using in-depth interviews; personal observations and use of questionnaire. Data analysis was done on the costs and returns, the margin of safety ratio, and BEP. The results for poultry egg production in rural areas proved that the business is more profitable. Kucharski and Wywial (2019) presented and analysed alternative methods of determining the BEP for heterogeneous sales by considering econometric modelling methods. The researchers determined production levels that meet the basic condition sets for the BEP in the economic analysis. In the study, econometric modelling methods are original, though, are not well mentioned in the literature related to the subjected matter. But, in simplified form, BEP optimization for the heterogeneous product sales was reported by Kucharski and Wywial (2019). Singh *et al.* (2017) studied cost and returns of milk production of cow and buffalo to figure out break-even point. The overall average value of BEP was found to be 3.75 % and 2.30 % for the cow and buffalo, respectively. Survey technique was used for primary data collection. Secondary data was viewed and recorded from different Government offices and published records. Rahmann *et al.* (2017) investigated the interaction between the optimal sizing of battery energy storage systems (BESS) Technologies and major factors affecting their profitability when considering peak shaving applications in distribution networks (DN) for customers. The researchers figured out the BEPs for different BESS technologies and considering a wide range of life cycles, efficiencies, energy prices and power prices. In the study, an optimization method for the sizing of BESSs was proposed with the description of the case study. The Break-even analysis revealed the costs of different BESS technologies required in making the peak shaving applications to be financially viable. Syrůček *et al.* (2018) reported calculation of BEPs and assessment of profitability in sucker cow herds. A questionnaire covering production, reproduction and economic traits was used for data collection in years 2014, 2015 and 2016. All the above studies on investment concluded that fixed costs are not directly related to the level of production. Conversely, variable cost is indirectly proportional to the volume of output. Above all, total fixed costs do not change as the level of productions increase.

In health service provision, Comans *et al.* (2013) analysed the cost of conventional face-to-face clinic and video conferencing clinic using BEP analysis. The researchers considered the views of the health finder in the regional centres. A spreadsheet-type model was estimated to get a point where the costs of providing a regional clinic with special support in person were equal to those providing the clinic using specialist support by videoconferencing (Comans *et al.*, 2013).In Agricultural mechanisation, Kadhim *et al*. (2018) showed break-even cost analysis to reveal the minimum area or working hours which must be exceeded to make the business profitable. A questionnaire-approach was used in the study. In light of experimental results, hiring decision for Agricultural mechanization is more profitable to buying different agricultural machinery. Several researchers have explained the application of break-even analysis to various scales of enterprises. Barletta *et al.* (2018) proposed the structure of requirements and modality needed for the environmental break-even point (e-BEP) analysis. The research work further provided a simple and graphic-based decision-making tool for chief executive officers (CEOs) and production managers in their business and technology investments, respectively. For Circular Economy, researchers see no obstacles in embedding the e-BEP in established frameworks and technologies for environmental BEP assessment.

Now for comparison purpose, break-even and sensitivity analyses are two business analysis methods. The two explained relationship between production costs and revenue generated. Sensitivity analysis is a useful financial tool for analyzing how changes in different values of a set of independent variables affect other dependent variable under a given set of conditions and assumptions. Various applications of sensitivity analysis methods have been reported in the literature; geography, economics, biology, engineering and open source energy system modeling(Hamby, 1995; Frey and Patil, 2002; Lenhart et al., 2002; Saltelli, 2002; Saltelli et al., 2005; Saltelli and Annoni, 2010; Li et al., 2019). Meanwhile, by the virtue of comparison; firstly, break-even analysis method is a global method which focuses on simultaneous variation of multiple inputs, while sensitivity analysis focuses on one input at a time. Secondly, break-even analysis is applicable to different models for choosing among alternative options, while nominal range sensitivity analysis (NRSA) is only applicable to a deterministic model with a number of assumptions. Thirdly, break-even analysis is more complex for model with many decision options, unlike NRSA that requires nominal range for specific input. Fourth, unlike sensitivity analysis, break-even analysis involves graphical representation. Fifth, unlike sensitivity analysis, best use of break-even analysis is to provide key inputs for linear models, verification and validation purposes. Sixth, break-even analysis is a more informative method than sensitivity analysis that addresses a limited range of input values owing to the fact that there was no capture for the clear interactions or relationships among inputs. Last but surely not the least, break-even analysis provides more robust insights than sensitivity analysis (Frey and Patil, 2002; Cullen et al., 1999).

In the early 1960s, computer system and its associated software have become accepted in the domains of mechanisation, controlling and automation of the production process (Webb and Hoben, 1983). Nasution and Pramana (2019) developed a numerical algorithm for break-even analysis to speed up cost analysis required in the design of an unmanned aerial vehicle. The researchers aimed to estimate the number of quantity (units) needed to arrive at BEP and its corresponding price per unit, as well as obtainable profit gap. The developed algorithm was implemented on in-house software. Mechanization implies the use of machines and mechanical technology to carry out operations and replacing the traditional methods involving human and/or animal labour. Through the mechanized process, the productions and productivity increase to meet the needs of a growing population of the people within the timely operations. A number of research studies have been carried out on the mechanization of locust bean (*iru*) production (Owolarafe et al., 2013, 2010). Meanwhile, many small businesses such as *iru* processors face a lot of challenges when trying to determine the short-term profitability and are uncertain to determine the profits at all in any specific month (Edwards and Jones, 2002). BEPs are more useful in the clarification of possible economy of scale incorporate economic analysis (Nielsen and Hjort-Gregersen, 2002). A monthly BEP is a useful control standard that provides an easier means of determining whether profits were made (acceptable performance) or whether losses were sustained (unacceptable performance, which may require corrective action) in a given month. The BEP also serves as a means to establish a control standard which is the first step in the management control process to identify a criterion for the success rating in any performance area. Measuring performance, comparing the performance to the standards and taking appropriate actions comes after the set standards. The technique gives an acceptable, accurate and reasonable estimation of profits or losses. This study presents break-even and sensitivity analyses for profitability/losses determination and risk analysis, respectively using a case-study approach with a view to guiding the processors on the choice of appropriate methods for their scale of *iru* production.

### 2.1 *Iru* production as a case study

*Iru* is a fermented condiment produced from African locust bean through traditional and mechanized methods. The production is performed in a restricted geographical area, thus usually managed by a single owner. Contrarily to the mechanized method, traditional *iru* production process depends more on manpower, but less on the use of processing machine. *Iru* production uses immediately available local natural resources, being a small-scale enterprise, hence respond quickly to sudden changes in any of the factors of production. In this study, a case study approach was used to determine the profitability of *iru* production over a specific time. The case study was carried out with a locust bean processing centre in Ile-Ife, Osun State, Nigeria, which has production and sales of locust bean as one of the major economic activities of low-skilled women in the state. The production centre owned by a popular processor called *Iya Abidogun*, who produces fermented condiment from African locust beans using the traditional and mechanized methods of production, interchangeably and periodically.

## 3 Materials and methods

Several analysis methods have been reported in the literature (Hamby, 1995; Frey and Patil, 2002; Lenhart *et al*., 2002; Saltelli, 2002; Saltelli *et al*., 2005; Saltelli and Annoni, 2010). These include nominal range sensitivity analysis, break-even analysis, and regression analysis, scatter plots analysis and others. By the virtue of comparison between break-even analysis and sensitivity analysis, break-even analysis is a global method which focuses on simultaneous variation of multiple inputs, while sensitivity analysis focuses on one input at a time. Break-even analysis is a more informative method than sensitivity analysis that addresses a limited range of input values owing to the fact that there might be no clear interactions among inputs with a number of assumptions (Frey and Patil, 2002; Cullen *et al.*, 1999).The research data was acquired through visitation and personal observation in the centre, and the use of a structured oral interview. During production cost analysis, market prices as at then were used to determine costs and returns from physical inputs and outputs (Niu et al.,2016).The break-even analysis and sensitivity analysis were done on the *iru* production process.

### 3.1 Break-even analysis of *iru* production

Data analysis was carried out using costs, returns, BEP and contribution marginal ratio. The production cost and returns analysis were used to calculate the profitability or losses incurred in the production used. In this study, mathematical relationships used for BEP analysis are as follows (Niu et al., 2016):

Revenue = Quantity of the product × Selling price;

Profit = Revenue – Total cost;

Total cost = Fixed cost + Variable cost;

Contribution = Revenue – Variable cost (or Sales per unit – Variable cost per unit);

BEP (Quantity) = Total fixed Cost / Contribution per unit);

BEP (Price) = Total fixed cost per unit + Variable cost per unit; and

According to Reddy and Ram (1996), the margin of safety is corresponding to the contribution margin ratio. Reddy and Ram (1996) calculated margin of safety in a percentage. Because of this, the contribution marginal ratio was estimated as a percentage in this study.

### 3.2 Sensitivity analysis of *iru* production

According to Dachin et al. (2016), sensitivity analysis can also be referred to as a budgetary technique that is used to study the effect of assumptions in view of the changes in business sizes regarding the gross margin. Gross margin is the difference between total revenue and total variable cost. Simply put as applicable to sensitivity analysis, total cost is an amount of money spent by investment to reach a particular production output. Fixed cost is any expenses incurred by investment that does not change irrespective of increase or decrease in production volume over a specific period of time. Variable cost is an expense that changes in proportion to production output of investment. A rate of return on investment (RORI) is a net amount of profit or loss incurred over time by investment which is expressed in form of a percentage based on initial cost of investment.

Noteworthy, this ‘what-if’ analysis is applied as the elasticity of gross margin to changes in business sizes by +/- 5%, 10%, 15% and 20%.In this study, the mathematical relationships for sensitivity analysis are as follows (Adetomiwa et al.,2020):

$$TC = FC+VC \tag{2}$$

$$RORI=((TR-TC)/TC\times 100) \tag{3}$$

Where: TR stands for Total Revenue, TC stands for Total cost, FC denotes Fixed cost, VC denotes Variable cost and RORI denotes Rate of Returns on Investment.

## 4 Results and discussion

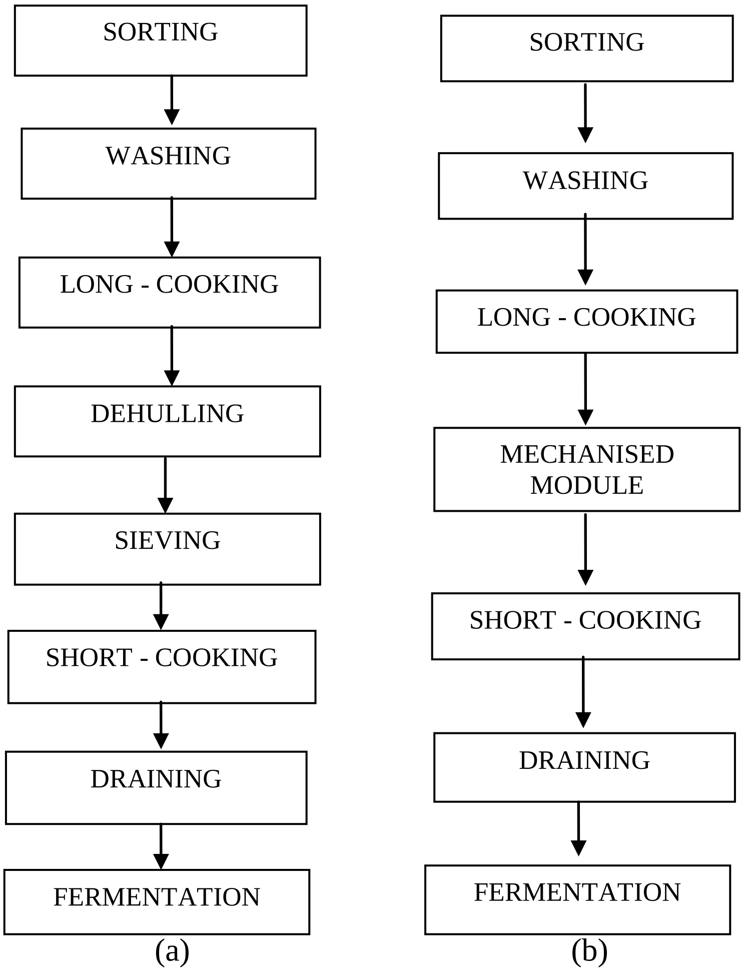
An assessment to the profitability and selection criteria to choose a typical method of *iru*production are conducted by using the two applicable methods. Good agreements are noticed between the results obtained from mathematical calculations and graphical-based method. The results and values (as seen in Tables 1-6) were prepared based on the analysis.

### 4.1 Amonthly BEP calculations and break-even analysis (a case study)

Figures 1 (a) and (b) provide insight into activities involved in the traditional and mechanized methods of *iru* production, respectively. The differences in the number of production activities are responsible for the reason of different cost estimations for the two production cases. The processor sells *iru* of different sizes at different selling prices in different community markets over a longer time. The processor believes the business was profitable every month, but she was not certain. To ascertain and determine BEP (which is a useful control standard to determine monthly profit or loss), the fixed cost, variable cost and revenue values were calculated from cash flow information that is pre-existing in her business records (for three months). The cost of cooking pot, aluminium stainless tray, water container, sieve, land rent, miscellaneous expenses and machine constitutes fixed cost. Money spent on African locust bean, firewood, daily wages of co-worker, fuel and oil is termed as variable cost.

In order to calculate monthly BEP for her business, Tables 1-3 display determination of fixed costs, variable costs, average revenues and contribution margin for the traditional method of *iru* production. Likewise, Tables 4, 5 and 6 are for the mechanized method. The Monthly break-even points for both traditional and mechanized methods of the centre were then determined following the BEP calculations as shown below. The values of fixed cost and variable cost components that as itemised in Tables 1 and 2 for traditional *iru* production process (TIPP), and Tables 4 and 5 for mechanized *iru* production process (MIPP), respectively, were used. The values are estimated based on field observations. Sometimes, the values used in each case are taken as an assumption number based on the experience (Nasution and Pramana, 2019).

Expected life span for the cooking pot, aluminium stainless tray, sieve, water container and machine were 26 months, 12 months, 6 months, 12 months and 72 months, respectively. Tables 7-9 display determination (with respect to the depreciated value) of fixed costs, variable costs, average revenues and contribution margin for the traditional method of *iru* production. Likewise, Tables 10-12 are for the mechanized method.




Figures 1 Activities involved in traditional and mechanized *iru* production processes, respectively

**Table 1 Monthly fixed cost for traditional *iru* production process (TIPP)**

| Categories | October | March | May | Monthly Average |
|---|---|---|---|---|
| | ₦ | ₦ | ₦ | ₦ |
| Cooking pot | 21,300 | 21,300 | 10,910 | 17,837 |
| Aluminum stainless tray | 1,300 | 1,000 | 700 | 1,000 |
| Water container | 9,000 | 7,200 | 6,000 | 7,400 |
| Sieve | 1,500 | 1,000 | 1,000 | 1,167 |
| Land rent | 1,500 | 1,500 | 1,500 | 1,500 |
| Miscellaneous expenses | 10,000 | 0 | 0 | 3,333 |
| Total | 44,600 | 32,000 | 20,110 | 32,237 |

**Table 2 Monthly variable cost for TIPP**

| Categories | October | March | May | Monthly Average |
|---|---|---|---|---|
| | ₦ | ₦ | ₦ | ₦ |
| African locust bean | 32,000 | 32,000 | 30,400 | 31,467 |
| Firewood | 5,600 | 6,500 | 6,800 | 6,300 |

| | | | | |
|---|---|---|---|---|
| Total | 37,600 | 38,500 | 37,200 | 37,767 |

**Table 3 Monthly sales revenues for three months, TIPP**

| Sources | October | March | May | Monthly Average |
|---|---|---|---|---|
| | ₦ | ₦ | ₦ | ₦ |
| Fermented condiment sold | 80,000 | 70,000 | 80,000 | 76,667 |
| Fermented condiment left | 6,000 | 2,800 | 7,200 | 5,333 |
| Total | 74,000 | 67,200 | 72,800 | 71,334 |

**Monthly BEP for the TIPP**

BEP (₦Sales) = Fixed cost (FC) / Contribution margin ratio (CMR)

CMR = 1- (Average variable costs / Average sales revenues)

CMR = 1- (37,767 / 71,334) = 1 – 0.5294= 0.4706 = 47.06%

BEP (₦Sales) per month = FC / CMR = 32,237 / 0.4706

BEP (₦Sales) per month = 68,502

Conclusively, *Iya Abidogun* using the TIPP makes profit from *iru p*roduction whenever her sales receipts exceed ₦ 68,502 per month. This implies that her business makes profit only in the month of October and May using traditional method of *iru* production.

**Table 4 Monthly fixed cost for the mechanized *iru* production process (MIPP)**

| Categories | October | April | June | Monthly Average |
|---|---|---|---|---|
| | ₦ | ₦ | ₦ | ₦ |
| Cooking pot | 21,300 | 21,300 | 21,300 | 21,300 |
| Aluminum stainless tray | 1,300 | 1,300 | 1,300 | 1,300 |
| Water container | 9,000 | 8,500 | 8,500 | 8,667 |
| Sieve | 1,500 | 1,200 | 1,200 | 1,300 |
| Land rent | 1,500 | 1,500 | 1,500 | 1,500 |
| Miscellaneous expenses | 10,000 | 10,000 | 10,000 | 10,000 |
| Cost of machine | 125,460 | 0 | 0 | 41,820 |
| Total | 170,060 | 43,800 | 43,800 | 85,887 |

**Table 5 Monthly variable cost for the MIPP**

| Categories | October | April | June | Monthly Average |
|---|---|---|---|---|
| | ₦ | ₦ | ₦ | ₦ |
| African locust bean | 48,000 | 40,000 | 32,000 | 40,000 |
| Firewood | 8,400 | 7,000 | 5,600 | 7,000 |
| Daily wages of co-worker | 3,600 | 3,000 | 2,400 | 3,000 |
| Cost of fuel and oil | 6,000 | 5,000 | 4,000 | 5,000 |
| Total | 66,000 | 55,000 | 44,000 | 55,000 |

**Table 6 Monthly sales revenues for three months, MIPP**

| Sources | October | April | June | Monthly Average |
|---|---|---|---|---|
| | ₦ | ₦ | ₦ | ₦ |
| Fermented condiment sold | 150,000 | 150,000 | 145,000 | 146,333 |
| Fermented condiment left | 8,500 | 5,000 | 1,000 | 4,833 |
| Total | 141,500 | 145,000 | 144,000 | 141,500 |

**Monthly BEP for MIPP**

BEP (₦Sales) = Fixed cost (FC) ₦ / Contribution margin ratio (CMR)

CMR =1- (Average Variable Costs / Average sales revenues)

CMR = 1- (55, 000 / 141, 500)= 1 – 0.3887= 0.6113= 61.13%

BEP (₦Sales) per month = FC / CMR

BEP (₦Sales) per month = 85, 887/ 0.6113

BEP (₦Sales) per month = 140,499

Conclusively, *Iya Abidogun* using the MIPP makes profit from *iru* production whenever her sales receipts exceed ₦140,499 per month. This implies that her business makes profit in the month of October, April and June, using mechanized method of *iru* production.

**Table 7 Monthly fixed cost for TIPP based on depreciated values**

| Categories | October | March | May | Monthly Average |
|---|---|---|---|---|
| | ₦ | ₦ | ₦ | ₦ |
| Cooking pot | 591.67 | 591.67 | 303.06 | 495.47 |
| Aluminum stainless tray | 108.33 | 83.33 | 58.33 | 83.33 |
| Water container | 750 | 7,200 | 6,000 | 616.67 |
| Sieve | 250 | 1,000 | 1,000 | 194.45 |
| Land rent | 1,500 | 1,500 | 1,500 | 1,500 |
| Total | 3,200 | 2,941.67 | 2,528.06 | 2,889.92 |

**Table 8 Monthly variable cost for TIPP based on depreciated values**

| Categories | October | March | May | Monthly Average |
|---|---|---|---|---|
| | ₦ | ₦ | ₦ | ₦ |
| African locust bean | 32,000 | 32,000 | 30,400 | 31,467 |
| Firewood | 5,600 | 6,500 | 6,800 | 6,300 |
| Miscellaneous expenses | 10,000 | 0 | 0 | 3,333.33 |
| Total | 47,600 | 38,500 | 37,200 | 41,100.33 |

**Table 9 Monthly sales revenues (based on depreciated values) for three months, TIPP**

| Sources | October | March | May | Monthly Average |
|---|---|---|---|---|
| | ₦ | ₦ | ₦ | ₦ |
| Fermented condiment sold | 80,000 | 70,000 | 80,000 | 76,667 |
| Fermented condiment left | 6,000 | 2,800 | 7,200 | 5,333 |
| Total | 74,000 | 67,200 | 72,800 | 71,334 |

**Monthly depreciated BEP values for the TIPP**

BEP (₦Sales) = Fixed cost (FC) / Contribution margin ratio (CMR)

CMR = 1- (Average variable costs / Average sales revenues)

CMR = 1- (41100.33 / 71,334) = 1 – 0.5762= 0.4238 = 42.38%

BEP (₦Sales) per month = FC / CMR = 2889.92 / 0.4238

BEP (₦Sales) per month = 6,819.07

Conclusively, *Iya Abidogun* makes profit from *iru* production whenever her sales receipts exceed ₦6,819.07 per month. This implies that her business makes profit every month.

**Table 10 Monthly fixed cost for the MIPP based on depreciated values**

| Categories | October | April | June | Monthly Average |
|---|---|---|---|---|
| | ₦ | ₦ | ₦ | ₦ |
| Cooking pot | 591.67 | 591.67 | 591.67 | 591.67 |
| Aluminum stainless tray | 108.33 | 108.33 | 108.33 | 108.33 |
| Water container | 750 | 708 | 708 | 722 |
| Sieve | 250 | 200 | 200 | 216.67 |
| Land rent | 1500 | 1,500 | 1,500 | 1,500 |
| Cost of Machines | 1,742.50 | 1,742.50 | 1,742.50 | 1,742.50 |
| Total | 4925.50 | 4850.50 | 4850.50 | 4,875.50 |

**Table 11 Monthly variable cost for the MIPP based on depreciated values**

| Categories | October | April | June | Monthly Average |
|---|---|---|---|---|
| | ₦ | ₦ | ₦ | ₦ |
| African locust bean | 48,000 | 40,000 | 32,000 | 40,000 |
| Firewood | 8,400 | 7,000 | 5,600 | 7,000 |
| Daily wages of co-worker | 3,600 | 3,000 | 2,400 | 3,000 |
| Cost of fuel and oil | 6,000 | 5,000 | 4,000 | 5,000 |
| Miscellaneous expenses | 10,000 | 10,000 | 10,000 | 10,000 |
| Total | 76,000 | 65,000 | 54,000 | 65,000 |

**Table 12 Monthly sales revenues (based on depreciated values)for three months, MIPP**

| Sources | October | April | June | Monthly Average |
|---|---|---|---|---|
| | ₦ | ₦ | ₦ | ₦ |
| Fermented condiment sold | 150,000 | 150,000 | 145,000 | 146,333 |
| Fermented condiment left | 8,500 | 5,000 | 1,000 | 4,833 |
| Total | 141,500 | 145,000 | 144,000 | 141,500 |

**Monthly depreciated BEP values for MIPP**

BEP (₦Sales) = Fixed cost (FC) ₦ / Contribution margin ratio (CMR)

CMR =1- (Average variable costs / Average sales revenues)

CMR = 1- (65,000 / 141,500) = 1 – 0.4594= 0.5406= 54.06%

BEP (₦Sales) per month = FC / CMR

BEP (₦Sales) per month = 4,875.50/ 0.5406

BEP (₦Sales) per month = 9,018.68

Conclusively, *Iya Abidogun* makes profit from *iru* production whenever her sales receipts exceed ₦9,018.68per month. This implies that her business makes profit every month.

BEP explanation for TIPP using graphical method

Figure 2 depicts the graph (without depreciated values)of BEP for the traditional *iru* production process. It could be observed that the total cost for the TIPP increases simultaneously with the increase in the number of unit sales of *iru* produced up to the specific point of intersection in which they equal to each other. Initially for the fixed cost of ₦44,600, with the processing of 25 kg of *iru*, *the* total cost is ₦56,350 and sales (revenue) is ₦25,000 With the processing of 50 kg of *iru*, the total cost is ₦68,100 and sales (revenues) is ₦50,000.00. Both total cost and sales increase as the number of *iru* produced increases, up to a point of intersection where there are no production differences (profit or loss) between units produced per cost. At BEP, the unit quantity is 84 kg and production cost are ₦68,502. No gain or loss at the BEP. Meanwhile, above BEP, sales values are greater than the total cost as a unit quantity of *iru* increases. Thus, processors gain more profit and running the business successfully.

Figure 3 depicts the graph (based on depreciated values using sensitivity analysis**)** of BEP for the traditional *iru* production process. It could be observed that the total cost for the TIPP increases simultaneously with the increase in the number of unit sales of *iru* produced up to the specific point of intersection in which they equal to each other. Initially for the fixed cost of ₦3,200 with the processing of 25 kg of *iru*, the total cost is ₦39,950 and sales (revenue) is ₦25,000. With the processing of 50 kg of *iru*, the total cost is ₦76,700 and sales (revenues) is ₦50,000. Both total cost and sales increase as the quantity of *iru* produced increases, up to a point of intersection where there are no production differences (profit or loss) between units produced per cost. At BEP, the unit quantity is 8kg and production cost are ₦6,819.07. No gain or loss at the BEP. Meanwhile, above BEP, sales values are greater than the total cost as a unit quantity of *iru* increases. Thus, processors gain more profit and running the business successfully.

(a) BEP explanation for MIPP using graphical method

Similarly, to the plotted graph of BEP for TIPP, Figure 4 shows a diagrammatic representation of a BEP for the mechanized *iru*production process (MIPP). If shareholders want to achieve BEP, which reckons with profitability, BEP can be determined from the BEP equations (Kucharski andWywiał, 2019; Kampf et al., 2016; Barletta et al.,2018). Both total cost and revenue increase along with the increase in output units. One hundred and twenty-four thousand, and six hundred naira only (N124,600) was initially spent as a fixed cost for the MIPP. In processing of 25 kg of *iru*, *the* total cost is N152,100 and revenue was N95,000. At 86 kg of outputs and production cost of N164,000, a BEP was reached, where total cost and revenue are the same. Processor earns a profit or incurs losses above or below the point of intersection, respectively. Thus, processors are expected to maintain productions above BEP to earn more profits.

Figure 5 shows a diagrammatic representation of a BEP (based on depreciated values using sensitivity analysis) for the Mechanized *Iru Production* Process (MIPP). Both total cost and revenue increase along with the increase in output units. Four thousand, three hundred and eleven naira,and eleven kobo (N 4,311.11) was initially spent as a fixed cost for the MIPP. In processing of 25 kg of *iru, the* total cost is N 43,061.11 and revenue was N47,500. At 8 kg of outputs and production cost of N9,018.06, a BEP was reached, where total cost and revenue are the same. Processor earns a profit or incurs losses above or below the point of intersection, respectively. Thus, processors are expected to maintain productions above BEP to earn more profits.

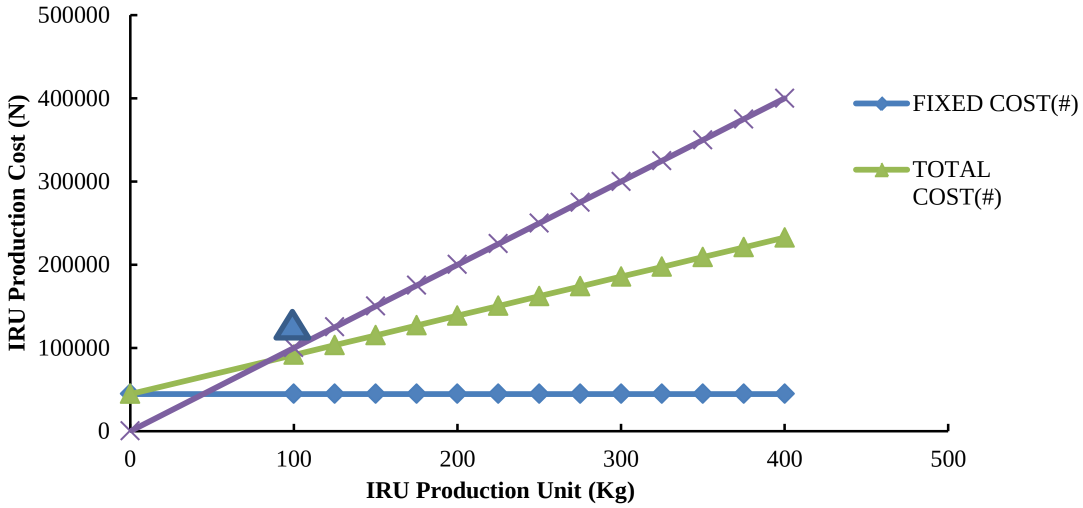



Figure 2 Production cost against production unit (Traditional; without depreciated values)

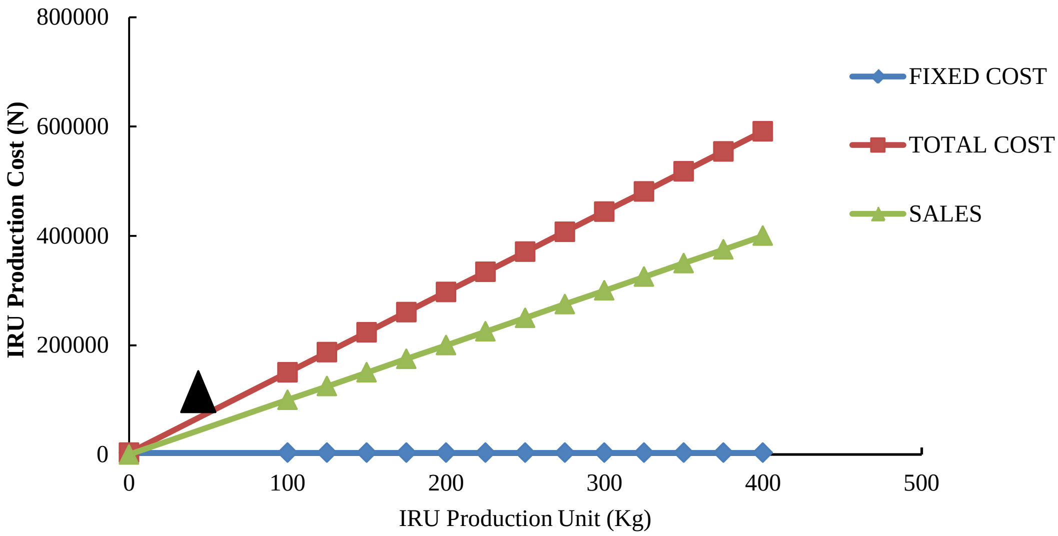



Figure 3 Production cost against production unit (Traditional; with depreciated values)

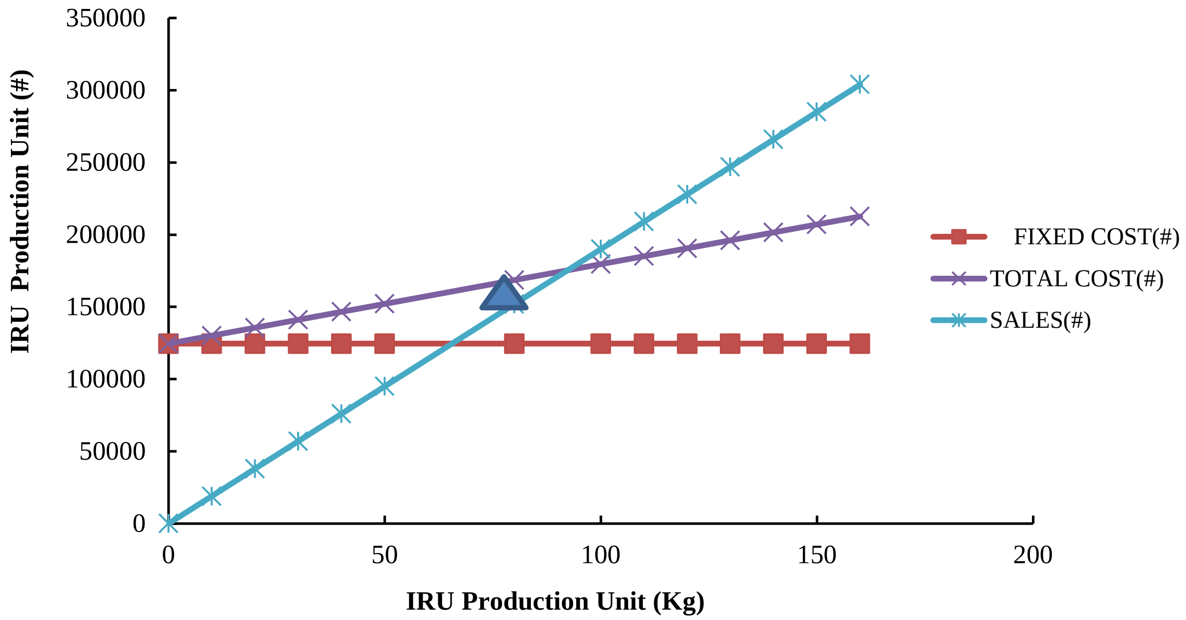



Figure 4 Production cost against production unit (Mechanised; without depreciated values)

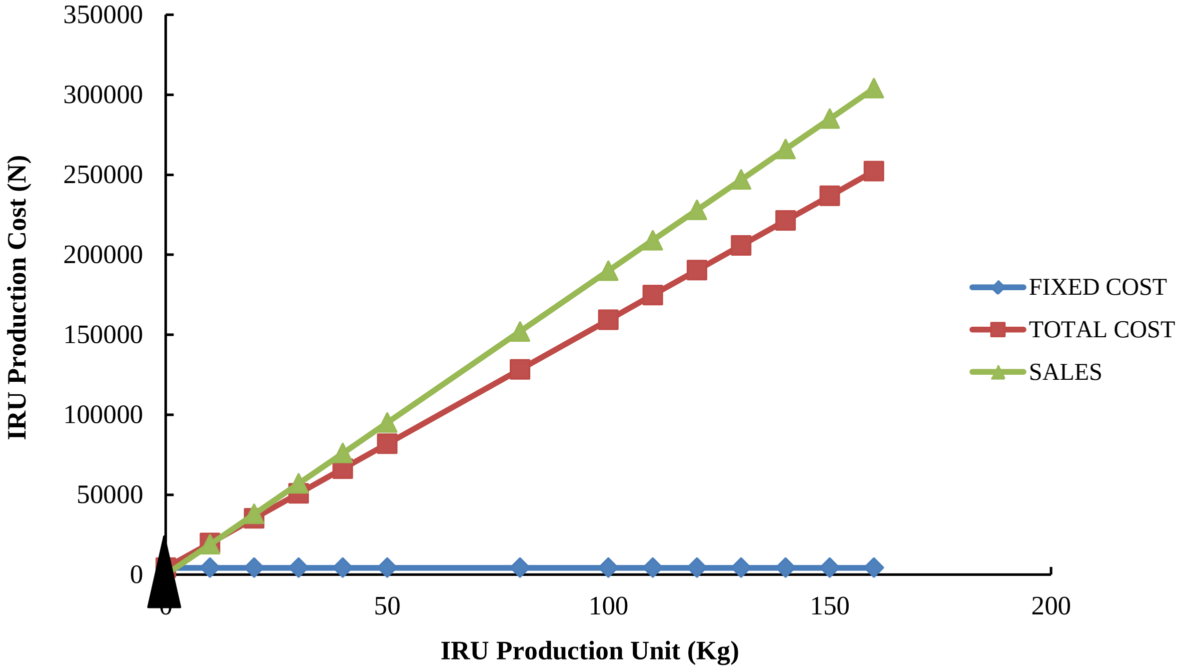



Figure 5 Production cost against production unit (Mechanised;with depreciated values)

(b) BEP explanation for combined TIPP and MIPP using graphical method

Applying the break-even analysis in the same manner reported by Edwards and Jones (2002) to the combined TIPP and MIPP, twenty-five kilograms (25 kg) of outputs (*iru*) was produced with a total cost of ₦56,350 and ₦138,350 for the TIPP and MIPP, respectively. Fifty kilograms (50 kg) of outputs took ₦68,100 and ₦152,100 for the TIPP and MIPP, respectively. At BEP of 325 kg for the *iru* production unit and ₦197,000 for the production cost, both TIPP and MIPP have the same total cost(Figure 6). At this point of intersection, a processor can easily decide to choose any of the two methods, since the results are the same. Above BEP, MIPP is more preferable to TIPP, because MIPP took lesser production costs and gave more profit. The mechanized process was also found to utilize a lesser quantity of water and shorter production time, while traditional process gave more final product, fermented African locust beans (Atoyebi et al.,2021). Thus, for the large-scale production, MIPP is better to be adopted by processors.

In applying the break-even analysis to the combined TIPP and MIPP using depreciated values of collected data, twenty-five kilograms (25 kg) of outputs (*iru*) was produced with a total cost of ₦39,950 and ₦43,061.11for the TIPP and MIPP, respectively. Fifty kilograms (50 kg) of outputs took ₦76,700 and ₦81,811,11 for the TIPP and MIPP, respectively. At BEP of 325 kg for the *iru* production unit and ₦197,000 for the production cost, both TIPP and MIPP have the same total cost(Figure 7). At this point of intersection, a processor can easily decide to choose any of the two methods, since the results are the same. Above BEP, MIPP is more preferable to TIPP, because MIPP took lesser production costs and gave more profit. The mechanized process was also found to utilize a lesser quantity of water and shorter production time, while traditional process gave more final product, fermented African Locust Beans (Atoyebi et al.,2021). Thus, for the large-scale production, MIPP is better to be adopted by processors.

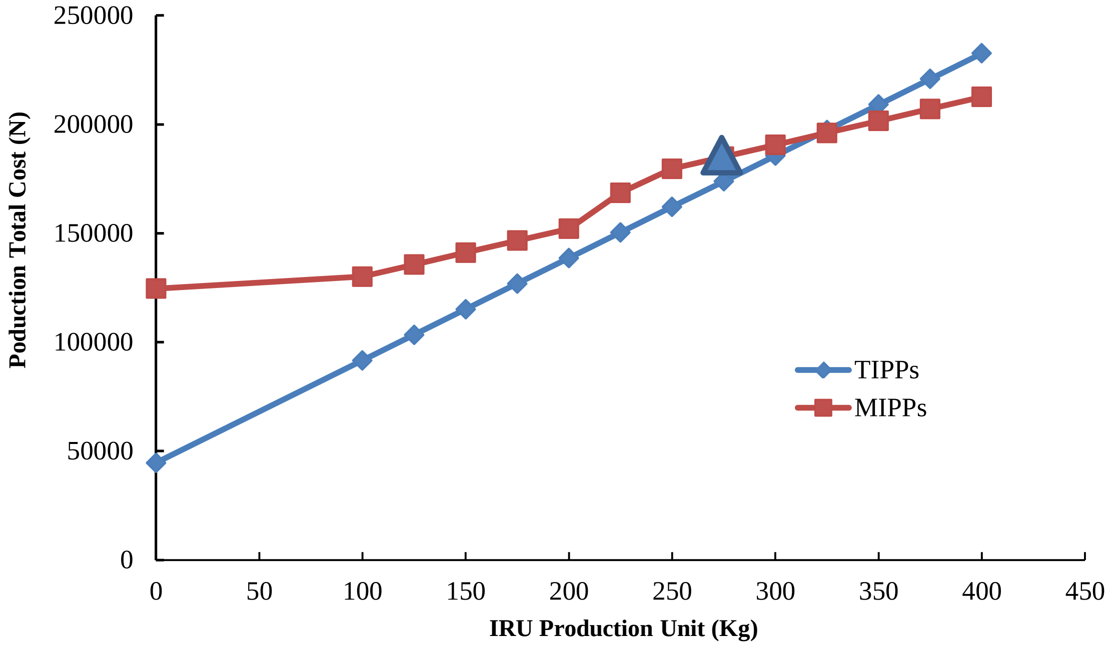



Figure 6 Production total cost against production unit
(Combined traditional and mechanized methods; without depreciated values)

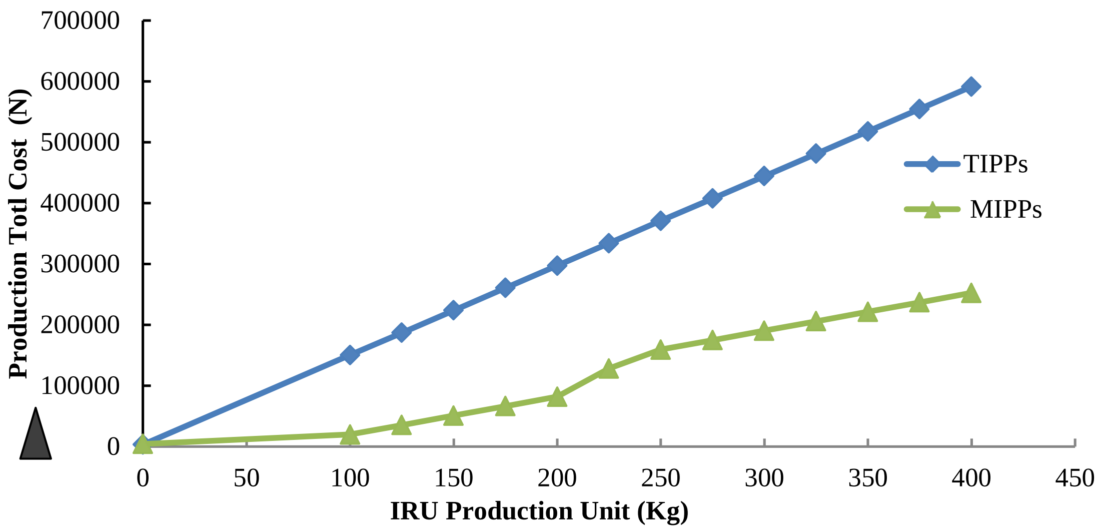



Figure 7 Production total cost against production unit
(Combined traditional and mechanized methods; with depreciated values)

Break-even analysis: In view of discussion of above results, TIPP had a BEP where *iru* production cost and production units were ₦ 68,502 and 84 kg, respectively. While MIPP had a BEP where *iru* production cost and production units were ₦ 164,000 and 86 kg, respectively. Combined traditional and mechanized methods of *iru* production had a BEP where *iru* production cost and production unit were ₦ 197,000 and 325 kg, respectively. The implication of this is that, it is profitable for the processor to adopt traditional method if production units are less than 325 kg and adopt mechanized method if the units exceed 325 kg. This result will assist the processor in planning the production process considering the fact that there is seasonal variation in the supply of raw materials. The results of the BEP analysis, both mathematical and graphical methods, are consistent and in line with the findings in many studies (Niu et al.,2016; Barletta et al.,2018; Syrůček et al.,2018; Singh et al.,2017; Comans et al.,2013; Kampf et al.,2016; Nasution and Pramana, 2019; Kucharski et al.,2019; Kadhim et al.,2018;Edwards and Jones, 2002). Although researchers studied and made findings in different application areas, the same notable features and procedures are strictly followed. According to the author' knowledge, this research paper and its findings are original and never reported in the existing literatures on the subject. Meanwhile, in-house softwares are application software for performing specific tasks and medium for system implementation. For instance, Microsoft word for documentation purposes, Microsoft excel for financial calculations/analysis, and MATLAB environment for implementing a numerical algorithm.

Based on sensitivity analysis method, TIPP had a BEP where *iru* production cost and production units were ₦ 6,819.07 and 5 kg, respectively. While MIPP had a BEP where *iru* production cost and production units were ₦ 9,018.06 and 8 kg, respectively. BEP for the combined traditional and mechanized methods of *iru* production could not be estimated since it has insignificant value. The implication of this is that, it is preferable to adopt BEP analysis based on available data by processor to sensitivity analysis using this case study.

Generally, productions above a point of intersection will yield profit for the processor. Comparing monthly sales (revenues) and calculated BEP for the *Iya Abidogun* production centre as a case study described above, the profit and loss were determined which could not have been reached through informal cash flow analysis since the production centre had a positive cash flow each of the three months. However, the processor can determine whether or not the businesses are making a profit or not in a particular month through comparison of calculated BEP value and monthly sales revenues for the month. The processor can refine the BEP to accommodate seasonal demand factors and significant changes in products for the new accumulation of production cost and sales data in future months. The proposed technique presented above is no replacement for the traditional income and cash flow statements used to record the production centre performance rate over specific months. Although, the use of cash flow data to calculate profitability will never be perfectly accurate because the different production costs will occur in different periods than the receipt of their sales revenues and some fixed costs are not paid at even intervals. As a result, the inaccuracies in production record are mitigated using monthly averages and reduced as processor estimate the averages over longer periods. Thus, the BEP is useful as a control standard for checking whether or not the business made a profit in a particular month. Sensitivity analysis is also a good risk analysis method to determine whether processors are to continue *iru* production or not based on changes in inputs that lead to changes in outputs. The paper could serve as a reference point to promote mechanization of *iru* production.

### 4.2 Sensitivity analysis and rate of return for the case study

In this study, the rate of return on investment (RORI) was estimated in terms of production cost ($C$), total revenue ($TR$) and total cost ($TC$). That is, RORI = $\frac{(TR-TC)*100}{TC}$(Adetomiwa et al., 2020). Where actual cost = total cost and total revenue = return (R):

RORI for TIPP = ((71,334 – 43,990.25) / 43,990.25)

× 100 = 62.16%.

RORI for MIPP = ((141500 – 69,875.50) / 69,875.50) × 100 = 102.50%.

Table 13 revealed how rate of returns on investment (RORI) for TIPP changes with increasing in production cost. At actual production cost (C) of 43,990.25 with the fixed return (R) value of 71,334 the RORI was 62.16%. When production cost increased by 10%, 15%, 20%, 25%, 30% and 35%, the RORI decrease to 47.42%, 41.01%, 35.13%, 29.73%, 24.74% and 20.12%, respectively. At the RORI value of 41.01% and below, the investment is not viable for recommendation and it should not be finance with the use of bank loan. Table 14 also revealed how rate of returns on investment (RORI) for TIPP changes with decreasing in revenue (R). At actual production cost (C) of 43,990.25 with the fixed production cost (C) of 71,334, the RORI value was 62.16%. When revenue reduced by 10%, 15%, 20%, 25%, 30% and 35%, the RORI decrease to 45.94%, 37.83%, 29.73%, 21.62%, 13.51% and 05.40%, respectively. At the RORI value of 37.83% and below, the investment is not viable and it should not be recommended for finance with the use of bank loan.

In a similar manner, Table 15 revealed how rate of returns on investment (RORI) for MIPP changes with increasing in production cost. At actual production cost (C) of 69,875.50 with the fixed return (R) value of 141,500.00, the RORI was 102.50%. When production cost increased by 10%, 15%, 20%, 25%, 30% and 35%, the RORI decrease to 84.09%, 76.09%, 68.75%, 62.00%, 55.77% and 50.00%, respectively. At any RORI value of 45% and below, the investment is not viable for recommendation and it should not be finance with the use of bank loan. Likewise, Table 16 revealed how rate of returns on investment (RORI) for MIPP changes with decreasing in Revenue (R). At actual production cost (C) of 43,990.25 with the fixed production cost (C) of 69,875.50, the RORI value was 102.50 %. When revenue reduced by 10%, 15%, 20%, 25%, 30% and 35%, the RORI decrease to 82.25%, 72.13%, 62.00%, 51.88%, 41.75% and 31.63%, respectively. At the RORI value of 41.75% and 31.63%, the investment is not viable and it should not be recommended for finance with the use of bank loan.

Generally, at any value of RORI that is below 45%, the investment (*iru* production) should not be recommended for taking bank loan. Hence, the *iru* production is not viable.

**Table 13 Sensitivity analysis of rate of return on TIPP (Increasing Cost)**

| Variable RORI | Cost (C) | Return (R) | RORI | Remark |
|---|---|---|---|---|
| Actual Cost | 43,990.25 | 71,334.00 | 62.16% | Actual estimate |
| + 10% | 48,389.28 | 71,334.00 | 47.42% | Recommended |
| + 15% | 50,588.79 | 71,334.00 | 41.01% | Not-Recommended |
| + 20% | 52,788.30 | 71,334.00 | 35.13% | Not-Recommended |
| + 25% | 54,987.81 | 71,334.00 | 29.73% | Not-Recommended |
| + 30% | 57,187.33 | 71,334.00 | 24.74% | Not-Recommended |
| + 35% | 59,386.84 | 71,334.00 | 20.12% | Not-Recommended |

**Table 14 Sensitivity analysis of rate of return on TIPP (Decrease revenue)**

| Variable RORI | Cost (C) | Return (R) | RORI | Remark |
|---|---|---|---|---|
| Actual Cost | 43,990.25 | 71,334.00 | 62.16% | Actual estimate |
| - 10% | 43,990.25 | 64,200.60 | 45.94% | Recommended |
| - 15% | 43,990.25 | 60,633.90 | 37.83% | Not-Recommended |
| -20% | 43,990.25 | 57,067.20 | 29.73% | Not- Recommended |
| -25% | 43,990.25 | 53,500.50 | 21.62% | Not- Recommended |
| -30% | 43,990.25 | 49,933.80 | 13.51% | Not- Recommended |
| -35% | 43,990.25 | 46,367.10 | 05.40% | Not- Recommended |

**Table 15 Sensitivity analysis of rate of return on MIPP (Increasing cost)**

| Variable RORI | Cost (C) | Return (R) | RORI | Remark |
|---|---|---|---|---|
| Actual Cost | 69,875.50 | 141,500.00 | 102.50% | Actual estimate |
| + 10% | 76,863.05 | 141,500.00 | 84.09% | Recommended |

| | | | | |
|---|---|---|---|---|
| + 15% | 80,356.83 | 141,500.00 | 76.09% | Recommended |
| + 20% | 83,850.60 | 141,500.00 | 68.75% | Recommended |
| + 25% | 87,344.38 | 141,500.00 | 62.00% | Recommended |
| + 30% | 90,838.15 | 141,500.00 | 55.77% | Recommended |
| + 35% | 94,331.93 | 141,500.00 | 50.00% | Recommended |

**Table 16 Sensitivity analysis of rate of return on MIPP (Decreasing revenue)**

| Variable RORI | Cost (C) | Return (R) | RORI | Remark |
|---|---|---|---|---|
| Actual Cost | 69,875.50 | 141,500.00 | 102.50% | Actual estimate |
| - 10% | 69,875.50 | 127,350.00 | 82.25% | Recommended |
| - 15% | 69,875.50 | 120,275.00 | 72.13% | Recommended |
| -20% | 69,875.50 | 113,200.00 | 62.00% | Recommended |
| -25% | 69,875.50 | 106,125.00 | 51.88% | Recommended |
| -30% | 69,875.50 | 99,050.00 | 41.75% | Not- Recommended |
| -35% | 69,875.50 | 91,975.00 | 31.63% | Not- Recommended |

## 5 Conclusions

In this paper, an assessment of the importance of break-even analysis and sensitivity analysis are only conducted for a homogeneous food product, fermented African locust bean, using two cases. We have been able to establish a BEP, a point of intersection between total revenues (sales) and total cost of production resources for the traditional and mechanised processes of *iru* production. Good agreements are noticed between the results obtained using break-even analysis and sensitivity analysis. MIPP is shown as the best option for a by a processor for processing large quantity of raw material since the process took lesser production costs, yields more outputs and gave more profits above BEP compared to TIPP system. BEP could serve as a referential point among *iru* processors for further studying and improving profitability. Likewise, sensitivity analysis could help processor to make positive decision-making as soon as there is price changes and general price inflation for either or both inputs and outputs that may occur at the unpredicted time in the future. The considerations for the future directions may be further enriched by determining BEP for heterogeneous products that are possible to be manufactured at a specific time with the help of the machines to see possibilities of optimizing production capacities and estimating profitability/losses in producing non-homogeneous products by a small-scale business.

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## Conflicts of interest

The authors declare no conflict of interest.

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