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43 a flocculant to clear water and as a source of Ben oil, a non-drying and extremely stable oil. This  
44 oil, which was once used for lubricating watches and other delicate machinery, is clear, sweet, and  
45 odorless, almost never going rancid. It is edible and is becoming increasingly popular in the  
46 cosmetics industry. Leaves and young branches are used as fodder. Moringa may also be used in  
47 fish and poultry feeds.

48 Researchers and pharmaceutical corporations are interested in it because of its potential and variety  
49 of uses. As a result, the demand for moringa and related products is rising. There is a global  
50 demand for moringa, particularly in industrialized nations like the United States and Japan. Just  
51 3.8% and 7.3%, respectively, of the demand for moringa oil in the United States and the European  
52 Union, could be satisfied (Bernavides et al., 2008). In order to increase the supply of moringa and  
53 satisfy the demand, additional workers must be put on the line. Both local communities and the  
54 world market would gain from it. Also, because moringa seed oil is used in the cosmetics industry  
55 and is seen as a more affordable alternative source of biodiesel, demand is expected to increase  
56 (Animashaun and Toye, 2014). Thankfully, Nigeria has a competitive advantage over other  
57 African nations because moringa is only grown in a few countries that are located in tropical and  
58 subtropical zones. Tapping into this opportunity, the federal government may produce over \$500  
59 billion in annual revenue from moringa and thousands of new jobs (FAO, 2011). Despite this, it is  
60 quite unfortunate that the level of moringa production among farmers in Nigeria is generally low  
61 (Omotosho et al., 2013). This is a major concern and the factors influencing the low production,  
62 have been traced to some socio-economic factors such as age, level of farmer's income, level of  
63 education, and so on. However, the rate of moringa production within the country could gradually  
64 increase with the idea of profit accruing to its production (Ojo et al., 2016).

65  
66 However, intending farmers are concerned about the returns of moringa. Asking the question, how  
67 efficient is *Moringa oleifera* in yielding profit? This is because profit is the driving force of any  
68 farmer into business (Maudos et al., 2002). Profit is the difference between income and costs.  
69 There are essentially two types of profit concepts. These are the earnings in accounting and  
70 business. Only explicit costs are taken into account when calculating accounting profit, however,  
71 both implicit and explicit costs are taken into account when calculating economic profit (Kolawole,  
72 2006). No matter how practical a business may be, Thompson (2005) and Overton (2007) contend  
73 that the question of economic profit should be thoroughly investigated before beginning. But,  
74 effective use of the resources at hand is required to achieve maximum profit. The price of inputs  
75 is one of the key elements affecting how profitable moringa production is. Efficiency is the  
76 comparison of what is actually produced with what can be achieved with the same consumption  
77 of resources such as money, time, labor, etc. Since the objective of every moringa producer is to  
78 minimize cost production and maximize profit, which conforms to the rule of production  
79 economics. Profit efficiency refers to a farmer's capacity to produce with the highest possible profit  
80 while spending the least amount possible on fixed production costs and variable inputs (Azeez et  
81 al., 2013). Be that as it may, not much effort has been put into investigating the profit efficiency  
82 of moringa production. In several kinds of literature, studies have been carried out on the technical  
83 efficiency of moringa (Azeez et al., 2013; Tafesse et al., 2020), production performance (Danso-  
84 Abbeam et al., 2021), production and marketing (Islam et al., 2021), Profitability of moringa (Ojo  
85 et al., 2016). Several studies on moringa have also been conducted in Nigeria, but little focus has  
86 been placed on measuring profit efficiency. Based on the above information, this study is  
87 motivated by a number of pertinent questions: what are the socio-economic characteristics of

88 moringa producers? What are the costs and returns to moringa production? And what are the  
89 factors determining the profit efficiency of *Moringa oleifera* production?  
90

91 We proposed a hypothesis that several socio-economic characteristics of moringa producers affect  
92 how profitable they are. These qualities are examined in relation to moringa in order to offer a  
93 rational perspective based on empirical evidence on the potential costs and benefits of growing  
94 *Moringa oleifera*. Knowledge of these can help shed light on how to lessen poverty and food  
95 insecurity in Nigeria. This study is required to add to the body of knowledge on crop profit  
96 efficiency studies, particularly those that focus on the production of moringa, with the secondary  
97 goal of enhancing the welfare of moringa farmers in Nigeria. Last but not least, it will give  
98 government organizations and developmental organizations additional knowledge to improve  
99 regulations and assess the profitability of moringa. As a result, the findings would be helpful in  
100 formulating appropriate strategies for the increase of moringa production in the region and the  
101 economy as a whole. The results would also offer pertinent information for more research on  
102 moringa production.  
103

## 104 **Materials and methods**

### 105 **Area of study**

106 This study was carried out in Osun State, an inland State in the Southwestern geopolitical zone of  
107 Nigeria. It lies between longitude 4<sup>0</sup>N and 5° E and latitude 7<sup>0</sup>N and 8 ° N. Osun State is located  
108 in the Tropical western region of Nigeria. It is bounded in the north by Kwara State, in the east  
109 partly by Ekiti State and partly by Ondo State, in the south by Ogun State, and in the west by Oyo  
110 State. According to the 2006 census reports by National Population Commission in Nigeria, the  
111 population of Osun State stood at about 4.14 million consisting of the Yoruba ethnic group. The  
112 State has two distinct climatic seasons. The State experience raining season, with about three  
113 months of the dry season. The wet season commences from April to October, and the dry season  
114 operates between November and March (Oluwasola et al., 2016). Osun state has natural vegetation  
115 comprised of moist evergreen and semi-evergreen forests and secondary forests, with mean annual  
116 rainfall ranging between 1400 to 2000mm. Mean annual temperature ranges between 26°C to 27°C.  
117 The state's soil and climatic condition are suitable for cultivating a wide range of crops. The State  
118 was selected because farming is predominant in this area, and they major in the production of  
119 permanent crops.

### 120 **Sampling procedure**

121 Primary data were used for this study. Following Ojo et al. (2016), the multi-stage sampling  
122 procedure was used to select respondents for the study. In the first stage, five Local Government  
123 Areas (LGAs) were purposively selected based on the predominance of moringa farmers in the  
124 LGAs. In the second stage, two villages were randomly selected from each LGA. In the third stage,  
125 15 moringa producers were randomly selected in each village. A total of 150 respondents were  
126 interviewed.

### 127 **Analytical techniques**

128 The study employed descriptive statistics, farm budgetary technique, and the Stochastic frontier  
129 model to analyze the data collected.  
130

131 **Descriptive statistics**

132 Descriptive statistics such as frequency, percentage, and mean were used to describe the socio-  
133 economic characteristics of moringa producers in the study area.

134 **Budgetary analysis**

135 Budgetary analysis was used to estimate the cost and return on the moringa enterprise. Basically,  
136 it involves the estimation of total revenue and total cost from the same production period. The  
137 difference between the two parameters is the measure of net profit or net return for that period.

138 The technique is expressed as:

139  $TC = TFC + TVC$  (1)

140  $TR = P \times Q$  (2)

141  $GM = TR - TVC$  (3)

142  $\pi = GM - TFC$  (4)

143  $\pi = TR - TC$  (5)

144 Where  $\pi$  = profit on moringa production; TR = Total Revenue; TFC = Total fixed cost; TVC =  
145 Total Variable Cost; TC = Total Cost; GM = Gross Margin

146 **Gross margin analysis**

147 Gross margin analysis is the difference between gross farm income and total variable cost  
148 (Mohammed et al., 2011). Normally, it is used to determine the potential profitability (Samm,  
149 2009; Kehinde, 2021).

150 The gross margin analysis was estimated from costs and returns in moringa production.

151 Following Mohammed *et al.* (2011), Adeyemo et al. (2020), Kehinde (2021), and Oluponna et al.  
152 (2022), the gross margin model is expressed as follows:

153  $GM = TR - TVC$  (6)

154 Where; GM = Gross margin (₦/ha); TR = Total revenue or the total value of output from the  
155 moringa enterprise (₦/ha). It is the product of the average output per hectare multiplied by the  
156 market price. The price used was the market price of the year 2017; TVC = Total variable cost or  
157 the cost used up in producing moringa (N/ha). This includes the cost of inputs such as seed cost,  
158 agrochemicals (herbicides and insecticides), labour cost (family labour and hired labour), and other  
159 miscellaneous expenses.

160 The formula is given as:  $GM_i = \sum_{i=1}^n P_i Y_i - C_i$  (7)

161 Where;

162  $GM_i$  = Gross margin of producer per hectare I;  $P_i$  = price per kg of moringa leaf and seed of  
163 producer I;  $Y_i$  = Total quantity in kg of moringa leaf and seed of producer I;  $C_i$  = Total variable  
164 costs incurred on producer I;  $i \dots n$  = Total number of moringa producers

165 Subsequently, a net return was obtained from the gross margin.

166 Net returns = GM - TFC (8)

167 where,

168 TFC = Total fixed cost

169

170 **Profitability and efficiency ratio**

171 The following ratios were calculated to understand how profitable moringa production is.

172 Operating expense ratio = TVC/GR (9)

173 Net return on investment/Return Per Naira outlay = NI/TC (10)

174 Benefit Cost Ratio (BCR) = TR/TC (11)

175 Expense Structure Ratio = TFC/TVC (12)

176 Profitability Index or profit margin = NI/GR (13)

177 Where,

178 GR is Gross Revenue; NI is Net Income; TC is Total Cost

179

## 180 Stochastic frontier production function

### 181 Theoretical model

182 The Stochastic frontier approach (SFA) was used to determine the profit efficiency of Moringa  
183 oleifera production and the factors affecting profit efficiency in moringa production. The frontier  
184 production function shows the maximum amount of output obtained from the given inputs, thus  
185 representing maximum efficiency (Tijani, 2006; Kehinde and Olatidoye, 2019). This method is  
186 still the most widely used for estimating efficiency, and more especially, profit efficiency (Akite  
187 et al., 2022). It has been extensively utilized in determining how profitable a crop grower is  
188 (Saysay et al., 2016; Wongnaa et al., 2019; Jonah et al., 2020). SFA is helpful since it has two  
189 error components that are cumulative in nature and enables hypothesis testing. One element of the  
190 error takes into consideration the statistical noise connected to data measurements, while the other  
191 element measures departures from the frontier connected to production inefficiency. So, a  
192 producer's incentive for operating at the frontier is profit efficiency (Akite et al., 2022). On the  
193 other hand, a profit frontier is the highest possible profit function (le et al., 2020). The stochastic  
194 profit technique also takes into account the fact that any mistakes made when making production  
195 decisions result in lower sales or profits for the company. The profit lost from failing to operate  
196 on the frontier would be referred to in this context as profit inefficiency, which can then be  
197 expressed as a linear function of the explanatory variables describing farm characteristics (Battese  
198 and Coelli, 1995). This approach was chosen for estimating profit efficiency because of its ability  
199 to estimate farm-specific efficiency levels and sources of inefficiency in a single-step procedure  
200 using the Maximum Likelihood Estimation (MLE) method. The stochastic profit frontier model is  
201 therefore specified as:

$$202 \pi_i = f(p_{ij}, Z_{kj}) \text{Exp} \cdot e_i \quad (14)$$

203 Where,

204  $\pi_i$  = normalized profit of the  $j^{\text{th}}$  farm calculation as gross revenue minus the variable inputs divided  
205 by farm-specific output price, p

206  $p_{ij}$  = price of  $j^{\text{th}}$  variable input encountered by the  $i^{\text{th}}$  farm divided by the out price

207  $Z_{kj}$  = level of the  $k^{\text{th}}$  fixed factor in the  $i^{\text{th}}$  farm

208  $e_i$  = error term

209  $i \dots \dots n$  = number of farmers in the sample

210 Furthermore, Rahman (2003) postulated that the error term behaves consistently with the frontier  
 211 concept and is composed of two random parts as specified in equation (15).

$$212 \quad e_i = V_i - U_i \quad (15)$$

213  $V_i$ = symmetric error term presumed to be independently and identically distributed, it is two-sided  
 214 in nature representing random effects, measurement errors, and statistical noise.

215  $U_i$ =one-sided error term representing the inefficiency of the farm.

216 The inefficiency  $U_i$  is thus expressed as in equation (16).

$$217 \quad U_i = \delta_0 + \sum \delta_1 z_{ai} \quad (16)$$

218  $z_{ai}$ = (1 x m) vector of farm-specific variables varying across respondents and not over time.

219  $\delta_0$ = (m x 1) vector of unknown coefficients of farm-specific variables.

220 The inefficiency  $U_i$  is non-negative demonstrating a profit deficit from its maximum possible value  
 221 that will be provided by the stochastic frontier. Since the MLE method was employed in estimating  
 222 stochastic profit frontier and inefficiencies simultaneously, it is thus expressed in variance  
 223 parameters as in equations (17) and (18)

$$224 \quad \sigma^2 = \sigma_v^2 + \sigma_\mu^2 \quad (17)$$

$$225 \quad \gamma = \frac{\sigma_\mu^2}{\sigma_\mu^2 + \sigma_v^2} \quad (18)$$

226

### 227 **Empirical model**

228 The explicit Cobb-Douglas functional form for the moringa farmers in the study area is therefore  
 229 specified as follows:

$$230 \quad \ln \pi_i = \ln \beta_0 + \ln \beta_1 X_{1i} + \ln \beta_2 X_{2i} + \ln \beta_3 X_{3i} + \ln \beta_4 X_{4i} + \ln \beta_5 X_{5i} + (V_i - U_i) \quad (19)$$

231 Where

232  $\pi_i$  = normalized profit computed as total revenue less variable cost divided by firm-specific  
 233 moringa price;  $X_1$  = cost of family labour;  $X_2$  = cost of hired labour;  $X_3$  = transport cost;  $X_4$  = seed  
 234 cost;  $X_5$  = pesticide cost

235

### 236 **Inefficiency model**

237 The inefficiency model ( $U_i$ ) is defined as

$$238 \quad U_i = \delta_0 + \delta_1 W_{1i} + \delta_2 W_{2i} + \delta_3 W_{3i} + \delta_4 W_{4i} + \delta_5 W_{5i} + \delta_6 W_{6i} + \delta_7 W_{7i} + \zeta_i \quad (20)$$

239 Where  $W_i$  is the socioeconomic variables included in the model to indicate their possible influence  
 240 on the profit efficiencies of the moringa farmers (determinant of profit efficiency).

241 Where,

242  $W_1$  = Gender;  $W_2$  = Age;  $W_3$  = Level of education;  $W_4$  = Household size;  $W_5$  = Moringa farming  
 243 experience;  $W_6$  = Moringa farm size;  $W_7$  = Record keeping (dummy variable)

## 244 **Results and Discussion**

### 245 **Socio-economic characteristics of moringa farmers**

246 The socioeconomic characteristics of the respondents were presented in Table 1. About 55.3% of  
 247 moringa producers were male. This shows that in the study area, moringa production is  
 248 predominantly a male-dominated enterprise. The average age of the respondent was 44.92 ( $\pm 13.68$ )  
 249 years. This is an indication that moringa production is mainly done by young people who are active  
 250 and within their productive age group. This corresponds to the findings of Nenna, (2016). The  
 251 majority (85.3%) of respondents were married. This shows that most of the respondents are  
 252 responsible for their families. This conforms with Azeez et al. (2013). Most (86.7%) of the  
 253 respondent were educated. This implies that the farmers tend to embrace a new innovation or  
 254 technology that will improve their efficiency and the use of resources (Adewuyi et al., 2013). All  
 255 the sampled producers had an average farm size of 0.30 ( $\pm 0.08$ ) hectares. It implies that the study  
 256 area is dominated by small-scale farmers. The majority (80.7%) of respondents operate moringa  
 257 on a part-time basis. This suggests that most respondents do not fully concentrate on moringa  
 258 production. The majority (86.7%) of respondents' financial capital source is from personal savings.  
 259 It also suggests that producers may face financial constraints by not having easy access to other  
 260 sources of funds, such as a bank. The average farming experience was 19.93 ( $\pm 13.15$ ) years. This  
 261 suggests that the farmers have many years of farming experience. The majority (67.3%) of  
 262 respondents had access to extension services This implies information about new technologies in  
 263 cocoa production will be properly disseminated among the farmers. This could be ascribed to the  
 264 fact that extension services keep farmers abreast of new farm technologies (Alao et al., 2020;  
 265 Adeyemo et al., 2020). The mean household size of about 7.00 ( $\pm 3.09$ ). This implies that  
 266 households are excessively large, which could serve as a cheap source of farm labour for the  
 267 farmers (Anigbogu et al., 2015).

268 **Table 1: Socio-economic Characteristics of Moringa Farmers**

Variables	Moringa Farmers
Age (years)	44.92( $\pm 13.68$ )
Male (%)	55.3
Married (%)	85.3
Formal education (%)	86.7
Household size (#)	7.00 ( $\pm 3.08$ )
Personal saving	86.7
Farm size (ha)	0.30( $\pm 0.08$ )
Formal education (%)	86.7
Years of farming experience	19.93( $\pm 13.15$ )
Extension visit (%)	67.3
Part-time (%)	80.7

270 Source: Field survey, 2017

271  
 272 **Profitability of moringa enterprise**

273 Table 2 presents the profitability of the moringa enterprise. However, the total cost (TC) was  
 274 determined by the addition of both the variable cost and the fixed cost, and it summed up to  
 275 ₦55,709.0471. The variable cost took the larger percentage of about 90.4% of the total cost  
 276 incurred in moringa production, while the fixed cost calculated using the depreciated value was  
 277 9.63% of the total cost. In addition, of all the various costs incurred in production, hired labour  
 278 took the largest percentage which accounted for about 48.35% of the total cost. This confirms that



279 Moringa oleifera production is an employer of labour as stated by Ojo et al. (2016). The mean  
 280 depreciated value of ₦807.87 spent on processing equipment was 1.48% of the total cost. This is  
 281 an indication that most producers of moringa spend less on processing. This could imply that most  
 282 farmers are reluctant to add value to Moringa oleifera production. About 3.67% of the total cost  
 283 was spent on the seed. This low percentage was attributed to the fact that most moringa producers  
 284 in Osun State received free improved seeds from non-governmental agricultural agencies such as  
 285 Youth Initiative for Sustainable Agriculture, Women Farmers Advancement Network, and OFFER  
 286 centre in Iwo, Osun State, among others. Pesticide application was 4.11% of the total cost, which  
 287 signifies that producers do not commonly apply pesticides or do not apply them in large quantities.  
 288 The cost incurred on using capital signifies the cost spent in running capital equipment on the farm.  
 289 This includes fueling, leasing, repair of damages, etc. This cost takes about 19.49% of the total  
 290 cost This is an indication that moringa oleifera production is labour intensive, not capital-intensive.  
 291 The average gross margin realized was ₦275,958.819. An average Net farm income (NFI) value  
 292 of ₦270,591.2529 was realized in the study area. A positive NFI shows that an enterprise is  
 293 profitable and worth continuous execution. Since the net profit of moringa production was positive,  
 294 therefore producers generate profit and should continuously involve themselves in its production.

295

296 **Table 2: Budgetary Analysis of Moringa oleifera production in Osun State, Nigeria.**

S/N	ITEM	MEAN AMOUNT (₦)	PERCENTAGE
<b>A</b>	<b>Total Revenue</b>	<b>326,300.3</b>	
	<b>Variable cost</b>		
	Family labour	5,110.667	9.17
	Hired labour	26,938	48.35
	Transport cost	3,095.667	5.56
	Seed cost	2045.147	3.67
	Pesticide	2,292	4.11
	Cost incurred on the use of capital	10,860	19.49
<b>B</b>	<b>Total Variable Cost/ha (TVC)</b>	<b>50,341.481</b>	<b>90.37</b>
<b>C</b>	<b>Gross margin (TR-TVC)</b>	<b>275,958.819</b>	
	<b>Fixed cost</b>		
	Rent on land	3,941.747	7.08
	Depreciated value on implement	617.9524	1.11
	Depreciated value of processing equipment	807.8667	1.45
<b>D</b>	<b>Total fixed cost</b>	<b>5,367.5661</b>	<b>9.63</b>
<b>E</b>	<b>Total Cost/ha (TC) = (TFC+TVC)</b>	<b>55,709.0471</b>	
<b>F</b>	<b>Net Income (NI) = (GM-TFC)</b>	<b>270,591.2529</b>	

297 Source: Field survey, 2017; Notes: ₦ = Naira (Nigerian currency)

298

299 As shown in Table 3, the return to moringa production in Osun State was approximately ₦5.48  
 300 which is greater than 1, and the benefit-cost ratio was ₦5.857. This shows that the moringa  
 301 enterprise in the study area is well managed. The study further suggests that the business of  
 302 moringa production is viable and profitable. This is in line with the study carried out by Ojo et al.

303 (2016). Moringa producers operate at a profit margin of 82.9% in Osun State. This indicates that  
 304 for every ₦1 income received, ₦0.829 of profit is generated. The net return on investment of the  
 305 enterprise was ₦4.86. This indicates that for every ₦1 spent on total cost, ₦4.86 is generated as  
 306 profit. This shows that moringa production has a huge return on investment. The operating  
 307 expenses ratio was 0.182. This indicates that for every ₦1 received from the gross margin, ₦0.182  
 308 was spent on total variable cost. The enterprise expense ratio was 0.1066. This ratio indicates that  
 309 there is less fixed cost than variable cost. The profitability index for this enterprise was ₦0.98.  
 310 This confirms that moringa production is a profitable venture in Osun state.

311 **Table 3: Profitability ratios estimated in Moringa oleifera production in Osun State.**

S/N	Profitability ratios	Calculated value
1	Benefit-cost ratio	5.857
2	Profit margin	0.829 (82.9%)
3	Operating expense ratio	0.182
4	Expense structure ratio	0.107
5	Net return on investment	4.857
6	Rate of return	5.482
7	Profitability index	0.981

312 Source: Field survey, 2017; Notes: ₦ = Naira (Nigerian currency)

313

### 314 **Stochastic frontier production function**

315 The results of the estimates of the parameters of the stochastic frontier and the inefficiency model  
 316 are presented in Table 4. The coefficient of the gamma parameter ( $\gamma$ ) of 0.99 was significant at a  
 317 1 percent level of significance. The sigma squared  $\delta^2$  indicates the goodness of fit and correctness  
 318 of the distributional form assumed for the composite error term, while the gamma  $\gamma$  indicates that  
 319 the systematic influences are unexplained by the production. The mean profit efficiency was  
 320 18.73%. It implies that, on average, the respondents were able to obtain just 18.73% of the optimal  
 321 profit from a given set of inputs. This indicates that most farmers are relatively too low in  
 322 maximizing profit efficiency. In other words, about 81 % of the profit is lost to the inefficiency of  
 323 management. This suggests that a sizeable portion of the earnings from moringa production in  
 324 Osun State is wasted due to profit inefficiencies at the current input prices and technological levels.  
 325 Hence, there is potential to increase profit from moringa production by 81% in the short run. The  
 326 mean profit efficiency level obtained in this study was much lower than the levels reported by  
 327 Okorie et al. (2021) for Nigerian cassava farmers (73%), Wongnaa et al. (2019) for Ghanaian  
 328 maize farmers (48%), and Akite et al. (2022) for Ugandan smallholder rice farmers (65%).

329

330 The efficiency model revealed that the coefficient of hired labour (0.174) has a positive sign and  
 331 is statistically significant at 1% profit efficiency. An increase in the cost of hired labour by ₦1  
 332 would increase the farm's profit efficiency by 17.4%. The coefficient of family labour (0.062) also  
 333 has a positive sign and is statistically significant at 1% profit efficiency. An increase in the cost of  
 334 family labour by ₦1 would increase the farm's profit efficiency by 6.2%. This conforms with the  
 335 findings of Ojo et al., (2016). This could be because increasing labour rate would encourage more  
 336 labour to work in moringa production and marketing activities thus reducing losses from post-

337 harvest and weeds. Availability of family and hired labour, therefore, plays a censorious role in  
 338 achieving profit efficiency. The price of Seeds and pesticides have a negative sign and are  
 339 statistically significant at 1% and 5% respectively. The coefficient of seed cost was -0.159. This  
 340 negative sign conforms with the expected negative sign and was significant at 1% level. This could  
 341 be related to the upsurge in costs brought about by increased prices because seed costs account for  
 342 a significant part of moringa production. However, transportation cost showed a positive effect on  
 343 profit efficiency at a 1% level of significance. It was found that an increase in transportation cost  
 344 by ₦1 would increase the farm's profit efficiency by 7.9%.

345 The inefficiency model revealed that the level of education and farm size are the inefficiency  
 346 variables that have significant effects on the level of profit inefficiency. The level of education has  
 347 a coefficient of -1.404, it has a negative sign and is statistically significant at 1%. This suggests  
 348 that the level of education of the producers is a major constraint in moringa production. More  
 349 education brings about a decrease in inefficiency and as such increases profit efficiency. This  
 350 however conforms with Ezech et al., (2012). The consequence is that having completed many years  
 351 of education facilitates learning about new technology and developments that may increase the  
 352 profitability of moringa farmers (Okon et al., 2010; Okorie et al., 2021). Thus, extension  
 353 programmes should be used to fill the gaps in education among the farmers. Moringa farm size  
 354 has a coefficient of -1.404 which is also negative but statistically significant at 10%. This implies  
 355 that as the farm size increases, profit efficiency increases. Increased farm size may have  
 356 encouraged the employment of contemporary technology, resulting in greater efficiency benefits.  
 357 This conforms with Oyebanjo et al., (2021).

358  
 359 **Table 4: Maximum Likelihood estimates of the stochastic frontier function and profit**  
 360 **efficiency.**

Variable	Parameters	Coefficient	Standard Error	T-ratio
Constant	Beta 0	5.812	0.465	12.492***
Family labour	Beta 1	0.062	0.026	2.385**
Hired labour	Beta 2	0.174	0.030	5.882***
Transport cost	Beta 3	0.079	0.025	3.189***
Seed cost	Beta 4	-0.159	0.052	-3.052***
Pesticide	Beta 5	-0.094	0.038	-2.466**
Constant	Delta 0	7.251	2.088	3.474***
Gender	Delta 1	0.767	0.846	0.906
Age	Delta 2	-0.047	0.032	-1.469
Level of education	Delta 3	-1.404	0.453	-3.098***
Household size	Delta 4	0.193	0.144	1.338
Moringa farming experience	Delta 5	-0.202	0.192	-1.048

Moringa farm size	Delta 6	-1.814	1.015	-1.788*
Record keeping	Delta 7	-1.351	0.951	-1.421
Sigma-squared		5.649	1.553	3.638***
<b>Gamma</b>		<b>0.99999999</b>	<b>0.00000755</b>	<b>132458.900***</b>
<b>Mean technical efficiency</b>	<b>18.73</b>			
<b>Log likelihood function</b>	<b>-286.76843</b>			
<b>LR test</b>	<b>70.840005</b>			

361 Source: Field survey, 2017 \*\*\*, \*\* and \* shows statistical significance at 1%, 5% and 10%

362 Notes: ₦ = Naira (Nigerian currency)

363

### 364 Conclusion and recommendations

365 This study investigated the profit efficiency of Moringa oleifera production. A multistage sampling  
366 procedure was used for selecting 150 respondents for the study. The data were analyzed using  
367 descriptive statistics, budgetary analysis, and stochastic frontier production function. The  
368 descriptive statistics revealed that many of the respondents were male (53%), married (85%), and  
369 had formal education (87%). The results further revealed average values of 45 years for age, 7  
370 people for household size, and 0.3 ha for farm size. Moringa production had a cost-benefit ratio of  
371 ₦5.857, profit margin of ₦0.182, expense structure ratio of ₦0.107, a net return on investment of  
372 ₦4.857, rate of return of ₦5.482, and profitability ratio of ₦0.981. Results obtained from the  
373 stochastic frontier model showed that moringa farmers had an average profit efficiency of 19% in  
374 their production. The empirical results from the frontier model showed that the price of family  
375 labour, seed, pesticides, hired labour, and transport costs significantly influence the profit  
376 efficiency of moringa farmers. However, years of education, and farm size were the major sources  
377 of profit inefficiencies among moringa farmers. This study concluded that moringa producers in  
378 Osun State were profit inefficient, despite the high returns to moringa production. The findings  
379 further revealed that the level of education and farm size influenced the profit efficiency of  
380 moringa production. Based on the finding of the result, the study concluded by inferring from the  
381 results obtained that there is scope for increasing the profitability of moringa production in the  
382 study area by directing policy focus on the significant inefficiency factors. It was recommended  
383 that attempts at improving farm incomes need to look at enhancing the value of family and hired  
384 labour to achieve significant positive effects on moringa profits. Also, Channels of distribution  
385 need to be enhanced beyond local communities and extend to other States as well as other countries  
386 through exportation. This should be done in an attempt to improve transportation costs because of  
387 its positive and significant effect on moringa production. Finally, training should be provided to  
388 less educated farmers to enable them to adopt the best moringa farming practices and adopt  
389 innovative ideas in processing in order to add value to moringa. Moringa farmers in the study area  
390 should register in adult education centers to improve their efficiency. The same study should be  
391 encouraged in other zones of the country. A study should be conducted on the impact of profit  
392 efficiency on the welfare of moringa farmers in the area.

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