BEHIND THE BUTTER: AN ENERGY ANALYSIS OF SHEA BUTTER PROCESSING

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Sachibu Mohammed and the women of the Suglo Mboribuni Shea butter processing group
Introduction

The Shea tree is a tree of the Sapotaceae family indigenous to Africa. The West African variety of the Shea tree is the Vitellaria paradoxa. The tree grows naturally in the wild Savannah belt of West Africa and in over 20 countries across Africa including Ghana (WATH Technical Report No. 3). The Shea fruit consists of a thin, tart, nutritious pulp that surrounds a relatively large, oil-rich nut from which Shea butter is extracted. Africa produces about 1,760,000 ton of raw Shea nuts annually from its wild trees. In Ghana, as in many West African countries, the Shea tree is a major economic tree that provides the livelihoods of millions of people especially rural families. It is traditionally processed and locally used as cooking oil or as butter for the skin and hair. As will be shown below, almost every part of the fruit and seed is useful for one purpose or the other. Notwithstanding the economic importance of this tree, the process of extracting butter from the raw Shea nuts still remains rudimentary and very laborious, in often very dangerous environments ranging from the risk of snake bites during the collecting stage, and exposure to smoke and heat in the highly inefficient processing stage.

Project Background

The project was conceived following reflections on a learning visit by the SNV Renewable Energy Team to the Tiehisuma Shea butter processing group in the Tamale metropolitan area of the northern region. As the group conducted the SNV team of advisors through the various stages of Shea butter processing, interesting, probing and clarifying questions and comments revealed a significant understanding and detail by the women of the work they do. At the same time, several questions on energy, financial and economic cost could not be answered.

Improving the energy efficiency of Shea butter processing would fit well in the SNV Ghana Renewable Energy Promotion Programme (GREPP 2012-2015) and would offer the opportunities of cross sectorial linkages between renewable energy and agriculture. Based on these considerations, a concept paper was prepared. This was further developed into a project implementation plan, which was discussed between the SNV RE and the agriculture teams. Implementation of the plan was led by the SNV RE team and supported by the Agricultural team. The first step of the plan was the characterization of the Shea butter processing process. To the knowledge of both teams, this was not yet done in Ghana or elsewhere in the detail required. It was felt that the planned characterization would increase the knowledge on the Shea butter processing process and provide vital information for the next steps of the implementation plan.

This activity falls under the SNV Ghana Energy, Poverty and Gender (EnPoGen) project. This project builds on the work carried out by the World Bank Asia Alternative Energy Program (ASTAE), which is summarized in the synthesis report by K.V. Ramani and E. Heijndermans1. The SNV Ghana EnPoGen project intends to provide improved energy services to small scale industries that are dominated by women. The improved energy services reduce fuel wood and other biomass consumption, improve the working environment and improve product quality through improved process understanding and control. The small scale industries targeted in the SNV Ghana EnPoGen project include Shea butter manufacturers, palm kernel oil producers, groundnut oil producers, rice parboilers and pito brewers.

Objectives

The overall objective of the EnPoGen Shea Butter Project is to improve income and working environment of rural women by introducing clean and efficient stoves in Shea butter processing. Specific objectives are;

1. To reduce fuel wood consumption for Shea butter making by women cooperatives.
2. To improve the economics of Shea butter making by reducing the cost of energy.
3. Improve the working conditions of Shea butter making by reducing the exposure to wood smoke.
4. Improve product quality through better process control and cleaner working environment.

The Project Team

The Shea butter production process characterization exercise was led by Sachibu Mohammed with guidance from Enno Heijndermans. The Tamale Agricultural team and provided valuable support and guidance. The report is prepared jointly by Sachibu Mohammed and Enno Heijndermans with contributions from Christopher Bakaweri, Cynthia Awuni, Jalil Zakaria and Zakaria Isaahaku. This study would not have been possible without the dedication and support of the women of the Suglo Mboribuni Shea Better Processing Group.

Methodology of the Study

Following the development of the concept idea and project implementation plan, e-mail and telephone discussions were held within the SNV renewable energy team to fine tune the idea. This was followed by an extended sharing and discussion of the concept with the Agricultural team of SNV Ghana who has a long established reputation in Shea nut production and marketing.

In discussion with the agricultural team, criteria for the selection of suitable Shea butter processing groups were established. A total of three Shea butter processing groups were identified from which one was selected for the investigation. The three processing groups were visited and detailed discussions with their members were held. The SNV team also initiated initial consensus building. The following groups were visited: the Tungteiya Shea Butter Extraction Women’s Association; and the Tiehisuma and Suglo Mboribuni subgroups of the Pagsung Shea Butter Processing Association.

A first round of visits, interviews and discussions were held with all three groups. The discussions focussed on the energy and the financial and economic issues of their business. This process led to the final selection of Suglo Mboribuni as this group was most committed to the study and willing to share required information.

A detailed briefing and consensus building session was then held with the Suglo Mboribuni group as part of the inception activities of the study. On reaching consensus, the project commenced with a team of three SNV advisors, led by Sachibu Mohammed. The women were mobilized by the coordinator of Africa 2000, a local organization contracted by SNV that mobilises and works with Shea butter processing groups. A total of four days were used to carry out the process characterization. All necessary tools and equipment needed to conduct the study were secured, assessed and assembled. Data collection instruments were developed and discussed.
The four-day exercise was closely monitored by SNV, the group itself and Africa 2000 to ensure that all inputs were identified, measured and timed. The process itself was timed and all outputs and wastes were measured.

An initial report was developed and shared with the team for comments. This was further developed into a second draft report. A validation workshop was then conducted, based on the second draft report. The objective was to discuss, question and agree on the validity of the data collected and the analysis done. Key participants in the validation workshop were the women of the Suglo Mboribuni group, the RE and agriculture teams of SNV and Africa 2000.

Inputs from the validation workshop were used to finalise the report. This was then widely shared within SNV Ghana for comments and inputs.

**Equipment**

Measuring instruments used included;

1. A platform scale
2. A table top scale
3. A graduated liquid container
4. A thermometer
5. A stop watch
6. A measuring tape

**Unit of analysis**

To standardize the data, all inputs and outputs are based on a ‘controlled’ one (1) jute bag of dry Shea nuts which weighed 87 kg. It should be noted that actually, this weight varies depending on the supplier and season in which the nuts were purchased. Nuts purchased during the peak of the harmattan season are usually very dry due to high temperatures and likely to weigh less than those purchased during a rainy season which is likely to weigh more due to retained moisture.

**Existing Literature**

One of the most comprehensive studies of Shea nuts and butter processing in northern Ghana is the *Shea Butter Value Chain Refining in West Africa WATH Technical Report No. 3* by John Addaquaye, under the sponsorship of USAID and West African Trade Hub (Addaquaye, 2004). While this study has been comprehensive in coverage and included a detailed value chain analysis of the activity in West Africa, it did not address in sufficient detail the technical details. For instance the study did not capture all the critical stages of Shea butter processing (see Figure 1). A number of other studies also describe the processing of Shea butter in northern Ghana, but once again, not in the detail required. The other studies include the work of the Global Shea Alliance².

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Figure 1: Shea butter processing flow diagram according to John Addaquaye.

The Shea Nut Processing Chain

In order to gain a complete and detailed understanding of the Shea butter making process, it is important to clarify and differentiate between the Shea nuts processing chain and the Shea butter processing chain (it should be noted that both processes are combined in Figure 1). First and foremost, the Shea nuts processing precedes Shea butter processing since nuts have to be processed and stored before being converted into butter through a completely different process which will be seen below. The main difference, therefore, is that there is no Shea butter without Shea nuts but there can be Shea nuts without Shea butter. The nuts processing chain is not the subject of this report and will only be discussed briefly. Although two different economic activities, they are linked in terms of the quality of butter produced at the end of the butter chain.

The Shea nut processing chain is discussed based on the Global Shea Alliance best practices guide (Figure 2)³.

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QUALITY SHEANUTS
best practices for production

Figure 2: Pictorial view of the entire Shea nut processing chain
1. As illustrated in Figure 2, the Shea nuts process chain commences with collection by hand of the ripe (fallen) fruit from the ground under the Shea tree (see Figure 3). This usually requires a larger basin and smaller hand-held bowl that is used to collect the fruits from around the tree. The hand-held bowl is then emptied into the basin which stands on the ground at the base of the tree. The fruit consists of an edible pulp, which surrounds a hard nut. The nut consists of a hard shell that surrounds a soft seed. The seed is the part used in producing Shea butter. When ripe; the pulp around the nut is soft and can be easily removed from the nut (de-pulping) by hand or some other means. The amount collected per day usually depends on the head-carrying capacity of the collectors who are usually rural women (see Figure 4).

![Figure 3: Collection of Shea fruits](image3)

![Figure 4: Carrying Shea fruits home](image4)

2. De-pulping of the fruit is done by hand or by feeding the whole fruit to animals. The pulp is also edible for humans. In the case of de-pulping by hand, the soft pulp is simply pressed off the nut. In the case of feeding the fruit to animals, the animals eat the edible pulp leaving behind the nut as the nut is not edible. For purposes of higher quality butter, it is recommended that within seven days of collection, the de-pulped nuts be boiled in water for about 40 minutes (this may have to do with destroying free-fatty acids producing enzymes). Before boiling, the seed is naturally glued to the shell. One of the objectives of the boiling is also to loosen the seed in the shell to aid de-shelling. Boiling is done at home or at the processing centre using the traditional three-stone cooking stoves. The fruit and the nut are given in Figure 5. A cross section is given in Figure 6. Please note the pulp (yellow/green) the shell (brown) and the seed (pink/white).

![Figure 5: Shea fruit and nut](image5)

![Figure 6: Cross section Shea fruit](image6)

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4 It should be noted that others use the term nut, both for the nut and the seed (see Figure 2).
3. The boiled nuts are then given a first stage sun drying on a clean surface such as a mat, cemented ground or drying racks. The objective of this first drying is to loosen the seed from the shell for easy de-shelling.

4. After the boiled nuts are fully dried, it is recommended that de-shelling is done within 3-4 days. Traditional de-shelling is done using a light weight hand-held wooded structure or stone to crack and remove the shell\(^5\) from the seed.

5. The isolated seeds are then sorted to remove bad seeds and impurities. Good whole seeds and good broken seeds are separated from broken shells, stones, un-broken nuts and bad whole seeds and bad broken seeds. The broken shells, stones and other impurities are a waste product and thrown away (left in the field).

6. The second sun drying is done to ensure that the isolated seeds are free from moisture as moist seeds do not give good quality butter and easily rot. During this stage bad seeds and impurities are still removed.

7. Before storage, moisture is checked by random hand-pressing of the dried seeds. Good seeds are harder and drier whereas bad seeds are softer and wet.

8. Finally, the dried seeds are stored preferably in jute bags (highly recommended) in dry airy environments to avoid fungi infection and rotting. It is recommended that at this stage the seeds should not be stored in plastic bags as this can increase heat and moisture and spoil the seeds. The standard weight for a jute bag of seeds at this stage is 87 kg. This marks the last stage of the nuts processing chain (see Figure 2). Depending on the type of entrepreneur involved, the seeds are either sold to the butter making processor or processed into butter by the collector.

**The Shea Butter Processing Chain**

There are three different main methods for the production of Shea butter: traditional manual processing, semi-mechanized (using hydraulic/mechanical presses) and fully mechanized industrial methods (Aquaduaye, 2004). In Ghana, the traditional manual processing predominates. The other two methods are hardly used, due mainly to the infant nature of the commercialization of the activity. Processing groups are largely household family units and micro and small scale producers being currently organized in cooperatives through the efforts of the Shea Alliance / Shea Network under the initiative of SNV Ghana and its partners. The semi and fully industrialised processing methods give higher yields per unit input of the raw material than the traditional method. This report will deal with the traditional manual processing method of Shea butter making.

**The Traditional Manual Processing**

For the purposes of this project, an 87 kg of unsorted Shea seeds and four women (labour) are used as the basis for assessing the financial cost of producing Shea butter. The study identified 12 distinct steps to produce Shea butter from Shea seeds (as opposed to the 7 steps indicated in Figure 1). The 12 steps are given in Figure 7.

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\(^5\) This report uses the terms shell and de-shelling. Others use de-husking (Figure 1 and Figure 2).
Figure 7: Schematic presentation of the 12 processing steps from stored seeds to sale. The Shea butter making process starts where the Shea nuts processing stage ended, at the stored Shea nut seeds. In this project, a stored jute bag full of Shea seeds weighed 87 kg. This was confirmed by weighing. Figure 8 show this on a platform scale recorded on 16th October 2012 at one of the Shea butter processing centres. The Shea butter production group involved in the exercise is Suglo Mboribuni. The group is located in the Sagnarigu district of the Northern Region of Ghana.

Figure 8: Weighing jute bag of Shea seeds

Below each process step is discussed in detail.

1. **Sort Seeds**: The first step in the Shea butter processing chain is an additional sorting step (see Figure 9 and 10). Four (4) women will sort in 33 minutes a bag of 87 kg of Shea seeds. This is in total 132 minutes of labour. The sorted seeds weighed 86 kg. Therefore, this stage produced 1 kg waste. The composition of waste is sand, stones, nut shells andspoiled seeds. This processing step is schematically given in Figure 11.

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6 Source: SNV Ghana Renewable Energy Team Field Study, 2012
2. **Wash Seeds to Remover Dirt:** In the second stage, 86 kg sorted seeds are washed to reduce impurities and improve quality (see Figures 12 and 13). This process takes 17 minutes using 4 women (68 minutes of labour) and 96 litres of water. The time involved includes time for fetching water from a nearby well. The well is about 3 metres from the washing point where the water is needed. The well is fed from ground water and harvested rain water. Though the group rain-harvests water for their processing, the cost of this needs to be considered as a critical part of the cost of production. Additionally, it is acknowledged that there may have been some wastage of water by the women given that it is seen to be rain harvested and therefore ‘free’. The cost of constructing the rain harvesting systems for instance needs to be taken into consideration.

3. **Shade Dry Washed Seeds:** The washed seeds are then shade-dried for about 23 minutes to drain the water of the washing stage while maintaining some moisture to aide further processing (see Figures 14 and 15). The objective of this is to enhance crushing, maximize crushing yield and to reduce Free Fatty Acids (*details on the chemistry are not known*). It is observed that if the seeds are dried under high temperature, it causes the seeds to begin “oiling” thereby sticking inside the milling machine at the crushing stage. The weight of the nuts after washing and drying was 87 kg. The extra 1 kg is due to the moisture (water) content introduced at the washing stage. The dried seeds were then
head-carried to grinding mill located some 85 metres from the processing centre for crushing. The total labour time for the shade drying was 92 minutes (see Figure 16).

Figure 12: Fetching water for washing
Figure 13: Washing the seeds
Figure 14: Shade drying of washed seeds
Figure 15: Carrying washed seeds to mill

Figure 16: Second and Third Step Flow Diagram
4. **Pound/Crush into Grit:** There are two ways of crushing the washed seeds depending on the size and economic status of the entity doing the processing. In very remote communities, this is done manually using a ‘dum-bell shaped’ wooden structure. The seeds are crushed against a hard surface to give various crushed sizes suitable for manual or mechanical milling. For purposes of this project, we focused on the mechanical crushing and milling (see Figures 17, 18, 19 and 20). It took 11 minutes to mechanical crush the 87 kg of washed and dried nuts using 0.9 kilowatthour (kWh) of electricity energy (ECG metre reading before and after crushing – Before crushing 41,585.9 and after crushing 41,586.8). Two women were involved, bringing the total labour input to 22 minutes. *It must be noted that the mill operator indicated that the milling machine was faulty at the time of crushing and that under normal operation, it could have taken just under five minutes to crush the 87 kg of nuts.* The cooperative had to pay the mill operator two Ghana Cedis (GHc 2.00) for the crushing of 87 kg of nuts. According to the Electricity Company of Ghana (ECG), for commercial customers such as the Shea butter processing group, any consumption of electricity between 0-300 kWh cost GHc 0.2293 per kWh. Therefore, for the total of 0.9 kWh used for crushing, the total electricity cost is GHc 0.21. This excludes the share of the service charge of GHc 3.20 per month, charged to every commercial electricity consumer. The weight of the crushed nuts is 86 kg. This implies a loss of 1 kg of nuts between the transportation of the nuts to the grinding mill and after crushing. This loss is noted to have occurred at the crushing stage through the repetitive process of the crushing. This step is schematically presented in Figure 21.

![Figure 17: Crushing mill and mill owner](image1.png)

![Figure 18: Loading seeds into crusher](image2.png)
5. **Sun Dry Grit:** The crushed seeds (grit) are then sun-dried\(^7\) for 30 minutes to reduce the moisture content (which was introduced at the washing stage) (see Figure 22 and 23). This is done to enhance quick roasting and save energy at the roasting stage. The sun-dried grit is kept overnight for roasting the following day. Steps 1-5 occurred within one day (16\(^{th}\) October 2012) starting at about 10:20 am and ending at about 4:40 pm. Before roasting, the sun dried grit weighed 86 kg. This means that weight loss appears to be small as it could not be measured. The total labour input for this step was 60 minutes.

\(^7\) Sun drying is said to increase the FFA content of the nuts and is therefore not recommended. Shade drying is recommended to keep free fatty acid content low.
6. **Roast to Aid Oil Extraction:** This is the first step in the processing of the butter that uses intense heat. Steps 1 to 5 are low temperature processing steps. The intense heat steps are normally done the next day depending on the quantity of nuts and labour involved. In the 6th step, the grit is roasted to aid the extraction of oil (see Figures 24 and 25). It took 90 minutes to roast the 86 kg of sun-dried grit. The weight after roasting is 84 kg. For roasting 13.8 kg fuel wood and 6 kg of Shea waste briquettes were used. The fuel wood costs 0.11 GHc/kg and therefore the fuel wood cost for roasting comes to 1.52 GHc. As briquettes are a by-product of earlier production, its cost is not quantified. The labour input for roasting was in total 180 minutes. The weight difference between sun dried crushed seeds and the roasted seeds is said to be due to a number of factors including evaporation of water during roasting, loss of seeds during collection from the platform and the roller roasting process. The schematic presentation of step 5 and 6 is given in Figure 26.
7. **Milling or Grind into Paste:** The next stage involves milling of the roasted grits into a paste (see Figures 27 and 28). This took 40 minutes and 4 kWh of electricity (41,681.2 – 41,677.2). Six (6) litres of water was added at the milling stage through the washing of the grinding apartment of the mill. The cooperative paid GHc 4.00 for the milling. The electricity cost alone was GHc 0.92. The weight of the paste was 80 kg. *This means a loss of about 10 kg from the roasted grit to the paste. The weight loss is expected to be in paste remaining in the mill, evaporation of water and other losses.* The total labour input from the cooperative was 40 minutes (see Figure 29).

![Figure 27: Milled paste](image1)

![Figure 28: Milled paste](image2)
8. **Mix with Water and Knead:** The paste from the milling is then mixed with water and kneaded. This is done in several batches of about 10 kg paste each (about 8 batches). The volume of the pan used in the kneading was 48 litres but this is not completely filled with the paste for kneading and varies depending on convenience. It measures 62 cm at its top opening, 33 cm in height and 36 cm at the base. The first stage of the kneading process is the addition of room temperature water to enable the use of bare hand to stir the paste (see Figure 30 and 31). Hot water is then added to aid the oil extraction. A total of 228 litres of water was used in the entire kneading process (about 30 litres per batch). The entire kneading process takes 3 hours and 22 minutes to complete using 4 women (in total 13 hours and 28 minutes of labour). Within about one hour of kneading, crude butter begins to appear from the brown paste (see Figure 32 and 33). Through kneading, two fractions form. A watery fraction on the bottom with the crude butter fraction floating on top. The water fraction after kneading is brownish in colour. Interestingly, the volume of that fraction is also exactly 228 litres. The weight of crude butter produced after kneading is 63 kg. This means that the dirty water fraction must weigh 245 kg. The dirty water fraction is put in an open tank so that the water can evaporate (see Figure 34). What is left is a brown solid that can be used as a fuel (see Figure 35). About 24 kg Shea waste briquettes are produced from the dirty water fraction. The schematic presentation of this step is given in Figure 36.

The 228 kg (one litre = one kg) water added comprised of 184.7 kg cold and 43.3 kg hot/warm water. To heat the water a car rim stove was used (see Figure 37). To heat the water, 17.3 kg of fuel wood and 12.1 kg of shea briquettes was used. The water was left on fire over almost the entire period of kneading (3 hours and 28 minutes). The cost of the fuel wood was GHc 1.90.

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8 This is based on evaporation tests that revealed that the solid fraction was 9.8% by weight.
Figure 30: Mixing paste with water

Figure 31: The long kneading process starts

Figure 32: Crude butter starts to appear

Figure 33: Separating butter from the dirty water fraction

Figure 34: Transferring dirty water fraction to settling tank

Figure 35: Sediment from settling tank as raw material for Shea waste briquettes
9. **Emulsion Cooking**: The 63 kg of crude butter/emulsion was boiled for 90 minutes in a 96 litre aluminium cooking pot of 6 millimetres thickness (see Figures 38 and 39). The pot measured 52 cm in height/depth, 60cm in diameter across its bulged middle part and 56 cm at the brim (open mouth). It is important to note that the thickness of the aluminium cooking pots varies from one group to another and this affects the time it takes to boil a specified amount of oil. As a result of boiling, three distinctive fractions form: (1) the froth that floats on the liquid oil (this is continuously skimmed off); (2) the light yellow oil that floats on a dark brown liquid; and (3) the dark brown liquid at the bottom (see Figures 40 and 41). After the 90 minutes of boiling, 28.3 kg of oil was collected (35.4 litres of 0.8 kg/litre). The bottom fraction weighted 10.8 kg and the weight of the froth was very small. From the material balance follows that 23.9 kg was lost, probably as water.
vapour, other volatiles and other losses. The froth is waste and the bottom fraction is added to the sediment of the settling tank and used for making Shea waste briquettes (see Figure 35). It is estimated that 10.8 kg bottom fraction can produce 7.5 kg Shea waste briquettes (70% solids).

The women use both fuel wood and Shea waste briquettes as fuel for boiling. To boil 63 kg of crude butter/emulsion, the fuel wood consumption was 18 kg (costing GHc 1.98) and the Shea briquettes consumption was 13 kg. The total labour input in this step is 90 minutes. This includes time for cooking (stirring and froth removal) and fuel handling (see Figure 42).

![Figure 38: Emulsion cooking starts](image1)

![Figure 39: Emulsion cooks](image2)

![Figure 40: Fractions start to separate](image3)

![Figure 41: Collecting the oil](image4)
10. **Collection and Filtering:** While still hot, the oil is then collected from the pot and filtered through a cloth. This takes two women 23 minutes (46 minutes labour input).

11. **Solidification of Liquid Shea Oil:** The filtered butter oil is then left in a pan in an open airy place to cool and to become semi solid (see Figures 43, 44 and 45). Gradual stirring of the hot oil is done to facilitate quicker cooling. Depending on a processing group’s financial standing, some groups use air conditioners to fasten the solidification process. This is, however, not common among smaller processing groups such as Suglo Mboribuni, due to the high cost of air conditioners and the associated electricity bill of operating them. The cooling and semi solidification takes 24 hours. The total labour input is only 30 minutes.
12. **Packaging:** After the oil cooled into a semi-solid state, it is packed in a carton box with polythene lining. The polythene lining prevents any escape of the oil. It is recommended to collect the butter oil into a desired final packaging chamber before solidification so that the solidified butter can assume the shape of the desired container (see Figures 46 and 47). The carton box measures (L*H*W) 45*20*31 cm and contains 30 kg Shea butter. One bag of seeds produces 28.3 kg Shea butter which is a little less than one full carton box. The cost of the carton box with polythene lining is 0.10 GHc per box, based on procurement of 500 boxes and 500 polythene bags. The Shea butter is now ready for sale (see Figure 48 and 49). The packaging takes 30 minutes and requires a total labour input of 60 minutes. Figure 50 shows the diagram of the last 3 steps.
Process Summary

The twelve process steps are summarized in Table 1. From Table 1 it can be concluded that from 87 kg seeds, 28.3 kg Shea butter can be produced (0.325 kg butter/kg seeds). To do this, the cooperative needs almost 34 hours and 27 hours of labour input. It will need to pay the mill owner GHc 6 for crushing and milling and consumer 330 litre of water (11.6 litre of water per kg Shea butter), 49.1 kg of fuel wood (1.7 kg fuel wood per kg of Shea butter), and 31.1 kg of Shea waste briquettes (and producing 31.5 kg Shea waste briquettes).

Energy

From the forgoing it is clear that time, energy, labour, and water are the main input factors for Shea butter processing. Analysis is focused on energy, and financial inputs and outputs. For the energy analysis, we are interested in the specific energy consumption (kg fuel wood/kg Shea butter). In the financial analysis, we are interested in cost and benefits of Shea butter production. This includes the cost of labour and the investment cost.
Table 1: Shea Butter Production Process Summary

<table>
<thead>
<tr>
<th>Step</th>
<th>Process</th>
<th>Input</th>
<th>Output</th>
<th>Duration</th>
<th>Labour Input</th>
<th>Other Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sort Seeds</td>
<td>87 kg stored seeds</td>
<td>86 kg sorted seeds</td>
<td>33 minutes</td>
<td>132 minutes</td>
<td>1 kg waste (sand, stones, bad seeds, shell residues)</td>
</tr>
<tr>
<td>2</td>
<td>Wash Seeds to Remove Dirt</td>
<td>86 kg sorted seeds</td>
<td>Washed seeds</td>
<td>17 minutes</td>
<td>68 minutes</td>
<td>96 liter water from water tank at site</td>
</tr>
<tr>
<td>3</td>
<td>Shade Dry Washed Seeds</td>
<td>Washed seeds</td>
<td>87 kg washed and shade dried seeds</td>
<td>23 minutes</td>
<td>92 minutes</td>
<td>Ambient air used for drying</td>
</tr>
<tr>
<td>4</td>
<td>Pound/ Crush into Grit</td>
<td>87 kg washed and shade dried seeds</td>
<td>86 kg crushed seeds (grit)</td>
<td>11 minutes</td>
<td>22 minutes</td>
<td>Pay GHc 2 to mill owner who uses 0.9 kWh electricity costing GHc 0.21. 1 kg material lost</td>
</tr>
<tr>
<td>5</td>
<td>Sun Dry Grit</td>
<td>86 kg crushed seeds (grit)</td>
<td>Sun dried grit</td>
<td>30 minutes</td>
<td>60 minutes</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Roast to Aid Oil Extraction</td>
<td>Sun dried grit</td>
<td>84 kg roasted grit</td>
<td>90 minutes</td>
<td>180 minutes</td>
<td>13.8 kg fuel wood costing GHc 1.52, 6 kg Shea waste briquettes, 2 kg weight loss (water and volatiles)</td>
</tr>
<tr>
<td>7</td>
<td>Milling or Grind into Paste</td>
<td>84 kg roasted grit</td>
<td>80 kg paste</td>
<td>40 minutes</td>
<td>40 minutes</td>
<td>Pay GHc 4 to mill owner who uses 4 kWh electricity costing GHc 0.92. 6 liters of water. Total weight loss 10 kg.</td>
</tr>
<tr>
<td>8</td>
<td>Mix with Water and Knead</td>
<td>80 kg paste</td>
<td>63 kg crude butter</td>
<td>208 minutes</td>
<td>808 minutes</td>
<td>Using 228 kg water and producing 24 kg Shea waste briquettes. To heat the water, 17.3 kg fuel wood was used (costing GHc 1.90) and 12.1 kg Shea waste briquettes.</td>
</tr>
<tr>
<td>9</td>
<td>Emulsion cooking</td>
<td>63 kg crude butter</td>
<td>28.3 kg Shea oil</td>
<td>90 minutes</td>
<td>90 minutes</td>
<td>18 kg fuel wood (costing GHc 1.98), 13 kg Shea waste briquettes and producing 10.8 kg bottom fraction of which 7.5 kg Shea waste briquettes can be produced. Froth (small amount) and 23.9 kg weight loss.</td>
</tr>
<tr>
<td>10</td>
<td>Collection and Filtering</td>
<td>28.3 kg Shea oil</td>
<td>Filtered Shea oil</td>
<td>23 minutes</td>
<td>46 minutes</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Solidification of Liquid Shea Oil</td>
<td>Filtered Shea oil</td>
<td>Solid Shea oil</td>
<td>1440 minutes</td>
<td>30 minutes</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Packing</td>
<td>Solid Shea oil</td>
<td>28.3 kg packed Shea butter</td>
<td>30 minutes</td>
<td>60 minutes</td>
<td>One carton box with polythene lining costing GHc 0.10</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td>2035 minutes (33 hours and 55 minutes)</td>
<td>1628 minutes (27 hour and 8 minutes)</td>
<td>330 liter water, GHc 6 paid to mill owner 49.1 kg fuel wood costing GHc 5.40 Using 31.1 kg Shea waste briquettes Producing 31.5 kg Shea waste briquettes Packing materials costing GHc 0.10 for 30 kg Shea butter</td>
</tr>
</tbody>
</table>
There are two stages of intense energy application during the processing of Shea butter. These are the roasting and cooking of crude butter stages. The main type of fuel used was fuel wood and Shea waste briquettes. Different types of stoves were used for roasting and for cooking the crude butter. These are the roaster and the traditional 3-stone stove.

**The traditional three stone stove**

As shown in Figure 51, the traditional 3-stone stove is made up of three earth (lateritic) stones planted a few centimetres into the ground at equilateral triangular to each other. The height of the stones depends on the size of the intended cooking pot to the used. In this project, the height of the stove is about 40 cm from the ground. The distance from one stone to the other is about 55 cm.

The objective, however, is to keep the pot high enough to allow enough firewood underneath the pot. Hence, the bigger the size of the intended pot, the higher the height of the stones. The advantages of the three stone stove are that it can be constructed by the cook, it is cheap and it can use various fuels.

![Figure 51: Three stone stove](image)

![Figure 52: Dimension of the box of the roaster stove](image)

The most important concern with traditional 3-stone is its smoke production (incomplete combustion causing (indoor) air pollution) and low efficiency. Biomass fuels release large amounts of smoke when burned in this type of stove. These pollutants can result in several respiratory diseases. Another problem with this type of stove is the inefficiency in fuel consumption. Traditional wood fires are very efficient at turning wood into energy. However, traditional wood fires are inefficient at transferring the released energy into the cooking vessel. Most of the released energy in the wood is wasted by heating the surrounding air rather than transferring the heat to the substance in the cooking vessel. The inefficient transfer of energy requires the user to use more wood fuel, thereby increasing the amount of wood harvested from the surrounding environment. The increased demand for wood can further deplete the already stressed local natural environment.

**The Roaster Stove**

The roaster is a 97 litre cylindrical container that is mounted in a metal box. The roaster is used to roast the crushed seeds (grit). This stove is a locally designed stove, manufactured by a local blacksmith. The metal box is rectangular in shape and measures 83 cm in length by 54 cm in width by 42 cm in height (see Figure 52). It has metal plates at both sides and at the back. The plates are about 4 mm thick. Three sides of the stove are open (bottom, one long side and the top). Fuel wood
is fed through the open side. The cylindrical roaster rests on the two sides of the metal box (see Figures 53 and 54).

The cylinder has a door through which the crushed seeds are fed. After the container is fed with the seeds, it is mounted over the wood-fired stove and rolled continually until the grits are roasted brown. The advantages of this stove are that it is easy to use, made from locally available materials and by local expertise (the stove was constructed by a local blacksmith who relies on used and leftover scrap metal), and, therefore, easy to repair and relatively cheap (the stove costs between GHc 60–75). The disadvantages are that the stove is inefficient and emits a lot of smoke.

**Financial Performance**

The cost of one bag of Shea seeds, when it has to be bought, is about GHc 50.00. From this bag, 28.3 kg of Shea butter can be produced. The market value of crude Shea butter is GHc 2.50/kg. Therefore, the selling price of the Shea butter produced from one bag of Shea seeds is GHc 70.75. The difference between the price of a bag of seeds and the price of the resulting 28.3 kg of crude butter is GHc 20.75. This needs to pay for all inputs.

The cooperative pays for the grinding (GHc 2) and milling (GHc 4). The cooperative further buys 49.1 kg fuel wood, costing GHc 5.40 (49.1 kg at GHc 0.11/kg). This information is summarized in Table 2 (excluding cost of labour and financing).

**Table 2: Expenditure and Income Statement for 87 kg seeds**

<table>
<thead>
<tr>
<th>Cost Item</th>
<th>GHc</th>
<th>Income Item</th>
<th>GHc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buying Seeds</td>
<td>50.00</td>
<td>Sales Shea Butter</td>
<td>70.75</td>
</tr>
<tr>
<td>Crushing Seeds</td>
<td>2.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milling Grit</td>
<td>4.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel wood</td>
<td>5.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packing</td>
<td>0.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>62.34</td>
<td><strong>TOTAL</strong></td>
<td>70.75</td>
</tr>
</tbody>
</table>

If the difference (GHc 8.41) would be available for labour cost (in total 27 hours and 8 minutes), the women would earn GHc 0.31 per hour. This is 55% of the 2012 minimum wage (GHc 4.48 per day or
GHc 0.56 per hour\(^9\). The amount is, however, not in full available for wages as it also needs to cover at least the depreciation of equipment.

**Ratios**

From the results of the study, a number of ratios can be derived. Relevant ratios are given in Table 3.

<table>
<thead>
<tr>
<th>Ratio</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kg seeds per 1,000 kg of Shea butter</td>
<td>3,074 kg</td>
</tr>
<tr>
<td>Litres of water per 1,000 kg of Shea butter</td>
<td>11,660 litres</td>
</tr>
<tr>
<td>Kg of fuel wood per 1,000 kg of Shea butter</td>
<td>1,734 kg</td>
</tr>
<tr>
<td>Hours of labour per 1,000 kg of Shea butter</td>
<td>985 hours</td>
</tr>
<tr>
<td>kWh of electricity per 1,000 kg of Shea butter</td>
<td>173 kWh</td>
</tr>
</tbody>
</table>

**Findings**

The most striking finding is that Shea butter production is only marginally profitable. The results indicate that women work 27 hours, under sometimes difficult conditions (hard work, exposure to fuel smoke and heat), and do not earn anything near to minimum wages.

Another striking finding of the study was that women involved in Shea butter processing do not have the capacity to assess all the inputs and outputs of their business. They are unable to quantify or track how much time, energy, water and money they invest to process any particular quantity of Shea nuts. Consequently, they are unable to assess what would be a fair price of their end product.

Shea processing women are interested in the details of their work. They are interested in knowing the amount of resources they invest to produce a particular quantity of butter. This interest is demonstrated by their own suggestions of the need to track some of the stages of the process which seem overlooked by the researchers.

An assessment of the resource investments in processing the 87 kg of Shea seeds, indicates that the product is either under-priced in the market or that it is not financially viable considering the opportunity cost of labour in processing butter.

It was also found that a significant amount of energy is wasted in the process of processing Shea butter due to technological choice, design and construction inadequacies of the stoves being used.

Given the large amount of water used in the processing of Shea butter, an effective filtration and treatment of the water from the washing and kneading stages of the process can help save some resources. Water can be recycled and reused. This will not only reduce the cost of water used, but will also increase briquette yield from the waste water at the end of the kneading process.

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\(^9\) www.mywage.org/ghana/home/salary/minimum-wages
Recommendations

The following actions are recommended:

1. Because Shea butter processing appears to be only marginally viable, it is recommended to repeat this study at several additional Shea butter processing groups to confirm the findings. Follow-up studies can benefit from the results of this report and learn from its findings and mistake. All numbers presented must be checked and re-checked to be able to draw robust conclusions.

2. In addition to this process characterization it is recommended to encourage the Shea butter processing groups to keep proper records to get longer time-frame and therefore more reliable results. Of interest are quantities and price of Shea seeds bought, quantity and price of Shea butter sold, payments to mill owner (or energy cost of crushing and milling), payments for fuel wood, payments for packing materials and income from by-products.

3. Fuel wood cost is 8.7% of the total production cost. Given the fact that the margin is so small, reducing the cost of fuel wood may significantly increase the margin. It is, therefore, worthwhile to investigate the financial viability of introducing improved cooking stoves.

4. The study indicates that there is a need for focused and well-targeted capacity building for Shea butter processing groups. Specifically, this should target costing, input /output tracking, energy utilization and resource investments.

5. The production process may be simplified, working environment improved and financial viability increased by introducing appropriate technologies in Shea butter processing. This should be based on the weaknesses identified in the groups processing practices. In this case, appropriate technology could be directed at energy efficiency technologies, cooling technologies and water saving technologies.

6. Last but not least, to ensure effective poverty reduction among Shea butter processing groups who are mainly women, it is important to invest in one of two price maximizing strategies for Shea butter: (i) Intensify the advocacy for fair pricing for Shea butter; or (ii) Develop alternative (higher paying) markets for the product and by-products.

Conclusion

It is true that northern Ghana is endowed with the Shea tree as an important economic tree that serves as a source of livelihood for many people especially women. As a traditional women dominated activity, much of the process still remains rudimental with very good reasons though. In the context of inadequate employment opportunities in general and particularly for the age groups and educational levels of women involved in Shea butter processing, the venture is a critical economic activity for women of this part of the country.

Shea butter processing is a time, energy and resource intensive activity that demands sophisticated skills and knowledge which must be acknowledged. The market needs to pay for these investments. However, given the current price of Shea butter, especially in the local market where these groups sell, the price of the product does not seem to reflect or attract its true economic cost of production.

The use of energy and water in particular are quite critical to the Shea butter processing activity. With several weaknesses identified, simple and appropriate technological response is urgently needed. Further research in this area needs to compare a Shea butter processing group that uses energy and resource efficient technologies such as those recommended above and one that does not. The objective of this will be to make a case for or against the application of appropriate technology in Shea butter process.
Although the cooperative might have been reluctant to cooperate and did not see the benefits of a process characterisation at first, they became gradually more interested. They showed in the end a keen interest to understand the process better and know the inputs and outputs of each stage. This will form a basis for improvements in the process. It will also help to compare processes of different women groups so that they can learn from each other how to reduce the production cost and improve product quality. It is proposed to continue the process characterisation with other Shea butter processing groups. A proposal for this will be prepared together with the Agric team. Funding will be sought from Shea butter users such as the body shop.
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