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Cost-Benefit Analysis of *Chorkor* and Traditional Smoking Kilns for Fish Processing

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Abstract: Fish Processing parameters with regards to organoleptic evaluation and cost benefit analysis were studied. The chorkor smoked fish has an attractive colour, good taste and is of good quality. Cost benefit analysis showed that at all levels of operation, the chorkor is superior to the traditional smoking altar in terms of all indices of profitability. A major benefit of chorkor fish processing technology is in the area of environmental conservation due to the much lower fuel wood requirement. The chorkor is amendable to adaptation to gas fuel whereby a gas ring in the pit supplies the heat in place of wood.

Key words: Traditional smoking % Chorkor % Altar cost benefit analysis % Organoleptic evaluation

INTRODUCTION

The world's people who had no access to electricity in 2005 could be estimated at between over one billion (1.600,000,000) to over four billion (4.711,148,440). The estimate of the world's people who resorted to using solid biomass due to their lack of access to modern and clean energy sources in the same year could range from over two to three billion (i.e. 2.000, 000,000 to 3.614, 031,680). Considering the increasing population in the world and especially in developing countries (DCs), it was conservatively projected at the time that that two decades afterwards, about half a billion other people would to join the ranks of that existing energy poor people relying on solid biomass [1, 2] While the proportion of solid biomass consumed by the world's population out of the total energy consumed (10,029,096,000 metric t of energy equivalent (mtoe) in 2001 was 10.4%, the quantity of solid biomass used in Sub-Saharan African (SSA) countries was very high -exceeding 50% in 19 of the total 41 SSA countries for which reported data. Energy poverty globally and in SSA is a problem that has attracted the attention of researchers, some of whom have suggested solutions including large scale adoption and implementation of renewable energy alternatives [3, 4]. Similarly, the seriousness of energy poverty in Nigeria despite the nation's reputation as a leading exporter of petroleum oil and natural gas for about half a century since the discovery of commercial quantities of fossil fuels in the Niger Delta in the late 1950s made researchers to advocate for the implementation of alternative energy technologies [5, 6]. Several reasons justify the search for alternative energy sources in Nigeria.

Nigeria is located in West Africa between latitudes 4°16' and 13°53' and longitudes 2°40' and 14°41' maintains her position as the most populous country in Africa with her population rising from over 140 million people in 2006 [7] to about 152 million people in 2009 [8] and is still increasing rapidly. Surveys of the international poverty rate in Nigeria in 1997 showed that 70.2% and 90.8% of Nigeria's total population lived on less than US$1/day and US$2/day respectively [2]. Considering that

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the high poverty incidence including high expenditure on food and non-food goods and services (54.7% for the nation and 51.1% for the South-South region which roughly corresponds with the famous Niger Delta region [9], processing of fish produced by artisans is an important source of protein and income for the poor people. Energy poverty afflicts the nation's population that is distributed almost ubiquitously across the country's large area of 909,890km ^{2} and experiencing rapid urbanization that attained nearly 50% with thousands of urban centres scattered around the national territory and an equally vast rural area in 2009 [8]. The expanding population and human settlements (towns and cities) require increasing quantities of energy, which has been inadequate.

In Nigeria, the total energy (74,241,000 mtoe) used in 2001 comprised of the following: 77.5% solid biomass, 21.9% fossil fuel, 0.6% hydroelectricity, 0% of other renewables and nuclear energy. Only 40% of Nigeria's total population projected at 130,412,118, in 2005, had access to electricity supplied by a very unreliable grid [2 , 10].

Solid biomass include biomass such as saw dust, unprocessed wood, agricultural wastes and residue and other related fuels burned directly by a household to meet energy requirements. It burns inefficiently and produces noxious gases that cause respiratory diseases and death in human beings and the energy that results from it is frequently relatively lower compared to its modern rivals.

More recent surveys in 2003 and 2004 revealed that solid biomass dominated the energy sources of poor households in the Delta and elsewhere in Nigeria (71.0% wood fuel, 1.7% charcoal, kerosene/oil 25.8%, 0.6% electricity, 0.4% crop residue and saw dust, animal waste 0% and 0.1% others [11]. Therefore, there has been increasing interest in developing energy technologies for using biomass for cooking and heating by the poor in the Niger Delta and regions with similar characteristics.

Energy poverty also afflicts poor people in the Niger Delta, a fossil-fuel-rich region located around coastal Nigeria in the south central part of the country covering an area of about 110,624 km ^{2} [10] and stretching from south western Nigeria (marked by Benin River) to south eastern Nigeria (marked by the Cross River). The world's third largest mangrove forests and the precious resources associated with this ecological setting are found in the Niger Delta region. Among the resources of the region are about 150 species of fish, West African primates, hippopotamuses and rare pigmy hippos. The fame or reputation achieved by Nigeria as one of the world's leading producer and exporter of hydrocarbons mineral energy especially crude petroleum oil, associated with flaring of natural gas since the 1950s and more recently export of the natural gas, derives from huge deposits of these fossil fuel resources in the Delta. Ruefully, during the half century that export of these minerals empowered Nigeria's elite capitals especially Lagos and Abuja (and their power gladiators in the military and elsewhere) to receive global acclaim for their affluence, majority of the region's natives have been systematically pauperized and weakened through exclusion from the hydrocarbon industry operation and business while the process of exploiting them has wrecked untold environmental degradation thereby destroyed the livelihoods of the Delta people[12]. Under current geopolitical configuration, the Niger Delta comprises nine of the total 36 states that form Nigeria's federal government. The states include: (1) Abia, (2) Akwa Ibom, (3) Bayelsa (4) Cross River, (5) Delta, (6) Edo (7) Imo (8) Ondo and (9) Rivers. With a total population of over 31.2 million people in 2006, the Delta contained 22 percent of Nigeria's total population. Using the national growth rate of 3.2% / year [6] the population of the region might be about 34.4 million in 2010.

The development of technologies for producing energy for processing fish, such as drying using a smoking kiln, is a crucial issue in Nigeria for several reasons. Fish generally, including those produced by artisans and those imported or produced by large-scale fishing companies in Nigeria, is important in raising the nutritional value and life quality of the poor in the Niger Delta and most parts of Nigeria. The basic principle involved in the drying of food, either by natural or artificial means, is the reduction of moisture content to such extent that, decomposition by both bacterial purification and enzymatic autolysis is stopped or, at least sufficiently inhibited to ensure reasonable keeping quality [13]. The stability of smoked fish depends on the moisture content (water activity, aw) which is a measure of the water available to support the growth of micro organisms such as bacteria and mold. [14].

Fishing settlements in the Niger Delta and southern Nigeria and often preserve fish by smoke-drying using inefficient, low-quality, traditional methods. Due to their remote locations, these settlements lack basic social infrastructural facilities to use more sophisticated methods of smoke-drying their fish.

Common features of the various traditional methods include limited handling capacities, inefficient procedures, deficient product quality and short storage life. Smoke-drying of fish through wood burning is an age-old practice and is believed to have developed as an adjunct to drying methods of preservation [15]. In order to overcome some of these obstacles and to improve the quality of the smoked product, a new type of smoker was devised by the Food Research Institute of Accra, Ghana, assisted by the Food and Agricultural Organization of the United Nations (FAO).

The chorkor oven, which was designed in the 1970's, operates by channeling heat through a set of trays, thus increasing the temperature of air in the oven. Drought is induced within the chamber due to the trays acting as a chimney. Moisture removed from the fish during drying is either carried out with the air exhausted through the top of the trays, or it condenses on the inside surface of the wall created by the trays. Various tests have shown that the chorkor smoker reduces fly infestation and drying time [16]. To evaluate the results of these previous tests, the present study was conducted to compare the efficiency of the chorkor kiln with that of the traditional fish smoking methods utilized in the lower Cross River basin in south eastern Nigeria.

MATERIALS AND METHODS

A One-tier traditional Smoking altar constructed following practice in fish settlements in lower Cross River and Akwa Ibom states, using four (4) mangrove poles with forked ends. The chorkor kiln used was constructed according to standard design [17, 18]. Smoking was done with 50kg of fish for traditional altar and 50kg for chorkor for a period of twelve (12) hours 1 moisture reduction in both processing methods was determined by removing pieces of fish undergoing processing at one hour intervals.

Residual moisture content (Wr) was determined by drying to constant weight in a kotterman oven. The residual moisture (Wr) at the time of interval (ith) was then calculated as a percentage of the initial moisture content at that interval (Wr) thus:

Wr = 100.Wc. Wi -1
Where; Wi = Weight of fish tissue after one hour interval
Wc = Weight after drying to constant.

Heat distribution around traditional and chorkor kiln was done using thermometer at above drying surface, site of chorkor, 20 cm from stoke hole and traditional fire-shelf-life was determine after 22 days storage graph sheet placed on mould cobonizational taken using covered by the mould calculated.

=1 organoleptic analysis was done by a panel of fifteen (15) judges who ranked the smoked fish in terms of appearance, odour, colour, taste and texture.

The panelists were trained to brush their teeth and rinse their mouth with distilled water. An interval of thirty (30) minutes after every taste was given to enable panelist rinse mouth and start the next analysis. Neither of the panelists knew which smoked fish was processed with chorkor nor traditional altar [19].

A hedonic scoring method was design for fifteen (15) panelists as measuring properties in the test and their interaction with the properties at the products [20]. The scores were as a result of 30 judgments (15 panelists X 2 replicate).

1 - dislike extremely, 2 - dislike very much, 3 - dislike, 4 - dislike slightly 5 - neither like nor dislike, 6 - like slightly, 7 - like, 8 - like very much 9 - like extremely.

Cost benefit analysis which assesses the profitability of production system estimates projected profits that can reasonably be expected from a unit of investment. A comparative assessment was estimated for the cost of a good and what benefits are accruable from using the traditional and chorkor methods of fish processing. Analysis of each parameter produces information on returns of labour and capital investment which enables a direct comparison between the two systems.

Financial analysis was done for five (50 processing cycle using the parameters listed on table 1 as the basis for the analysis [20] .

RESULTS

The result of this study show that for most of the features compared, the chorkor smoker proved itself to have superior qualities over traditional methods of smoking fish product presentation to a great extent determines the market value and price of processes fish. The cost benefit analysis of the processing using either chorkor smoker or traditional methods demonstrates clearly, thee higher economic returns which could be expected by using chorkor smoker, tables 2, 3 and 4. When operated at similar capacities, the chorkor smoker gives higher economic returns than the traditional methods table 5. The "Gross Returns" and "Return on Investment (ROI)" using the chorkor are significantly higher than what obtained from using the traditional smoking altar. At this level, higher profit margin is achieved from servings in wood fuel consumed and from the higher net selling price of the product due to a much better appearance and presentation.

Table 1: Bases for comparative cost - benefit analysis (Chorkor/traditional)*

S/N	PARAMETER	GRADE
1	Operative chorkor unit	Double chamber
2	Operative traditional altar	Two tier
3	Life span of chorkor altar	5 years
4	Life span of traditional altar	18 months
5	Life span of traditional altar	5 years
6	Life span of smoking shed (chorkor and traditional)	3 years
7	Number of smoking cycles/per day/year	12 years
8	Capacity utilization for traditional altar	100%
9	Maximum capacity utilization for chorkor	100%
10	Low capacity utilization for chorkor oven	Equal to maximum for traditional
11	Maximum number of trays on chorkor oven	16 single trays (8 double trays)
12	Maximum weight of fish per chorkor oven	18 kg/tray (approx.)
13	Weight reduction achieved by drying	Up to 80%
14	NACB lending interest rate	15% pa.

*Some of the parameters and data above arose from interaction with fishermen in the marine states: Akwa Ibom State, Cross River.

Table 2: Small/Medium size fish smoked with traditional method (Maximum Capacity).

PARAMETER	UNIT	COST/UNIT ($US)	TOTAL COST ($US)
COST			
Fixed Cost	1/600	1,800	3
Traditional alter	1/360	2,000	5.5
Smoking			
Operation Costs	40kg	120	4,800
Fresh Fish	2	305	305
Fuel Wood	2	100	100
Labour			Sub-total = 5,205
Interest Payment			
Fixed Costs (15%)	1/120	570p.a	4.6
Operational Costs (15%)	1/120	780.6p.a	6.5
			Sub-total= 11.1
			Total = 5224.6
Benefits			
Smoke Fish	8kg	800	5,600
GROSS RETURNS			
(Total benefit – Total Costs)			375
RETURNS			
Returns of Labour			
(Gross Return/Man-day Worked)			375
Return on Capital (%)			7.20%
Gross Return/Total Cost x 100			

Table 3: Small/Medium size fish smoked with chorkor kiln at (Minimum Capacity).

PARAMETER	UNIT	COST/UNIT ($US)	TOTAL COST ($US)
COST			
Fixed cover (2)	1/600	2,000	3.3
Smoking shed	1/360	2,000	5.5
Smoking trays (2 pcs.)	1/180		8.3
Plywood cover	1/180	1,500	2.1
		3,800	Sub-total=19.2
Operation Costs			
Fresh Fish	40kg	120	4,800
Fuel Wood	1	130	130
Labour	5	120	120
			Sub-total=5,050.0

Table 3: Small/Medium size fish smoked with chorkor kiln at (Minimum Capacity).

PARAMETER	UNIT	COST/UNIT ($US)	TOTAL COST ($US)
Interest Payment			
Fixed Costs (15%)	1/120	2,157	18
Operational Costs (15%)	20-Jan	757.5	6.3
			Sub-total= 24.5
			Total = 5,093.5
Benefits			
Smoke Fish	8.0kg	750	6,000
GROSS RETURNS			906.5
(Total benefit – Total Costs)			
RETURNS			
Returns of Labour			906.5
(Gross Return/Man-day Worked)			
Return on Capital (%)			
Gross Return/Total Cost X 100			17.70%

Table 4: Small/Medium size fish smoked with chorkor kiln (Maximum Capacity).

PARAMETER	UNIT	COST/UNIT ($US)	TOTAL COST ($US)
COST			
Fixed Cost	1/600	2,000	3.3
chorkor Oven	1/360	2,000	5.5
Smoking shed	1/180		66.6
Smoking trays (16 pcs.)	1/180	12,000	2.1
Plywood cover		3,800	Sub-total = 77.5
Operation Costs			
Fresh Fish	288kg	120	34,560
Fuel Wood	1	560	560
Labour	5	120	600
			Sub-total = 35,750.00
Interest Payment			
Fixed Costs (15%)	1/120	2157	18
Operational Costs (15%)	20-Jan	53625	44.7
			Sub-total = 62.7
			Total = 35890.2
Benefits			
Smoke Fish	57.6kg	750	43,200
GROSS RETURNS			
(Total benefit – Total Costs)			7,430
RETURNS			
Returns of labour			1,486
(Gross Return/Man-day Worked)			
Return on Capital (%)			
Gross Return/Total Cost x 100			20%

Table 5: Profitability indices for chorkor and traditional processing at similar capacity

	Cross returns		Returns (Labour)		Returns Capital)	
Product type	Chorkor	Traditional	Chorkor	Traditional	Chorkor	Traditional
Max						
Capacity (chorkor and traditional)						
Small/medium fish	7,340	375	1,486	375	20.00%	7.20%
Limited						
Capacity (chorkor)						
Small/medium fish	906.5	-	905.5	-	17.70%	-

DISCUSSION

The basis of preservation of food by drying is the fact that micro organisms and enzymes need water to be active [21]. The purpose of preserving fish using either the chorkor or traditional methods is to reduce the moisture content to a level where the activities of spoilage microorganism are inhibited. The process also impregnates the product with components of wood smoke which enhances flavour and provides some surface anti-microbial activity. For smoke-dried fish, features which come under consideration in this regard include colour, texture and general appearance [13].

Adoption of a new technology such as the chorkor smoker in the maritime and coastal areas of Nigeria will depend on several factors. Most important of which are adequate extension support and a perception by the end users of the sustainability of the process [22]. The sustainability of the chorkor development project may be considered from the view point of [23] who considers the sustainability of the project as achievable only when it can deliver the level of benefits for period of time after financial managerial and technical assistance from extraneous sources have been terminated. The use of the mangrove tree predominantly for supply of fuel wood in most fishing settlements has led to a considerable depletion of the mangrove forests of Nigeria’s coastal areas. Post harvest losses in the artisanal fishery sector is a major contributor to the pervading poverty if fishermen in the maritime areas. The levels of between 20% and 40% estimated sector [24] can be controlled using chorkor smoker areas. Post harvest losses in the artisanal fishery sector is a major contributor to the pervading poverty if fishermen in the maritime areas. The levels of between 20% and 40% estimated sector [24] can be controlled using the chorkor smoker.

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