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Engineering Economy Studies on the Development and Production of Yoghurt using Indigenous Starter Culture

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Abstract

In this chapter, the economic viability of the production of yoghurt using indigenous starter culture is determined. Based on an output of 180 x 103 litres/year, the yield of the product, the quantities and costs of raw materials, centrifuge and incubator, were estimated at 100% capacity utilization (CU). The costs of land acquisition and factory building were obtained from contractors. The labour cost was also estimated for 60 staff members. The selling price of ₦120/litre of a similar product was adopted. Annual worth (AW), and present worth (PW) were calculated and used to establish the profitability of the products. The results showed that the proposed plant would produce 180 x 103 thousand litres of the yoghurt at full CU. The PW and AW showed that the product was economically viable with PW and AW greater than zero at 100% CU. At 100%, all the profitability indices for the product were positive. In conclusion, the production of yoghurt using indigenous starter culture is technologically and economically viable.

Keywords: *Engineering economy analysis; Indigenous starter culture; Yoghurt production*

1.0. Introduction

According to Bestshart (1982) food is an essential ingredient to sustain life. This can be obtained from plants and animals. Milk is one of such foods which can be obtained from an animal source (Bestshart, 1982). It has been established as nature's most complete food due to its endowed nutrients (protein, carbohydrate, minerals, vitamin) (Everette and McLeod, 2005; Dror and Allen, 2011).

Yoghurt is a fermented, often flavoured semisolid food made from milk. Its production involves controlled fermentation of the lactose content in milk giving rise to lactic acid, acetic acid, $C0_2$, acetaldehyde and diacetyl among others, through the use of starter culture which contains *Streptococcus thermophilus and Lactobacillus bulgaricus* (Adolfsson *et al*., 2004; Tamine & Robinson, 2004; Ifeanyi *et al*., 2013). According to literature, yoghurt has almost the same nutritional value as basic milk products (Buttriss, 1997, Ruud and Bert, 2004). The consumption and demand for yoghurt has increased worldwide (Nutraceuticals World, 2010; Nielsen and Ogden, 2015). In Nigeria, yoghurt consumption has been on the increase during the last decade largely by residents of both urban cities and rural areas (Dublin-Green and Ibe 2005). This increase has led to the establishment of small-scale factories solely for the production of yoghurt in many cities (Nwamaka and Chike, 2010). Olugbuyiro (2011) reported that there are different brands of yoghurt produced industrially in Nigeria, and Lagos State is one of its major markets where it is commonly hawked in the streets. There are reported cases of food infection and intoxication largely due to poor hygiene in the production, processing and storage of such foods (Stewart & Humphrey, 2002). However, some microorganisms such as *Staphylococcus aureus*, *Escherichia coli*, Coliform bacteria and Fungi have been well documented as yoghurt borne infection (Al-Tahir, 2005, Okonkwo, 2011, Belli *et al*., 2013, Ifeayin *et al*., 2013). These microorganisms produce enterotoxins which have been associated with food poisoning (Obende 1999, Uzeh 2006, WHO, 2012). One of the most important factors for yoghurt production is the type of starter culture used. Isolates of *B-Lactobacillus spp* and *F-Streptococcus spp* have the potential to be used as indigenous starters for the industrial production of yoghurt.

Starter culture is a microbial preparation of large numbers of cells of at least one microorganism to be added to a raw material to produce a fermented food by accelerating and steering its fermentation process. The group of lactic acid bacteria (LAB) occupies a central role in these processes, and has a long and safe history of application and consumption in the production of fermented foods and beverages. (Han *et al*., 2007, Nwamaka & Chike 2010, Ifeanyi *et al*., 2013, Tamang *et al*., 2016).

The amount used by dairy firms in Nigeria to import starter culture enzymes is in excesses of three hundred billion Naira (N300,000,000,000). The use of indigenous *starter cultures* for yoghurt production in Nigeria is scarce. However, the technology for the yoghurt starter culture production has been established recently at the Federal Institute of Industrial Research, Oshodi. An engineering economy study to establish its viability has not been carried out. Hence, this study

2.0 Engineering Economic Assessment

Engineering economy is a discipline concerned with the systematic evaluation of the cost and benefits of a proposed technical and business project or venture. Cost considerations and expenses are fundamental aspects of engineering practice. Engineering economic studies is a technique for addressing such concerns through the economic analysis of such engineering projects.

According to DeGarmo *et al*. (1990), basic methods in Engineering Economy studies include Present worth (PW), Annual worth (AW), Future worth (FW), Internal rate of return (IRR), External rate of return (ERR), and Benefit cost (B/C) ratio.

(a) Present worth (PW): The present worth (PW) method is based on the concept of all cash flows relative to some base or beginning point in time called the present. That is, all cash inflows and outflows are discounted to the base point at a minimum attractive rate of return (MARR) (DeGarmo *et al*., 1990).

$$PW = \sum_{n=1}^{n=k} R_i (P/A, i\%. N). - .\sum_{n=1}^{n=k} E_k (P/A, i\%, .N) \text{ - I (A/P, i\%, N) + } S_t \text{ (P/F, i\%, N)} \quad (1)$$

Where R_i = future cash inflows at the end of each year or a period
E_K = future cash outflow at the end of each year
S = Salvage value at period k
i = the MARR
N = study period or life (years) of the project
I = Investment cost

(b) Annual worth (AW): is a uniform annual series of amounts, for a stated study period that is equivalent to cash inflows (receipts or savings) and/or cash outflows (expenses) under consideration. In other words, the annual worth of a project is its annual equivalent receipts (or savings) ($\underline{R}$) minus annual equivalent expenses ($\underline{E}$), less its annual equivalent capital recovery (CR) amount which is defined below. An annual equivalent value of R, E, and CR is computed as the MARR. The study period is denoted by N, which is usually in years. In equation form, the annual worth is

$$AW = R – E – CR \quad (2)$$

$$CR = I (A/P, i\%, N) – S (A/F, i\%, N) \quad (3)$$

Where R = annual equivalent receipt
E = annual equivalent expenses
CR = annual equivalent capital recovery

The project is worthwhile if AW $\geq$ 0. (DeGarmo *et al*., 1990).
As long as the annual worth is greater than or equal to zero, the project is economically attractive; otherwise, it is not.

(c) Future worth (FW): Like the PW, future worth (FW) is the equivalent worth of all cash flows relative to an end point in time called the future. The future worth method is exactly comparable to the present worth method except that all cash inflows and outflows are compounded forward to a reference point in time called the future. The project is desirable when FW $\geq$ 0 (DeGarmo *et al*., 1990).

(d) Internal rate of return (IRR): The IRR method is the most widely used rate of return method for performing engineering economic analysis. It involves finding the interest rate at which the present worth of the cash inflow rate equals the present worth of the cash outflow.

$$\sum_{k=0}^{N} R_k (P/F, I\%, k) = \sum_{k=0}^{N} E_k (P/F, I\%, k) \quad (4)$$

Where R_k = net receipts or savings for the kth year
E_k = net expenditure including investments for the kth year
N = project life (or study period)
Once i has been calculated, it is then compared with the MARR to assess whether the alternative in question is acceptable. If i' $\geq$ MARR, the alternative is acceptable, otherwise, it is not (DeGarmo *et al*., 1990).

(e) External rate of return (ERR): The ERR takes into account the external interest rate (E) at which net cash flows generated (or required) by a project over its life can be re-invested (or borrowed) outside the firm. Cash flows are discounted to period 0 (the present) at E%. This can be represented in equation form by:

$$\sum_{k=0}^{N} E_k (P/F, E\%, k)(F/P, i'\%, N) = \sum_{k=0}^{N} R_k (P/F, E\%, N-k) \qquad (5)$$

Where R_k = excess of receipts over expenditures in period k
E_k = excess of expenditures over receipts in period k
N = project life or number of periods for the study
E = external re-investment rate per period.

A project is acceptable when i'% of the ERR method is greater than or equal to the firm's MARR (DeGarmo *et al*., 1990).

An engineering economic assessment was carried out on the production of non-alcoholic beverages from some tropical crops (breadfruit, potato, plantain and sweet cassava) (Ilori and Irefin, 1997), based on a production technology earlier established (Ilori *et al*., 1996). At small-scale level, the engineering economic study showed positive net present value (NPV) at 75% and 100% capacity utilizations. This indicated that the research result might lead to successful innovation if appropriate funding, management and business strategies were employed for its exploitation (Ilori *et al*., 1996).

Adeoti *et al.* (1998) carried out an engineering design and economic evaluation of a 6.0 m³ family-sized biogas project which could use cattle dung as substrate. The study showed that the NPV, IRR, B/C and payback period of the project were 0.05 million Naira, 17.52%, 2.26 and 6.6 years respectively indicating that the project had a good economic potential. Ilori *et al.* (1996) also proposed a cottage level technology for exploitation of mushroom biotechnology. The study revealed that the venture could be profitable at 2.5, 3.75 and 5.0 tonnes capacities per annum using two investment options for two mushroom varieties. The first option entails the complete production of spawn and mushroom cultivation, while the second option involves purchasing of spawn from a separate organization and using the spawn for commercial cultivation. Ethanol production via plant enzyme and hydrolysis of cassava and breadfruit flours was confirmed to be economically viable through a positive NPV obtained after the profitability analysis of the process (Ilori *et al.* 1996). Similarly, Babalola, Ilori, and Adegbite (2012) assessed the economic viability of organic fertilizer production in Nigeria. They discovered that the medium level technology (MLT) option recorded higher viability than the low-level technology (LLT) option at higher capacity utilization.

3.0 Methodology

3.1 Engineering Economic Analysis

In this study, the engineering economy analysis of the production technology was carried out. MARR of 20% was chosen for the study based on the existing bank interest rate. The number of employees required for the plant was also estimated.

Investment costs

The investment cost which is usually referred to as first cost (DeGarmo *et al.*, 1990) are made up of costs of land, building and equipment/machinery acquisition. It also includes costs of utilities and working capital. The cost of the plant/machinery was obtained from the procurement department of the Federal Institute of Industrial Research, Oshodi, Lagos, while the costs of land, factory building and utilities were obtained from professionals in the fields. The working capital was estimated as 10% of the cost of the plant.

Operating and Maintenance Cost

The raw material estimates were based on;

(i) the output of 180 x 10^3 litres per year of the plant at 100% capacity utilization.
(ii) based on market prices, the costs of raw materials for the product were then estimated.
(iii) labour and other operating costs were estimated based on what obtains currently in a similar organization.

Engineering economic viability
The engineering economic viability of the development and production of yoghurt using indigenous starter culture was determined using Present worth (PW) and Annual worth methods (AW), as stated in equations 1 and 2 above. The MARR of 20% chosen for this study was based on the prevailing bank interest as at the time of the study. The salvage value (S_K) for period k was assumed to be the book value (BV_K) of the asset at period (k). The straight-line depreciation method was used for the study. It was assumed that the loss in value is directly proportional to the age of the asset (DeGarmo *et al*., 1990). Thus, depreciation BV_K was calculated as follows:

$$d_K = \frac{B - S}{N} \quad (7)$$

$$D_K = \frac{K(B - S)}{N} \quad (8)$$

$$BV_K \equiv B - D_K \equiv S_K \quad (9)$$

Where: N = the depreciable life of the asset
B = cost of the machinery/equipment
d_K = annual depreciation deduction in the kth year
$1 \leq K \leq N$
S = salvage value at the end of the depreciation life of the asset
D_K = cumulative depreciation through year k

4.0 Result and Discussion

4.1 Engineering Economic Analysis

Table 1 shows the first cost to be ₦14, 270.8 x10^3 which comprises of costs of land and building (₦6,000 x10^3), facilities (₦4, 070 x10^3), utility equipment (₦400 x10^3), furnitures and fittings (₦300 x10^3), motor vehicles (₦1,500 x10^3) and working capital (₦2,000 x10^3)

Table 2 shows the data for engineering economic analysis of the investment cost. The investment cost includes cost of land, incubator/fridge, laboratory (Land & Building) and centrifuge estimates shown in Table 1. The annual disbursement includes labour cost, energy cost, maintenance cost and insurance cost. The annual cost of estimate for labour is ₦7, 500, 000.00.
The economic viability of the yoghurt production using indigenous starter culture was based on the present worth (PW) and annual worth (AW). The result of the test, using a minimum attractive rate of return (MARR) of 20% showed that the yoghurt production using indigenous starter culture was viable with PW value of ₦117, 804, 542. This indicates that the project will be viable and worthwhile for the investment.

The economic viability of the industrial production of yoghurt using indigenous starter culture was determined in this study. The process technology includes modifying the composition of and pasteurizing the milk; fermenting at warm temperatures; cooling; and adding fruit and sugar. Based on an output of 180 x 10^3 litres / year, and the yield of the product, the quantities and costs of the raw materials, centrifuge and incubator using their market prices, were estimated at 100% capacity utilizations (CU). The costs of land acquisition and factory building were obtained from contractors.

Table 1: Land and Machinery Acquisition for the Production of Yoghurt using Indigenous Starter Culture

	Description of Item	Number of Units	Unit Cost x 10^3	Amount (₦:k) x 10^3	Sub-Total (₦:k) x 10^3
(A)	Land and Building				
(i)	100 hectares of land	-	-	2,000	
(ii)	Factory Building 25 x 50 shed with aluminium roofing	-	-	4,000	
	Sub-Total	**-**	**-**	**6,000**	**6,000**
(B)	Facilities				
(i)	Centrifuge	1	3,000	3,000	
	Incubator / fridge	1	1,070.8		
	Sub-Total		**4,070.8**	1,070.8	**4,070.8**
				4,070.8	
(D)	Utility Equipment				
(i)	Generating Set 5 KVA	1	150	150	
(ii)	Bore hole	1	250	250	
	Sub-Total			**400**	**400**
(E)	Furniture and Fittings				
(i)	Office tables and chairs	-	-	100	
(ii)	ACs, fans, gear switches	-	-	200	
	Sub-Total	**-**	**-**	**300**	**300**
F)	Motor Vehicles				
(i)	Delivery Van	1	1,500	1,500	
	Sub-Total			**1,500**	**1,500**
(H)	Working Capital	-	-	**2,000**	**2,000**
	Total				**14,270.8**

The labour cost was also estimated for 60 members of staff. The selling price ₦120/litre of a similar product was adopted. Standard cost, annual worth (AW), and present worth (PW) were calculated and used to establish the profitability of the product.

The results showed that the proposed plant would produce 180,000 liters of yoghurt at full capacity. The PW and AW showed that the product was economically viable with PW and AW greater than zero at 100% CU. At 100%, all the profitability indices for the product were positive.

The data for engineering economic analysis such as investment cost, annual disbursement and revenue are shown in Table 2. The Product has the investment cost of ₦14,270,818 because the same facilities would be used to produce the product. The investment cost includes costs of equipment acquisition, land and building, motor vehicles and working capital (Table 1). The annual disbursements vary with product type. These annual disbursements include the cost of raw materials, operating and maintenance cost, labour cost, insurance cost and sales promotion cost. The operating and maintenance cost include costs of maintenance of machinery and factory building, office overheads, transportation and travels, telephone and auditing and other professional fees. The utility costs are the costs of electricity, fuel, diesel, lubricants and other consumables. The factory would require a general manager, secretary, production manager, accountant and engineer. Other workers include, among others, professionals and factory labourers. The annual cost estimate for labour (₦7, 500, 000) at 100% capacity utilization (Table 1).

Apart from raw material cost, each of the other cost estimates are the same in all the product at the same capacity utilization. Thus, the variation in the annual disbursement was due to that of raw materials cost which varied with the product type.

The standard cost, which is the cost per unit of output computed before actual production (DeGarmo, 1996) for product was ₦120. These was lower than the price per unit of output (₦150) estimated for the product. The implication is that if the actual production costs compare favourably with these standard costs, the operation of the plant will be profitable.

Table 2: Cash Flow of Industrial Production Yogurt using Indigenous Starter Culture

S/No.		Description of Item	Amount (₦)
A.	**Investment**		
	(i)	Incubator/Fridge	2,539,818.00
	(ii)	Laboratory (Land and Building)	7,000,000.00
	(iii)	Centrifuge	4,731,000.00
		Sub-Total	**14,270,818.00**
B.	**Annual Disbursement**		
	(i)	Raw materials	1,594,400.00
	(ii)	Labour cost	7,500,000.00
	(ii)	Energy cost	600,000.00
	(iii)	Maintenance cost	80,000.00
	(iv)	Insurance cost	11,300.00
		Sub-Total	**9,789,780.00**
C.	**Revenue**		
	(i)	Sales of yoghurt (at ₦120/unit)	21,600,000.00
D.	**MARR = 20%**		
E.	**Life of the project = 20 years**		
F.	**Profitability Index**		
	(i)	Present Worth (PW)	117,804,542.00
	(ii)	Amount Worth (AW)	6,858,553.79

The economic viability analyses of the product is based on the present worth (PW) and annual worth (AW). The result of the viability test, using a minimum attractive rate of return (MARR) of 20% shows that process is the most viable with PW value of ₦117, 804, 542 and AW value of ₦ 6,858,553.79 (Table 1). This indicates that the product is viable and worthwhile for the investment and also confirms the viability of the product at 100% capacity utilization.

5.0 Summary and Conclusion

This study assesses the economic viability of the production of yoghurt using indigenous starter culture. The quality of culture media and equipment for the production of the yoghurt using starter culture at industrial level, are estimated and the economic viability of the product is determined. The PW and AW for the yoghurt production using starter culture at 100% capacity utilization justified investment in the yoghurt production.

In conclusion, the development and production of yoghurt using indigenous starter culture is technologically and economically viable and consumer acceptability should not pose a serious problem. Hence, the production technology is recommended for commercialization to create wealth for entrepreneurs and nutrition for the populace.

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