Kathmandu University
Journal of Science, Engineering and Technology

Investment analysis of integrated milling-sieving-dewatering machine for grain slurry starch production

Egwuagu M. Onyekachi[a], Nwankwojike B. Nduka*[b], Onwuka S. Osinachi[b], Abam I. Fidelis[b], and Emeh C. Princewil[b]

[a]Department of Mechanical and Production Engineering, Enugu State University of Science and Technology, Enugu, Nigeria.

[b]Department of Mechanical Engineering, Michael Okpara University of Agriculture, Umudike, Nigeria.

Abstract

Economic viability of a continuous process milling-sieving-dewatering machine for grain slurry starch production was evaluated in this study using benefit-cost methodologies in order to encourage its wide acceptance/adoption. Benefit cost ratio, payback period, net present value and accounting rate of return constitute the economic parameters of the machine evaluated subject to prevailing economic indicators/market prices of materials in Abia State of Nigeria in 2020. Results revealed that the machine's benefit-cost ratio, payback period, net present value and annual rate of return as 1.86 years, 1.75, $593,140.90 and 31.41% respectively. The investment's benefit-cost ratio of 1.75 implies an inflow of $1.75 for every $1 spent The payback of 1.86years is far less than 10 years useful life of the machine while its 31.41% accounting rate of return outweighed banks maximum fixed deposits return of 16% and prime lending rate of 29% in Nigeria. Thus, the machine is recommended for advancement of grain slurry food processing sector due to its positive capital recovery prospect.

Keywords: Economic viability; milling-sieving-dewatering machine; grain slurry starch; production; slurry food diets/beverages

1. Introduction

Cereal grain slurry diets and beverages such as pap, *ndaleyi. agidi, kunu, burukutu and pito* constitute the most popular and locally sourced diets consumed in Nigeria. Almost every household in this country consumes cereal based slurry food diets or beverages daily because of their high nutritive value and quick process of preparing them from grain slurry starch [1, 2]. Processing of slurry starch from soaked grain involves sequential wet milling, sieving and dewatering operations. The work of [3] showed milling as the most successfully mechanized with the present day power driven bur mills while [1] revealed unsuccessful mechanization of the sieving and dewatering as the major bottle neck in this sector. This because the soaking process and varied unit operations involved in blending of the slurry starch into different diets/beverages always march the improvement trend of existing/emerging food processing technologies [4]. The excessive drudgery, food material loses, time and water consumption as well as unhygienic features of batch process of grain slurry starch production with mechanized milling/manual sieving and dewatering systems incited the ever increasing scarcity and high cost of freshly prepared (just in time) quality grain slurry starch in this country. The quest for mass production of quality slurry starch at low cost prompted progressive development of integrated milling-sieving systems by [5, 6, 3, 7, 4]. The continuous process slurry food milling and sieving machine developed by [4] constitutes the latest and most successful among these innovations. Thus, its advancement to a milling-sieving-dewatering system (Fig. 1) with the integration of a drum centrifuge filter and suction pump to enable a flow process of milling, sieving, dewatering and water recycling operations in this extraction process. This improve innovation is unique because it reduced drudgery and improved hygiene in this sector through elimination human contact involved in loading/discharging of intermediate processed grain paste among the three unit operations. Its screw-press based sieving unit which extract the slurry starch by compression process also aids the release of food materials from grain particles that were not properly crushed during the milling and it does not require adding of water to the milled grain paste but uses the water content of the paste for the sieving operation. Thereby reducing the process water consumption and food loss.

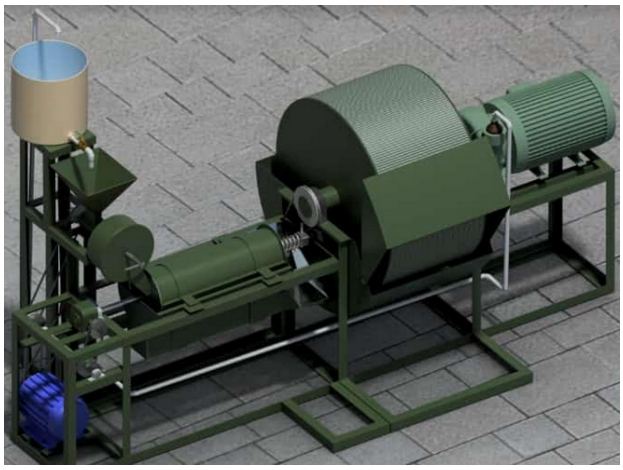

Figure 1: Grain slurry food milling-sieving-dewatering machine.

This integrated machine performs optimally with throughput, extraction efficiency, cake moisture content and specific energy

*Corresponding author. Email: jikeobodo@gmail.com

consumption respectively of 87Kg/h, 98.75%, 25.35% and 183kJ/Kg respectively [8]. This amounts to less than 2% slurry food loss to chaff and 19.64% reduction in the moisture content of the extracted slurry starch cake. Thereby increasing the shelf life of the cake and enhance its mobility. However this innovation is not yet widely sought for as expected despite these merits because of inadequate precise economic parameters to convince prospective investors o viability. Hence, the need for this machinery investment analysis. Investment analysis is a broad term for different methods of evaluating economic trends of charting past returns to predict future performance of systems [9, 10]. It determines risks, yield potential, or price movements of any system studied with the necessary entry price, the expected time for holding investments and the roles investment plays represents the key factors [10]. Thus, [11] showed machinery investment analysis as a key determinant of business profitability while [12] reported that it constitutes one of the most important considerations for business profitability in grain growing enterprises revealed overwhelming decades and benefits of its application in this sector.

Machinery investment analysis involves computation of return on investment of individual or group of machines/plant using the contract rates of all work the machine does in order to ascertain their level of capitalization [12]. Although, investment decision pointers such as Benefit Cost Ratio (BCR), Net Present Value (NPV), Payback period and Accounting Rates of returns are used individually to ascertain the economic efficiency of systems, their integrated methodology called benefit-cost analysis are often used in new machinery assessment because of its high prediction accuracy [13, 14]. Cost-benefit analysis is a tool for evaluating all the potential costs and revenues that may be generated prior to actual implementation of investment decisions in order to avoid the risk of going into an unprofitable venture and wasting valuable time and money [15]. This involves identification, categorization, projection, monetization, computing and comparison of present values of costs and benefits over the lifespan of an investment [13]. Integrated approach of benefit-cost analysis indicates that an investment is worthy when its projected potential benefits outweigh its costs; its rate of return exceeds the required minimum rate; its payback period is less than its salvage period and its net present value exceeds zero [15]. Application of this economic evaluation tools in successful machinery investment decisions is evident in report of [16] which revealed profitability of gari processing machines in Ondo State of Nigeria was with NPV, BCR and internal rate of return. Integrated BCR and IRR approach was also used in the feasibility study of small-scale palm oil processing in Nigeria by [17] while [18] showed a cost benefit ratio of more than one when cost and returns of cassava production in Ekiti state was analyzed. In addition, economic viability of mechanized maize crop farming in Pakistan and novel palm nut-pulp separating and oil pal broom processing machines were successfully forecasted benefit-cost methodologies [19-21]. It is therefore of economic sense that this study applies benefit-cost approach in investment analysis of prospects the novel continuous process milling-sieving-dewatering machine for grain slurry starch production to enable its general adoption since no investor or prudent manager will adopt a new technology without the conviction of its economic viability.

2. Method

The slurry food milling-sieving-dewatering machine was assessed for economic viability in this study with multi-criteria cost-benefit analysis measures. This involved computation and comparison of its payback period, accounting rate of return, net present value and benefit cost ratio using the prevailing economic indicators/market prices of materials in Abia State of Nigeria between January and December, 2020. The decision criteria applied include that the payback period of this machine must be less than its expected useful life of five years, its net present value and benefit cost ratio must be greater than zero and one respectively. In addition, the investment's rate of return must be greater than the upper limits of Nigerian banks' lending and fixed deposit interest rates in order to justify its possible funding from personal savings and bank credits. These monetary parameters were assessed based on Nigerian-Naira (₦) to United State-Dollar (US$) exchange rate of 0.0024. Since the performance of this machine is independent of the type/variety/size of the grain processed, maize grains (corn) were used in this investigation because it is the most productive grain crop and most dominantly applied for slurry food production in this country [2, 4]. Records showed the benchmark business registration cost, interest rate, corporate income tax rate for Nigeria companies (with turnover > US$2,437.18) as $60.93, 14% and 30% respectively within this study period. [22, 23]. The fixed deposit interest rate of Nigerian banks as at December 31, 2020 fall between 7.09 to 16% while their prime lending rates for agriculture or manufacturing ranges from 7 to 29% [23]. The maximum annual rent of required space for this business is $438.70 while $73.12 constitute Nigeria minimum wage per month during this investigation. Five (5) working days per week of 8 hours per day with one-hour break was also applied. Maize and water costs $0.88/kg and $0.005/litre respectively during this period while the fresh maize slurry starch food cake and chaff sale for $1.51/kg and $30/kg respectively. The cost of electricity for powering this machine was determined based on $0.1 per kW-h, being electricity price for business out fits in Nigeria during this study. The payback period (P_b), accounting rate of return (*ARR*), net present value (NPV) and benefit cost ratio (*BCR*) of the slurry food milling-sieving-dewatering machine were computed from its financial data collected and optimal performance parameters determined in this study using the following relations given by [13, 24].

$$P_b = \frac{C_i}{B_n} \tag{1}$$

$$ARR = \frac{B_n}{C_i} \tag{2}$$

$$NPV = \sum_{t=1}^{n} \frac{B_{\text{nt}}}{(1+r_i)^t} - C_i \tag{3}$$

$$BCR = \frac{\text{PVB}}{\text{PVC}} \tag{4}$$

$$PVC = \sum_{0}^{t} \frac{C_i}{(1+r_i)^t} \tag{5}$$

$$PVB = \sum_{0}^{t} \frac{B_n}{(1+r_i)^t} \tag{6}$$

Where C_i, B_n and B_{nt} constitute the initial investment cost, average annual net benefit (cash inflow) and net cash inflow at time, *t* respectively while PVC and PVB, are the respective present values of costs and benefits of the machine.

3. Results and discussion

The unit cost of fabrication and installation of the grain slurry food milling-sieving-dewatering machine was determined as three thousand, seven hundred and forty-four dollars, ninety-seven cents ($3,744.97) only while one hundred and seventy-two thousand, one hundred and sixty dollars, thirty-eight cents

Table 1: Analysis of Initial Investment cost and payback period of gran slurry food milling-sieving-dewatering machine.

Description	Expenditure ($)	Revenues ($)
Fixed costs		
Machine fabrication/ installation cost	3,744.97	
Business registration cost	60.93	
Salvage value of machine		0
Sub-total	3,805.90	
Annual recurrent expenditure		
Maize grain cost	158,771.66	
Fuel cost	1,071.82	
Water cost	3,802.00	
Maintenance cost	936.24	
transportation cost	2,281.20	
Wage	1,052.86	
Rent	438.69	
Sub-total	168,354.47	
Initial investment cost	172,160.37	
Annual recurrent revenue		
Sales from Maize Cake		290,696.62
Maize Chaff		10,343.66
Sub-total		301,040.28
Gross annual income		132,685.81
Less fixed cost recovery	380.59	
Net income		132,305.22
Less 30% tax	39,691.57	
Profit		92,613.65
Payback period	1.86	

($172,160.38) only constitutes its associated the initial investment cost (Table 1). This table also showed that this investment goes with a net annual profit (cash inflow) of Ninety-two thousand, six hundred and thirteen dollars, sixty-five cents ($92,613.65) only and a payback period of 1 years Eight months (1.86 years). Thus, processing slurry food with this machine is worthy since its payback period is less than its salvage period of ten years. In addition, its benefit-cost ratio shown in table 2 as 1.75 which implies a benefit of $1.75 for every $1 spent is also encouraging. Positive investment potential of this slurry food processing machine is also very obvious from table 3 which showed that its annual rate of return as 31.41% and its net present value as five hundred and ninety-three thousand, one hundred and forty dollars, ninety cents ($593,140.90) only. Positive net present value (> 0) is desirable of any worthy investment while 31.41% annual return of this machine is encouraging because it outweighed banks maximum fixed deposits return of 16% and prime lending rate of 29% in Nigeria. These indicated positive prospect of recovering credit used for funding this investment. Hence, advancing the grain slurry food processing sector with this slurry food milling-sieving-dewatering machine is encouraged.

4. Conclusion

This study confirmed that the novel grain slurry food milling-sieving-dewatering machine is economically viable. This because the machine's payback of 1.86years is far less than its 10 years useful life of the machine while its 31.41% accounting rate of return outweighed the prime lending rate of 29% in Nigeria. It also exhibits positive net present value and benefit-cost ratio of more than one expected of worthy investment. Thus, the grain slurry food milling-sieving-dewatering machine is recommended for general adoption and advancement of food processing sector because it reduced drudgery and food losses, improves hygiene/food security and very profitable.

Table 2: Analysis of benefit-cost ratio of gran slurry food milling-sieving-dewatering machine.

Period (Years)	PVC ($)	PVB ($)
0	172,160.38	301,040.28
1	154,403.93	269,991.28
2	138,478.86	242,144.65
3	124,196.29	217,170.09
4	111,386.81	194,771.38
5	99,898.48	174,682.85
6	89,595.05	156,666.23
7	80,354.30	140,507.83
8	72,066.64	126,015.99
9	64,633.76	113,018.83
10	57,967.50	101,362.18
Total	1,165,142.00	2,037,374.19
Benefit-cost ratio		1.75

References

[1] Oloyede O D, Sarafadeen K S & Fadele O K, Trends and Constraints of Grain Slurry Food Processing in Kaduna State, Nigeria. *Journal of Biosystems Engineering,* 41(2) (2016) 93-97.

[2] Ukwuru M U, Muritala A & Iheofor A O, Cereal Utilization in Nigeria, *Research Journal of Food and Nutrition,* 2 (3) (2018) 1-12.

[3] Nwankwojike B N, Onwuka O S & Orji N G, Design and Development of Integrated Slurry Food Processing Machine. Innovative Systems Design and Engineering, 6(12) (2015) 25-32. `https://iiste.org/Journals/index.php/ISDE`.

[4] Nwankwojike B N, Onwuka O S & Orji N G, Development of Slurry Food Milling and Sieving Machine, *Trademarks, Patents and Designs Registry, Federal Ministry of Industry, Trade and Investment. Abuja*. Patent No: NG/PT/NC/2019/3968, 2019.

[5] Tugbiyele O O, *Design of an "Ogi" Processing Plant*. Bachelor of Science Project, Department of Mechanical Engineering, University of Ibadan, Nigeria, 2009.

[6] Chuanzhong X, Liying C, Pei W, Yanhua M & Ding H, Development on a Hammer Mill with Separate Sieving Device. *Telkomnika Indonesian Journal of Electrical Engineering*, 10(6) (2012) 1151-1156.

[7] Egwuagu O M & Nwankwojike B N, Design Modification and Comparative Evaluation of Integrated Grain Slurry Milling and Sieving Machine. *International Journal of Scientific & Engineering Research*, 10(1) (2019) 1130-1134.

[8] Egwuagu O M, *Multiobjective Analysis of Grain Slurry Food Processing Machine Using Desirability Optimization Methodology*. Ph.D Degree Dissertation. Department of Mechanical Engineering, Michael Okpara University of Agriculture, Umudike, Nigeria, 2021.

[9] Gareth D M, Investment Analysis, http://business-school.exeter.ac.uk/module/index.php?, `https://people.exeter.ac.uk/gdmyles/Teaching/IAPM/finb1.pdf` 2017.

Table 3: Analysis of annual rate of return and net present value of gran slurry food milling-sieving-dewatering machine.

Period (Years)	Annual income ($)	Discounting factor at 14%	Present Value of income ($)	Depreciation ($)	Net income after depreciation ($)	Taxes at 30% ($)	Net income after taxes ($)	Initial Value of investment ($)	Final Value of investment ($)	Average ($)
1	132685.81	0.9	119000.72	380.59	118620.13	35586.04	83034.09	172160.38	170638.02	171399.2
2	132685.81	0.8	106727.1	380.59	106346.51	31903.95	74442.56	171779.79	170257.43	171081.61
3	132685.81	0.72	95719.37	380.59	95338.78	28601.63	66737.15	171399.2	169876.84	170638.02
4	132685.81	0.65	85846.97	380.59	85466.38	25639.91	59826.47	171081.61	169496.25	170257.43
5	132685.81	0.58	76992.8	380.59	76612.21	22983.66	53628.55	170638.02	16911566	169876.84
6	132685.81	0.52	69051.84	380.59	68,671..25	20601.37	48069.87	170257.43	168735.07	169496.25
7	132685.81	0.47	61929.9	380.59	61549.31	18464.79	43084.52	169876.84	168354.48	169115.66
8	132685.81	0.42	55542.51	380.59	55161.92	16548.57	38613.35	169496.25	167973.89	168735.07
9	132685.81	0.38	49813.91	380.59	49433.32	14830	34603.33	169115.66	167593.3	168354.48
10	132685.81	0.34	44676.15	380.59	44295.56	13288.67	31006.89	168735.07	167212.71	167973.89
Average	132685.81		76530.13	380.59	76149.54	22844.86	53304.68			169686.55
ARR (%)										31.41
NPV ($)										593140.9

[10] James C, Investment Analysis, `https://www.investopedia.com/terms/i/investment-analysis.asp`. October 2020.

[11] Cole R G, Peter J B & Steven T S, Machinery Investment Decisions: A Simulated Analysis for Cash Grain Farms. *Western Journal of Agricultural Economics*, `https://www.jstor.org/stable/i40044426` 13(2) (1988) 244-253.`https://www.jstor.org/stable/40987986`

[12] Will M, Machinery Investment Analysis. Farmonline Network. `https://www.farmonline.com.au/story/3582186/`, May 2017.

[13] Gerald S & Marta, An Overview of Benefit Cost Analysis. `http://www.agecorn.purdue.edu/staff/shively`, October 2015.

[14] David R, Ngulube P, Dube A, A Cost-Benefit Analysis of Document Management Strategies used at a Financial Institution in Zimbabwe, A Case Study, *SA Journal of Information Management.* 15 (2)(2013) `https://doi.org/10.4102%2Fsajim.v15i2.540`.

[15] *Jeanne G,* What Makes Cost Benefit Analysis Important? http://Smallbusiness.chron.com/cost-benefit-analysis-important-75211.html, February 2018.

[16] Ajila A S, Investment Analysis of Gari Processing Machineries in Ondo State, Nigeria, *World Journal of Food Science and Technology*, 1(2) (2017) 32-38.

[17] Ohimain E I, Emeti C I, Izah S C & Eretinghe D A, Small-Scale Palm Oil Processing Business in Nigeria; A Feasibility Study. Greener, *Journal of Business and Management Studies*, 4(3) (2014) 070-082.

[18] Toluwase S O & Abdu-raheem K A, Cost and Returns Analysis of Cassava Production in Ekiti State, Nigeria, *Scholarly Journal of Agricultural Science*, 3(10) (2013) 454-457.

[19] Aurangze M, Nigar S & Shah M K Benefit Cost Analysis of the Maize crop under Mechanized and Traditional Farming Systems in the North West Frontier Province, *Sarhad J. Agric,* 23 (1) (2007) 169-176.

[20] Nwankwojike B N, Odukwe A O & Agunwanba C J, Benefit Cost Analysis of Introducing Palm Nut-pulp Separating Machine in the Mechanized Small Scale Palm Fruit Processing. *Journal of Emerging Trends in Engineering and Applied Sciences,* 3(1) (2012) 38-44.

[21] Onwuka O S, Nwankwojike B N, Babalola O S, Awele A M, Chukwuma A & Edeh J C, Performance Optimization and Economic Analysis of Oil Palm Broom Processing Machine, *Nigerian Journal of Engineering, 28 (1)* (2021) 27-33.

[22] Cooperate Affairs Commission (CAC) Summary of Fees and Forms for Registration of Business Name, `http://new.cac.gov.ng/home/summary-of-fees-and-forms/`, March 2021.

[23] Central Bank of Nigeria (CBN) Interest Rate, Bank Deposit and Lending Rates, 2021. `www.cbn.gov.ng`. March 2021.

[24] Onwualu A P, Oluka S I & Offiong A, *Principles of Engineering Project Management*, SNAAP Press Ltd. Enugu, Nigeria (2002) (50-76): 122-139.