Analysis of the shea market in Africa. Application of concepts in Circular Economy to optimize the process at an economic, ecological and social level.

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Abstract

Circular economy, as opposed to the linear economy, is based on the intersection of environmental, economic and social aspects, maintaining the value of resources as long as possible and minimizing waste. The shea tree (Vitellaria paradoxa) is a species traditionally exploited in sub-Saharan Africa. The main product obtained from its seeds, through a long and strenuous process for women, is shea butter. The main objective of this bibliographic review is to collect information on different ways to improve the process, the situation of women workers and the conservation of the species.

Results are presented in 4 main lines. Firstly, the threats that affect the tree and certain recommendations for practices to improve its conservation. Secondly, different uses of the resources obtained from the shea. Thirdly, the study of the process and the provision of optimized methodologies to achieve greater efficiency. Finally, the current market situation is analysed, setting out the main threats and opportunities.

It is concluded that, despite the difficult situation in the sector, the shea market offers great opportunities. To achieve them, the education of the population, the provision of efficient legislation and the attraction of stable funding sources are essential. Cooperatives would stand out as the best global option to the market.

Resumen

La economía circular, en oposición a la economía lineal, se basa en la intersección de los aspectos ambientales, económicos y sociales, manteniendo el valor de los recursos el mayor tiempo posible y minimizando el desperdicio. El árbol del karité (Vitellaria paradoxa) es una especie tradicionalmente explotada en el África subsahariana. El principal producto obtenido de sus semillas, a través de un proceso largo y extenuante para las mujeres, es la manteca de karité. El objetivo principal de esta revisión bibliográfica es recopilar información sobre diferentes formas de mejorar el proceso, la situación de las trabajadoras y la conservación de la especie.

Los resultados se presentan en 4 líneas principales. En primer lugar, las amenazas que afectan al árbol y ciertas recomendaciones de prácticas para mejorar su conservación. En segundo lugar, diferentes usos de los recursos obtenidos del karité. En tercer lugar, el estudio del proceso y el aporte de metodologías optimizadas para lograr una mayor eficiencia. Finalmente, se analiza la situación actual del mercado, exponiendo las principales amenazas y oportunidades.

Se concluye que, a pesar de la difícil situación en el sector, el mercado del karité ofrece grandes oportunidades. Para alcanzarlas, la educación de la población, la disposición de legislación eficiente y la captación de fuentes de financiación estables son esenciales. Las cooperativas destacarían como la mejor opción global para el mercado.

Resum

L'economia circular, en oposició a l'economia lineal, es basa en la intersecció dels aspectes ambientals, econòmics i socials, mantenint el valor dels recursos el major temps possible i minimitzant el malbaratament. L'arbre del karité (*Vitellaria paradoxa*) és una espècie tradicionalment explotada a l'Àfrica subsahariana. El principal producte obtingut de les seves llavors, a través d'un procés llarg i extenuant per a les dones, és la mantega de karité. L'objectiu principal d'aquesta revisió bibliogràfica és recopilar informació sobre diferents formes de millorar el procés, la situació de les treballadores i la conservació de l'espècie.

Els resultats es presenten en 4 línies principals. En primer lloc, les amenaces que afecten l'arbre i certes recomanacions de pràctiques per millorar la seva conservació. En segon lloc, diferents usos dels recursos obtinguts del karité. En tercer lloc, l'estudi del procés i l'aportació de metodologies optimitzades per aconseguir una major eficiència. Finalment, s'analitza la situació actual de mercat, exposant les principals amenaces i oportunitats.

Es conclou que, tot i la difícil situació en el sector, el mercat del karité ofereix grans oportunitats. Per assolir-les, l'educació de la població, la disposició de legislació eficient i la captació de fonts de finançament estables són essencials. Les cooperatives destacarien com la millor opció global per al mercat.

Summary

List of Tables and Figures

Acronyms and abbreviations

CE	Circular Economy
LE	Linear Economy
IUCN	International Union for the Conservation of Nature
NTFP	Non-Timber Forest Product
FOSFA	Federation of Oils, Kernels and Fat Association
CBI	Cocoa butter improver
CBE	Cocoa butter equivalent
EU	European Union
USA	United States of America
NGOs	Non-Governmental Organizations

1. Introduction

1.1. Motivation of the study

The development of this project has been mainly motivated by the willingness to do an end-of-degree project with a real application and utility, not merely theoretical. In this way, the Non-Governmental Organization (NGO) "OAN International" [1] offered the possibility of developing a bibliographic review on shea butter that could have a useful application in the area where they carry out their projects: Nikki, Benin, Africa. The possibility of learning about this sector and, at the same time, about the concepts encompassed by the circular economy (CE) have served as foundations pursuing a study that could mean a change at an economic, social and ecological level for a community.

1.2. Objectives

This work tries to apply the concepts introduced by the CE through the available information on the global process of shea exploitation. It pursues an improvement in the working and salary conditions of women workers, social equity between women and men, improvements in market conditions and possibilities, and the optimization of energy and resource flows, aiming at maximum profitability and minimum environmental impact. The main lines of work focused in this study are:

1. The provision of conservation measures for the long-term maintenance of the species, as the origin of the resource.

2. Diversification in the applications of the resource, with the aim of optimizing its use by the population and minimizing waste.

3. The introduction of improved methodologies in the different processing steps, pursuing the optimization and profitability of production, reducing the energy and resources required and increasing the final quality of the product.

[1] OAN International is an NGO founded in 2014 with the aim of accompanying the development agents of the Nikki commune (Benin, Africa) through the exchange of knowledge and the joint creation of a model of sustainable, responsible and replicable cooperation. The joint work of volunteers and university students, hand in hand with the local population, has allowed the development of numerous projects at the social and health level, construction of infrastructures, training, etc., up to the present.

4. The analysis of the supply chain and the market situation, with the aim of identifying the points where the application of a restructuring is necessary, how to apply some of those changes and where the market opportunities lie.

1.3. Bibliographic review methodology

This research methodology has consisted foremost of the use of online search engines, mainly Google Scholar, together with the use of the search engine for articles, books and magazines of the UAB Online Library Service. From these search engines, databases such as Scielo, Academia or Science Direct have been accessed. To search for articles or thesis of interest, keywords related to the project have been used, such as: "*Vitellaria paradoxa* conservation", "shea butter market", "shea butter properties", "shea butter gender", "shea butter extraction". The steps followed once the article has been obtained have been:

1. Screening: reading of the title, abstract and keywords.
2. Full Reading of the articles selected.
3. Database compilation: collection of all the information of interest from the papers in a text document.
4. Final selection of information, synthesis and redaction.

Chapters of various books, all of them in electronic version have been consulted, in a similar way to that previously explained. In parallel, information and advice have also been obtained from complementary sources. These complementary sources have directly provided information in the form of their own documents or have recommended the reading of articles of interest.

2. Theoretical framework

2.1. Circular Economy

The concept of the circular economy (CE), as a branch of the Green Economy, has meant a revolution in recent years for all economic sectors. CE is an industrial model aiming to decouple environmental impact from economic activities, tending to the maximum eco-effectiveness. It

tries to act in the complex interconnection between society, natural environment and economic development (*"Triple bottom line"),* pursuing the scope of a sustainable development model, based on environmental quality, economic prosperity and social equity, for the benefit of current and future generations (Kirchherr et al., 2017).

The key point of the CE is the change from a Linear Economy (LE) with an *"end-of-life cycle"*, marked by a flow of extraction, manufacturing, use and generation of waste (Cejas et al., 2018), to a closed loop material flow. Each loop is an opportunity to generate more value than in the LE model. Due to current environmental and resources situation the linear model comes to an end because of the impossibility of its continuity and its inefficiency.

It goes from a *take-make-dispose* model to a more creative, innovative and productive services model, opening great chances of new business opportunities for the investors and increasing company's resilience. The application of different types of measures based on the extension of the use of the materials, the reduction of the consumption, and the decrease of resources and energy squandering (eco-efficiency) is required (Foster, 2020).

CE, as a new paradigm, must be applied at different levels. First, in a macro-level, which includes fiscal factors at a regional level and changes in economic conditions; secondly at a meso-level, which focuses on the changing of the supply chains and their organization; and finally at a micro-level, focusing on the individual, in the way we produce and consume resources (Donati et al., 2020). It has to be applicated from an holistic perspective, avoiding individual solutions due to current inter-dependence stablished by globalization, allowing collaboration between sectors and companies (Bonciu, 2014).

2.2. Shea butter market analysis in Africa

Shea butter is an important source of income for many households in sub-Saharan Africa. The resource is the second most important non-timber forest product (NTFP) after palm oil and it is obtained through work generally carried out by women. Despite the great importance of this market for the poorest population and its progressive but slow development in recent years, the truth is that it is trapped in a complicated situation. It is mainly carried out by inefficient traditional processes, without a clear situation and structuring of the market, nor a legislation that regulates and protects the interests of workers.

2.2.1. Shea tree study *(Vitellaria paradoxa)*

- Ecology

Shea tree, or karité in french *(Vitellaria Paradoxa. C.F. Gaertn),* is a spermatophyte species of the Sapotaceae family (Lamien et al., 2005) (see Annex A). It is an indigenous species from Africa, eminently from the western part of the continent, where it appears in 21 countries, in the so-called Shea belt (Figure 1), estimated at 100,000 km^2 (Lovett, 2013), mainly found in altered savanna biomes.

Figure 1. Map of the general distribution of Vitellaria paradoxa across West, East and Central Africa. Source: USAID West Africa Trade Hub. (Lovett, 2013).

It is a slow growing tree, with a life span that ranges from (Karambiri et al., 2017). Production maturity is reached between 20 and 45 years after planting. The individuals of *Vitellaria paradoxa* occur mainly in semi-domesticated ecosystems, called parklands. The trees appear scattered, giving rise to dispersed and not very dense populations. These ecosystems are not intentional intensive crops cultivated by the population to exploit their resources, but they are not natural populations either (Gijsbers et al., 1994).

- Conservation

According to the (IUCN, 2020) *Vitellaria paradoxa* is currently in a vulnerable conservation situation (VU), which includes it as a threatened species on the Red List of Endangered Species, due to its progressive population decline (Djossa et al., 2008). Table 1 lists the different threats facing tree conservation.

2.2.2. Uses and applications of the resource

One of the most important steps in optimizing and making the most of the shea tree is knowing what its uses and properties are, in this case, from each of the parts of the tree, and the products that can be obtained from them. In this way, all components can achieve its maximum profitability and be circularized, minimizing the amount of waste generated. West African societies have, traditionally, used the resources obtained from the shea tree for centuries. Virtually all parts obtained from the tree are used for food, medicine, cosmetics, religious, cultural or social purposes (Diarassouba et al., 2008).While some of the resources are obtained periodically from the tree (flowers, fruit and kernels) being renewable and sustainable ones, there are others whose extraction involves the loss of the tree (wood, bark, roots) or at least suppose severe damage to the plant, representing an inconvenience for the regeneration of the populations.

2.2.3.Shea butter production process

Within the production of shea butter we find 4 main steps: harvesting, curing, extraction and post-extraction (refining, fractionation and formulation). The shea market is currently at a transition point between rural traditional production and the slow, but progressive, mechanization and industrialization of the sector. The extraction process is long, complex and strenuous, especially in small-scale and rural production areas. A work cycle for obtaining the oil is around 5 to 6 hours (Abdul-mumeen et al., 2019). Only fully mechanized processing, normally only available outside Africa, develops post-extraction processes.

This document tries to compile some of the methodologies, trying to select those that have been shown to be the most efficient focusing on improving product quality, increasing productivity and optimizing storage, packaging and energy flows.

Table 1. Causes and effects of the different threats to the conservation of the species. Source: own elaboration.

Threat factor	Cause	Effect	Reference
Wood overexploitation	• Great firewood and charcoal sales growth.	• Deforestation of the species. • Substitution by firewood-producing species (faster growth rates and higher productivity).	(Boffa, 2015).
Seed overexploitation	• Over harvesting for the sale of seeds or its processing.	• Reduction of natural propagation and reproductive success of the species, preventing its regeneration (increasing population's mean age).	(Gijsbers et al., 1994).
Population's growth	• Increase of populations pressure. • Expansion of urban areas	• Reduction of the distribution area of the species. • Increased impacts on the ecosystem (pollution, reduction of biodiversity, increased over-exploitation of resources).	(Baziari et al., 2017).
Livestock	• Increase in livestock number.	• Damage to seedlings, by trampling or grazing, making it impossible for new individuals to regenerate (increasing population's mean age).	(Yeboah et al., 2011).
Pests and Diseases	• Poor condition of the trees	• Decrease in the productivity, the quality of the fruits and in the worst cases the death of the individual. • Seedling death before maturity (increasing population's mean age).	(Augusseau et al., 2006).
Climate change	• Increase in droughts, floods and fire frequency and intensity • Seasonal changes	• Effects on the distribution of the species and its phenology, still unknown. • Damage to seed propagation, germination and regeneration (increasing population's mean age).	(Ræbild et al., 2011), (Nyarko et al., 2012).
Intensive cash crops	• Substitution after land clearance of the parklands for intensive crops. ○ Fallow elimination or reduction.	• Adult trees elimination. • Regeneration impossibility. • Habitat degradation.	(Teketay & Bekele, 2003).
Regulation	• Inexistent or inefficient legislation. ○ Changes in land uses, always seeking a superior economic benefit.	• Tree population decrease. • Degradation of the ecosystem and environmental impact.	(Lovett, 2013).
	• Tenure legislation ○ Conflicts between landlords and farmers ○ Unregistered lands	• Farmers situation of insecurity and risk. • Impossibility of Governments management and control.	(Buyinza & Bosco Lamoris, 2015).
	• Management legislation	• Some laws enhance the replacement of parklands by cash crops. • Impossibility of removing diseased trees, transportation or pruning.	(Boffa, 2000) (Seghieri, 2019).
Social ignorance	• Lack of information on the application of conservation measures and land management.	• Poor parkland and resource management. • Population decrease and ecosystem damage.	(Augusseau et al., 2006).
Cultural interests	• Ethnic differences. • Gender differences. • Age differences. • Occupation differences.	• Conflicts about land uses • Isolation of women. • Parklands degradation and substitution for other uses.	(Meinzen-Dick et al., 1997), (Assé & Lassoie, 2011), (Boffa, 2000).

2.2.4. Commercialization. Study of the current situation. Local market, international market and threats

In Africa there are about 500 million trees of *Vitellaria Paradoxa*. Its commercial exploitation in all its forms has been estimated to contribute about 150 million US dollars annually, from the sale of 2.5 million tons of shea nuts (Bup et al., 2014). This market is an economic livelihood for around 18 million women along the shea belt (Naughton et al., 2017a). Commercialization has been increasing its number during the last decades (Nikiema & Umali, 2007).

Local trade remains the main selling mechanism in the shea market (Lovett, 2010). Local products have generally been discredited by the market, mainly as low-quality products. However, the offer and variety of this products grows progressively, expanding the market and improving the conditions of workers.

Once the product has been produced at the national level, especially in cosmetics, it can return to the gatherers, but at a much higher price (Bup et al., 2014). The existence of organizations, such as the "Federation of Oils, Kernels and Fat Association (FOSFA)", that control its development and establish a standardization of the quality of the products and their associated prices is essential (Masters et al., 2004).

As main importers we find the European Union (EU), the United States of America (USA) and Japan (Bup et al., 2014). Importers generally focus on buying dried kernels (Warra, 2011), so that they have processing plants (mechanical or chemical), from which they develop, outside Africa, the extraction and refining of the product. This allows them to obtain the greater part of the income by producing the final products (Masters et al., 2004).

Most of the international product (90%) is used in the food sector, mainly as a improver or equivalent component (CBI/CBE) of cocoa butter (Bup et al., 2014). The main downside is that shea butter prices fluctuate largely on the market depending on the availability and price of cocoa butter (Masters et al., 2004). The remaining 10% is used in the cosmetic sector (Bup et al., 2014). This sector is the one with the greatest profitability and future options for shea butter (Reynolds, 2010).

The supply chain for shea market is immersed in a situation of disorganization and a lack of quite serious information. This, together with the absence of effective legislation, results in a lack of connection between its different parts.

The backbone of the chain and its most important element, and at the same time, the most vulnerable one, would be the local pickers and producers (Aboubakar Dandjouma et al., 2009). Shea incomes improve household conditions, maintaining food security, reducing poverty (Kavaarpuo, 2010) and improving the social conditions of women, by being able to gain some independence from the financial power monopolized by husbands, allowing them to occupy a valuable social position (Bup et al., 2014). However, it requires strenuous and exploitative work for women.

The “Paradox of Paradoxa” refers to the existence of total isolation in communication and knowledge between the first links of the supply chain and the market. Shea butter is generally seen by international consumers as a product generated by the work of rural women, organic, ecological and based on gender and economic equity. However, 90% of the market is based on the sale of the raw material, the kernels, harvested in poor working conditions and with minimal income for the collectors (Bello-Bravo et al., 2015). To maintain the market and improve product quality, it is important that a good part of the benefits go back to local producers (Masters et al., 2004). They can then apply new methods to improve the quality and diversity of the product, in order to supply the demands of the international market, improving prices and their working conditions (Bello-Bravo et al., 2015).

Intermediaries are an essential link in the supply chain, acting as transporters, givers of warehouse and sellers of the product obtained locally by women. However, many of them act as a barrier to the empowerment of women and their economic independence (Bup et al., 2014). They deceive these women, taking advantage on their ignorance or abusing privileged position knowing of the seller's precarious situation (Naughton et al., 2017a).

Exporters or wholesalers are large importer companies of the product. In this part of the market we find a small number of main players who monopolize the sector. Six companies from the EU and the USA buy 60% of the nuts and 50% of the butter produced, while 4 multinationals control the whole refining process of the product worldwide (Bup et al., 2014).

In recent years a regressive trend in the market has been observed (Agúndez et al., 2020). Some of the possible threats that may have led to this are presented here.

- Lack of investment and corruption (Bup et al., 2014)(Naughton et al., 2017a).
- Extreme poverty conditions.
- Lack of research and projects to enhance the conservation, overexploitation and climate change.
- Globalization and other oils competition raising (Naughton et al., 2017a).
- The disorganised supply chain (Addaquay, 2004).
- Misinformation, lack of criteria, research, databases and general knowledge (Aboubakar Dandjouma et al., 2009).
- Men's appropriation of work and effort developed by women producers (Pouliot, 2012) and continuous abuses (Aboubakar Dandjouma et al., 2009).

3. Results

3.1. Recommended conservation measures

Evaluating its conservation status and the potential threats to this species this paper recommends to focus conservation measures in 4 main areas.

- Natural Parkland management:

Due to the limited study and development of shea plantations, along with their lower potential for success, conservation efforts should focus on facilitating the tree's natural regeneration process and traditional parkland management. Of vital importance is the establishment and respect of fallow periods (Baziari et al., 2017). Seedlings must be protected during the land cleaning period. Mulch seed coverage be applied for this matter (Buyinza & Bosco Lamoris, 2015). The promotion of natural propagation can also enhance regeneration. Limiting harvesting to a certain extent or to certain periods, so that a part of the seeds has the possibility to germinate.

The control of livestock, especially goats, to avoid trampling and the consumption of seedlings should be given by farmers (Gijsbers et al., 1994). The marking or fenced of the seedlings to prevent livestock access could be a partial solution. Burning the ground to enhance grass growth should be discouraged. To partially avoid the effect of fires, an advisable measure could be the seasonal cleaning of the land, eliminating part of the vegetation and fallen wood. The development of good pruning and tree management, despite what is commonly thought, leads to a greater benefit in their regeneration (Boffa, 2015). Pruning is also recommended to improve the microclimatic conditions around the trees for other crops (Seghieri, 2019), and to better fruit quality (Animasaun et al., 2019). Pruned material could be used as mulch (Dianda et al., 2009). The establishment of routine controls over the trees is essential to maintain good health conditions in the populations, greatly reducing diseases and pests.

The genetic study of populations allows the identification of the genetic diversity of the species. Protecting this diversity increases its resilience against environmental changes, ensuring its long-term conservation (Nikiema & Umali, 2007).

- Planting

Currently there are no real intensive crops of shea trees. However, the study of the ideal conditions for planting is being developed (see appendix A). In many areas, the creation of nurseries has been promoted through the development of very successful programs such as the one carried out by The She Project. Genetic studies of populations and individuals are taking great strides towards the domestication of the tree and the obtaining of those phenotypic traits that provide greater advantages, reducing growth and maturation times, increasing seed production, etc. (Kavaarpuo, 2010)(Ræbild et al., 2011).

- Education

The provision of information to the population is one of the keys to applying effective conservation measures. Evidence shows that when farmers perceive that trees bring gains they are more likely to invest actively in the protection and reproduction of parklands (Boffa, 2000). The benefits brought by the tree are multiple, through the sale of its products, the use of its resources and the benefits brought to the land. Farmers can benefit from the association with annual crops such as millet, cassava or cotton (Gbemavo et al., 2010). Grouped cultivation in clusters generates beneficial microclimates for production, a phenomenon that occurs with natural kernel dispersal (Zomboudré et al., 2005) (Gwali et al., 2012). Shea trees achieve better

soil conditions in infiltration, stability against erosion, fertilization and biodiversity (Seghieri, 2019)(Dianda et al., 2009). They also act as huge carbon sinks (Lovett, 2010) and can remove heavy metals from the ground (Orwa et al., 2009).

Farmers, and women workers in the sector, must obtain information from NGOs, Universities or Governments, on the best way to apply conservation measures. And be themselves the ones who act as defenders of said measures, as long as it does not pose a threat to their security.

- Legislation

The establishment by the governments of legislation measures regarding the conservation of the species is still a pending matter in most African countries. The lack of resources for the implementation of the measures and for monitoring their compliance greatly hinder effective action. This, together with the absence of protected areas, leads to a vulnerable situation for many species such as shea.

The implementation of legislation that regulates tenure, forcing the registration of land, is of great importance in order to apply measures and avoid conflicts (Boffa, 2000). The care of the land must be in charge of the owner, carrying out obligatory controls of diseases and pests, pruning, cleaning of the land...

Taking into account the will of the different population groups (depending on factors such as ethnicity, sex or age) is essential for the legislation to be effective, trying to minimize the exclusion of groups from the framework of action. The need has to be locally perceived and not imposed (Buyinza & Bosco Lamoris, 2015). This capacity of communities at the institutional level to manage tenure issues, when Government legislation is non-existent or inefficient, is one of the best responses for the future conservation of the parklands and it must be supported (Boffa, 2000).

3.2. Uses and applications of the resource

Table 2. Uses and properties of the shea resources. Source: own elaboration.

Resource	Use and Properties	Reference
Roots	• Oral paste against jaundice, stomach pain and diarrhea[1] • Bark has antimicrobial properties, and can be used as an antibiotic against some pathogenic organisms[2] • Chewing sticks, obtaining dental and antimicrobial benefits[3] • Used as a poison along with tobacco[4] • Heal horse sores (after boiling and crushing the bark)[4]	[1](Mainasara et al., 2016), [2](Garba & Salihu, 2011), [3](Temitope, 2015), [4](Teketay & Bekele, 2003)
Bark	• Antidiabetic and antioxidant properties from an extract of the powdered bark[5] • The use of infusions has antimicrobial activities, used to treat cattle infections with worms[6] • Treatment for diseases such as diarrhea, gastric problems, and dysentery[6] • Treatment for cobra bites and against jiggers[6] • Baths or drinks are made for its healing power. Bark decoctions are used on new-borns to stimulate lactation[6] • Curative effects against cough and leprosy[7]	[5](Miaffo et al., 2019), [6](Teketay & Bekele, 2003), [7](Oluwaseyi, 2014)
Wood	• Household utensils, stakes, posts, frames[8] • Firewood and for charcoal[8] • Fibers can be used in dietetics to make food products such as bread[9]	[8](Teketay & Bekele, 2003), [9](Akanbi & Oladele, 2014)
Latex (from bark and immature fruits)	• After a heating process and mixing with palm oil it gives rise to glue[10] • It can be used as chewing gum or a toy for children[10] • To repair drums and punctured drumheads[11] • Adhesive for some animal traps, such as birds[12]	[10](Teketay & Bekele, 2003), [11](Oviasogie et al., 2013), [12](Ferris et al., 2001).
Flowers	• Food like edible fritters[13] • To flavour tobacco[14] • To reduce chest pain[14]	[13](Oviasogie et al., 2013), [14](Ferris et al., 2001)
Leaves	• Decoction of leaves is used against migraines, in steam baths and to clean the eyes[15] • Used for stomach pain in children[15] • Foam obtention for washing[15]	[15](Teketay & Bekele, 2003)
Pulp	• Is eaten if it is sweet (matured)[16] • Used as a light laxative[17] • Processed for the extraction of a fine, sweet, white oil, which is used in the production of bread[17] • A thicker, butter-like oil, is obtained and used for cooking or the pulp is grounded to use as a food additive[17]	[16](Oviasogie et al., 2013), [17](Teketay & Bekele, 2003)
Nutshell	• In small concentrations to feed livestock[18] • Fuel for three stone fires[18] • Fertilizer and for the production of mulch[18] • It has antidiabetic properties[19] • Used in crops or in natural soil to absorb heavy metals in aqueous solution [20,21]	[18](Teketay & Bekele, 2003), [19](LI et al., 2019), [20](Eromosele & Otitolaye, 1994) [21](Of et al., 1996)
Others	• Shea tree is an important nucleus for beekeeping[22] • One of its parasitic plants (*Tapinanthus globiferus*) provide medicinal benefits[22] • Some of its substances can be used for their insecticidal or larvicidal properties in food storage[23] • The biomass left over from the entire process can be used to compost and generate biofertilizer	[22](Teketay & Bekele, 2003), [23](Buxton et al., 2020), [24](Oviasogie et al., 2013)

Resource	Use and Properties	Reference
Shea kernel (and shea butter)	• Use in the food industry, mainly as a substitute for cocoa butter (main use)[25] • Lowers total cholesterol levels, provides vitamin A and benefits the activity of coagulating factor VII[25] • Rancid butter is used as a waterproofing agent in doors and windows. Also to fill cracks in the walls [25] • Use it as a substitute fuel for kerosene, used for candles or lamps[25] • It can be used for bruises, swelling, dry skin or dermatitis, burns and chilblains[26] • Used as a hair softener, moisturizer, and as an anti-aging agent for the skin[26] • It has properties against, preventing cartilage breakdown and reducing pain[27] • Reduction of inflammation, antioxidant properties, and reduction of joint pain have been observed[28] • Decreases rheumatism, decongestion of the nostrils, leprosy, cough and can be used to treat small dislocations of bones[29] • It also has properties against allergic reactions and autoimmune conditions[29] • Creation of ointments, creams, lip balms, lubricants, shampoos[29] • Used as an accelerator for healing after circumcision, to prevent stretch marks in pregnant women[30] • Treatment against herpes[31] • Used as a sun cream and against sunburn has also been demonstrated[32] • Generation of soaps from fat, using rancid butter[33] • Used as a mosquito repellent and to protect crops[34] • Shea nut cake (by-product) has been used in animal feeding[35], and as fertilizer [36] • Applied in rituals, marriages, funerals or crownings[37] • Rancid butter can be used as an effective lubricant for machines[38] • Part of the production can be used for the generation of biodiesel, although this process is complex[39,40]	[25](Teketay & Bekele, 2003), [26](Dennie, 2012), [27](Sudirman et al., 2020), [28](Akihisa et al., 2010), [29](Nahm, 2011), [30](Oluwaseyi, 2014), [31](Masters et al., 2004), [32](Velasco et al., 2008), [33](Warra, 2014), [34](Konan et al., 2003), [35](Kochewad, 2017), [36] (Abdul-Mumeen et al., 2013), [37] (Ferris et al., 2001), [38](Alonge & Olaniyan, 2007), [39](Bello & Mamman, 2014), [40](Enweremadu et al., 2011)

3.3. Optimizing methodologies

The main opportunity to optimize processing lies in the current transition from the traditional manual model to a mechanized one. The acquisition of machinery is complex and expensive and there are few professional users. Also, the isolation of rural areas makes mechanization

difficult. However, the benefits brought by it are enormous. Initial financial support, either from governments or support associations, to enhance this mechanization is essential. The presence and creation of basic service infrastructures to obtain water or electricity are also very important points to consider.

Teaching and training on good methods, possibilities for improving procedures and using machines is a huge advance for communities, being able to teach them from one to another.

In tables 4 and 5 some of the methodologies to optimize the process are collected. The most efficient way of developing the process is summarised in Figure 2.

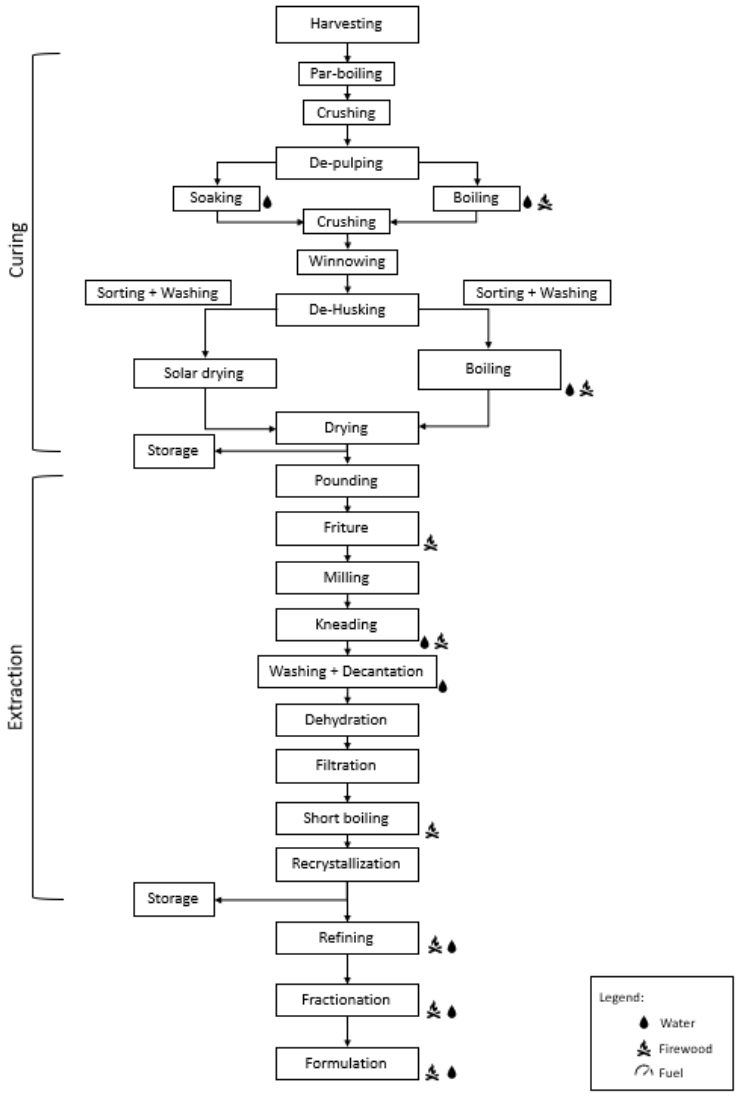

Figure 2. Diagram with the proposal of optimized steps to follow during the shea butter production process. Source: own elaboration.

Table 3. Problems and recommendations to apply to each of the steps of the shea butter production process. Source: own elaboration.

Process	Description	Problems	Recommendations	Reference
Harvesting	Collecting the fruits once they have fallen to the ground.	• Too much effort and time invested. • Property conflicts. • Poor quality fruits. • Security conditions for women against animals.	1. Means of transport[1] 2. Determine collection areas. 3. Pick up in groups of 3 or 4 women. 4. Collect frequently during harvest period[2] 5. Do not take sprouted, immature, fermented or mould-infested fruits[3] 6. Controlled burning of grass during flowering to facilitate visibility [1]	[1](Masters, 2002b), [2](Masters et al., 2004) [3](Lovett, 2013)
De-pulping	Separation of the pulp from the husked seed.	• Development of negative actions for seed quality. • Fermentation or infestation of the fruits for their storage. • Slow and tiring methods.	1. Do not bury the fruits or store them once collected [1,2,3] 2. Avoid aggressive methods such as the use of mallets that can damage the seed [4] 3. Develop a parboiling process (15-40') that facilitates the separation[5,6]	[1](Hyman, 1991), [2](Masters, 2002b), [3](Abdul-mumeen et al., 2019), [4](Alonge & Olaniyan, 2007), [5](Nikiema & Umali, 2007), [6](Masters et al., 2004)
De-husking	Separation of the husk from the seed. For this, a drying pre-treatment is carried out, together with the breakage of the shell and its elimination by winnowing.	• Continuity of the enzymatic processes that ferment the seed or make it germinate[1] • Slow and tiring methods. Decortication difficulty. • Increased toxicity by PAHs and peroxides [2,3] • Loss of material in the crushing and winnowing processes[4,6]	1. 1. Develop a boiling process (30-45 ', 100-105ºC)[2] 2. Do not develop smoking processes [2,3] 3. Use of crackers or shelling machines to facilitate the process [4]. 4. Ensure reduction of moisture content (sun drying, roasting, boiling)[5] 5. Replace winnowing baskets with blowers or automatic separators [4] 6. 6. Develop a process of soaking with the husked seed to facilitate decortication[7,8]	[1](Adams, 2015), [2](Abdul-mumeen et al., 2019), [3](Hyman, 1991). [4](Alonge & Olaniyan, 2007), [5](Schreckemberg, 2004), [6](Mensah, 2010), [7](Bup et al., 2011), [8] (Gezahegn et al., 2016b)
Drying	Drying the bare seeds to reduce their moisture content.	• Slow process (about 10 days), weather dependent [1]. • Poor drying methods, leading to fungal infestation, blackening and fermentation [2,3].	1. Washing the seeds after de-husking. 2. Implement drying measures that replace solar drying. 3. Do not develop smoking processes [4] 4. Development of a boiling process (95-120 ', 75-90ºC, 40-45mm nut size)[5,6] 5. Application of ovens[1], stoves[7] or solar dryers[8] (the latter not highly recommended [4,9]).	[1] (Abdul-mumeen et al., 2019), [2](Tano-Debrah & Ohta, 1994), [3](Mensah, 2010), [4](Masters, 2002b), [5](Bup et al., 2012), [6](Womeni et al., 2006), [7](Hyman, 1991), [8](Alonge & Olaniyan, 2007), [9](Bup et al., 2011).
Sorting	Selection of those seeds that have the optimal properties to achieve a quality product.	• It is a very slow and tiring process due to the large amount of seeds to check. • Storage or processing of infested seeds. • Processing of damaged, blackened or fermented seeds that decrease the quality of the product.	1. It is recommended to develop a progressive sorting after each one of the processing steps. 2. Sorting during harvesting, another prior to drying and another previous to storage is essential.	
Storage	Seed storage after all pre-treatments until extraction is continued.	• Storage of infested, damaged or fermented seeds. • Storage in humid conditions. • Use of materials that do not allow perspiration or damage the product. • Prolonged storage.	1. After a good pre-treatment process, do not exceed 2 years of storage [1,2] 2. Change the use of polyurethane bags for jute sacks [3] 3. Store in a cool, dry place, out of the reach of light [3] 4. Keep the seeds high off the ground (> 25cm)[3]	[1](Schreckemberg, 2004) [2](Bup et al., 2011), [3](Masters, 2002b).

Process	Description	Problems	Recommendations	References
Pounding and Milling	Process of transformation of the whole kernels into a fine paste by crushing.	• Slow and very tiring process. • Loss of part of the product. • Low extraction rates. • Affection of the composition of the kernels due to a lack of standardization of the ideal conditions for the processes.	1. Change the use of mallets or stones by grinders (pounding) and mills (milling)[1] 2. Maintain the temperature of the paste at about 40ºC to avoid solidification[2] 3. Perform a friture process after pounding to improve extraction (6-8 ', 140-150ºC, 2-6mm of particle [3]) 4. Use of toasters to facilitate the process [4] 5. Achieve particle size between 0.5 and 1mm [5] 6. Ideally use of more industrial machinery such as oil expellers[6], hydraulic presses[5], centrifuges [7] or manual presses[1] 7. Mechanisms for standardization of mechanized processes [8,9,10] 8. Study and application of enzymatic mechanisms [11,12] 9. Chemical processing is not recommended despite its efficiency, due to its risk of damage to health and the environment [13]	[1](Masters, 2002b), [2](Alonge & Olaniyan, 2007), [3](Womeni et al., 2006), [4](Schreckemberg, 2004), [5](Yé et al., 2007), [6](Gezahegn et al., 2016b), [7](Coulibaly et al., 2009), [8](Gezahegn et al., 2016a), [9](Yé et al., 2007), [10](Nikiema & Umali, 2007), [11](Tano-Debrah & Ohta, 1994), [12](Mensah, 2010), [13](Ajala et al., 2019).
Fat extraction	Separation of the fat from the rest of the components by means of a kneading process with cold and hot water that produces emulsification. After this, it is cleaned with water, boiled dehydrated, decanted, filtered and let to do recrystallization, obtaining the raw shea butter.	• Slow and very tiring process. • Low extraction rates. • High moisture content. • Alteration of properties and composition. • Presence of impurities.	1. Development of the process by workers with practice, who control the proportions of water and the speed of kneading [1,2] 2. Use of automatic mixers [3] 3. Developing dehydration by boiling for 20 ' [3] 4. Use filters between 1 and 10 microns[4,5] 5. Develop a new boil between 10 and 20 'after filtering [3] 6. Continuously and gently stir oil as it solidifies [6] 7. Adding antioxidants to butter from rosemary extract and white tea extract[7] 8. Work along a university or laboratory that can carry out a study of the composition of the butter produced, so that the process can be optimized if it is not suitable[8] 9. Work in groups to avoid exhaustion[9]	[1](Schreckemberg, 2004), [2](Abdul-mumeen et al., 2019), [3](Masters, 2002b), [4](Lovett, 2010), [5](Mensah, 2010) [6](Lovett, 2013), [7](Nahm, 2011), [8](CBI, 2019) [9](Naughton et al., 2017a).
Refining, fractionation and Formulation,	Refining allows to obtain a product free of impurities and clarified. It consists of 4 steps: Degumming, neutralization, bleaching and deodorization. After this the fractionation can separate the different components and the formulation add new substances.	• Eliminates the naturalness of the product. • Affects the composition of butter[1,2]. • Use toxic substances [2]. • It requires a large investment and very specialized machinery. • They are developed almost exclusively outside Africa [3]	1. Elimination of chemicals harmful to the environment and health such as organic solvents. 2. Creation of a refining plant in West Africa [4] 3. Facilitate common work between individuals, cooperatives and centralized factories [4]	[1](Akingbala et al., 2007), [2](Schreckemberg, 2004), [3](Lovett, 2010), [4](Addaquay, 2004)

3.3.1. Storage and Packaging

Shea butter can vary greatly in composition and properties if the materials and storage conditions suitable for it are not chosen. Although the optimum would be to sell the butter shortly after producing it, many sellers prefer to wait, looking for a better time to sell, to sell it when they are short of money or to improve the quality of the product (Mensah, 2010).

Among the different options that are usually available and depending on principal characteristics needed table 5 compiles the best packaging options.

Table 4. Analysis of the properties provided by the 4 main packaging materials (Glass, ceramics, plastic and calabashes), attributing a position to each of them based on their suitability (being 1st position given to the best of those materials for that specific property). Source: own elaboration.

	Material availability	Attractiveness	High temperature resistance (sterilization)	Hermetic seal	Shock resistance	Compression resistance	UV Protection	Reusability	Cheapness	Transportability
Glass	3rd	1st	1st	1st	3rd	2nd	4th	1st	4th	2nd
Ceramics	2nd	2nd	2nd	3rd	4th	1st	1st	2nd	2nd	4th
Plastic	4th	4th	4th *(except propylene)	2nd	1st	4th	3rd	3rd *(except propylene)	3rd	1st
Calabashes	1st	3rd	3rd	4th	2nd	3rd	2nd	3rd	1st	3rd

It may be especially interesting to invest in high-quality containers that can then be returned to the cooperative or the producers. This type of initiatives, together with some type of incentive or marketing strategy that benefits customers by returning the container, can be a great solution. Sellers should know that they can seek information on the best packaging, storage and transport options from NGOs, governments or shea associations.

3.3.2. Energy and resources. Environmental effect of the process

We can differentiate between the resources themselves: firewood, fuel, water or electricity and human effort. The main sources of contamination and energy and material expenditure are those that require the production of combustion. Therefore, the phases that include par-boiling, boiling or toasting processes. During the extraction process 48 Kg of firewood and 67 liters of

water are required for each 18.5 Kg of butter produced (Addaquay, 2004). Glew & Lovett, (2014) determined that in the production of 1 kg of butter for cosmetic products, 10,374 kg of CO2 were emitted.

Parklands are ecologically sustainable sources of materials, based on a non-intensive type of cultivation or semi-cultivation, which does not require major changes or actions on the land, without the need of fertilizers, large amounts of water or effects on the ecosystem (Naughton et al., 2017b).

Continuously breathing of toxic substances produced by the fire, especially when complete combustions do not occur are very dangerous for workers. The best option is the use of stoves or ovens, which greatly increase the efficiency of the process (Masters, 2002b)(Adams, 2015). They reduce the fuel used by 47% and the emissions emitted by 70%, reducing human toxicity by 83% (Naughton et al., 2017b). Also firewood should be of good quality and completely dry and well stored (Adams, 2015).

Centralization of the process brings great advantages in the efficiency of the use of time, effort and reduction of emissions. The benefit is up to 33% higher and required 54% less energy (Adams, 2015).

The education of women in good measures, ways to save time and energy, use and maintenance of machines and, in general, the trend towards their professionalization, is positioned as one of the market priorities (Bello-Bravo et al., 2015).

3.4. Shea Butter Market Opportunities

Achieving a progressive empowerment of women, mainly through education, economic independence and the imposition of much stricter government laws regarding gender violence (Chen, 2017). The presence of a powerful feminist collective (at least by region), presenting a single voice of women's opinion, would be of vital importance for their empowerment (Chen, 2017).

Presence of financial credits is vital on many occasions. They can be a result of the help of organizations and government financing, which allow to boost their businesses and which in a high percentage are fully returned (Masters, 2002a) (The Shea project, 2012).

One of the main market opportunities is certificate obtention, such as fair market or ecological production. These certificates add extra value to the product, achieving much higher prices for all suppliers. The existence of principles of transparency and traceability is essential (Masters et al., 2004).

The constant study of different processing methods, different machinery, extraction forms, drying and storage techniques, are the main driver towards improvements in the quality of the product and the working conditions of women (Yé et al., 2007).

Emergence of women's cooperatives seek to improve their working conditions, reducing their economic insecurity through the collaborative economy, risks sharing, and time and quality optimizing. At the same time they diversify the offer, reach new markets, stabilize their income by not depending on a single product and make more profitable the raw material and their effort (Bello-Bravo et al., 2015). However they must focus in some points:

- Achieve a correct structuring and organization of the corporation. Leaders must be elected by vote, placing special emphasis on the presence of women in positions of control. The cooperative must be an independent and autonomous entity in its decision, with the aim of achieving the maximum well-being of all its components and defending their labour rights against external agents (Masters, 2002a).
- Training in optimization practices, education and information for women producers, would be a common benefit for the industry (Pouliot & Elias, 2013). It is necessary to inform women about quality standards, packaging possibilities, optimization methodologies for processing, negotiation tools, (Bello-Bravo et al., 2015), and also how to use their money, financial management, investment and savings (The Shea project, 2012). Associations must act as nerve centres and contact networks for women, among themselves and with the outside world (Bello-Bravo et al., 2015).
- The poorest women are in great need of immediate income, so they sell the seeds as soon as they get them, preventing them from associating. If that critical point is alleviated with initial help, then women can associate and achieve a higher situation of stability. However, total autonomy and self-sustainability must be pursued (Masters, 2002a).

- Corporate networks and periodic conferences are essential for the standardization of the product in search of equity and fair trade, and the sharing of knowledge, confronting common problems, conflict resolution, etc. (Badini et al., 2011).
- Cooperatives could offer a great advantage in purchase of machines, to achieve a certain centralization of the process (Adams, 2015)(Addaquay, 2004). It would also be a great help if women had access to their own storage points and transportation methods, which would eliminate great dependence on intermediaries.
- Social activities must be stimulated by the federation, health insurance, adult literacy programmes and education. Creating buffer strategies for low-yield or low harvest seasons, such as generating financial funds or storing raw materials, can be of great help to members in difficult times (Kavaarpuo, 2010). They also attract and unite (The Shea project, 2012).

All the economic benefits reported back to households conclude in improvements in the general living conditions of all citizens, reaching better educational system, access to potable drinking, electricity, food security, creation of infrastructures, medical improvements, etc.

4. Conclusions

The shea market is currently in an extremely complex situation due to economic, social, geographic and environmental factors. Despite this, the economic opportunities offered by exploiting the tree are enormous and increasing progressively. Looking for the optimization of the process based on the principles established by the CE, a completely improved position can be reached for the workers and for the sector.

It is necessary to focus on three main work lines: education of the population, application of effective legislation and financing opportunities. From them, more beneficial and fair market conditions for women workers can be achieved, based on social equity. Tendency to apply more efficient methodologies that respect product quality, the progressive mechanization of the sector and the promotion of new lines of research would be also improved. All this included in a framework of environmental sustainability and stimulation of the conservation of natural

resources. Among all the opportunities to achieve these goals, the creation of centralized cooperatives where women carry out the entire process of production of shea butter stands out.

5. Bibliography

This bibliographic review has involved consulting a large number of scientific articles and books, with the aim of gathering useful information for each of the sections. Within these articles we have a small number of main articles that would make up the “Main Bibliography”, frequently cited and essential for structuring much of the work. On the other hand we would have the "Complementary Bibliography"; articles that have been used occasionally to obtain a specific data or idea.

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Appendix and Annex

Appendix A. Recommended planting conditions.

The kernels have a fairly short viability and should not be dried. The best sowing conditions to achieve germination would be with fresh kernel, with an ambient temperature of between 25 and 30ºC, at a depth of 1-5 cm, with a distance between them of 20x15 cm. They must be transplanted 1 year after germination, and can be placed directly in the field. Its development has also been achieved in polypropylene bags, in which they can develop for 3 years before being transplanted. On some occasions, some success has been achieved through the use of grafts, especially with growth hormones or biozymes (Kavaarpuo, 2010).

For field planting it depends on the cultivation objective pursued, ranging from 25 trees per hectare (20m x 20m), to 100 (10m x 10m). Techniques such as mulching or weed removal improve kernel growth, which must also be protected from trampling, livestock and fire. Also the application of manure, fertilizer (for 10 individuals it is recommended: 2.5 kg of ammonium sulphate, 1.5 kg of calcium phosphate and 1.5 kg of potassium chloride) and the elimination of dead or diseased trees improves productivity. Grouped cultivation in clusters is recommended for the generation of beneficial microclimates for production (not only for trees but also for the benefit of other crops such as corn), a phenomenon that occurs with natural kernel dispersal (Zomboudré et al., 2005) and to achieve better soils conditions in infiltration, fertilization and biodiversity (Seghieri, 2019). It has also been observed that, in protected areas, a greater number of juvenile individuals develops, aggregated on a small scale and in interaction with adult individuals, something that does not occur in crops, where only the best adult individuals are maintained, which can affect the long-term conservation of the species (Djossa et al., 2008).

Annex A. Morphological description of *Vitellaria paradoxa* (only species of the genus *Vitellaria*). Source: (Gaertn, 2018)(Nikiema & Umali, 2007).

- Deciduous tree.
- Average height between 10 and 25 meters.
- Bole:
    - Short 3- 4 meters up to 1 meter in diameter.
    - Barky. Blackish, greyish or reddish colour, very fissured. Produces white latex when cut.
- Branches:
    - Pubescent and reddish when young.
    - Glabrous once developed
- Crown:
    - Round to spindle-, umbrella- or broom-shaped

- Roots:
  - Taproot: 1-2 meters.
  - Secondary roots shallow (maximum as the taproot), concentrated at 10 cm depth and laterally up to 20 meters.
- Leaves:
  - Shape: Lanceolate to ovate-oblong.
  - Size: 10–25 cm × 4–14 cm.
  - Simple and spirally structured, generally concentrated at the tip of the branches.
  - Petiolated (3-10 cm).
  - Stipules small and caducous.
  - Base: cuneate to rounded, or slightly cordate.
  - Apex rounded to acute.
  - Margins entire to wavy.
  - Glabrescent to slightly hairy at both surfaces.
  - Pinnately veined with regularly and closely spaced veins.
- Inflorescences:
  - Grouped in dense fascicles.
  - Bisexual flowers.
  - White to creamy colour.
  - Pedicel up to 3 cm long.
  - Fragrant.
  - Sepals free, in 2 whorls of 3–4, 1–1.5 cm long.
  - Corolla with short tube and 6–8 lobes about as long as sepals
  - Stamens 6–8, inserted at top of corolla tube, free.
  - Ovary superior, globose to ovoid, pubescent.
  - Style long and slender
- Fruit:
  - Globose to ellipsoid berry 4–5 cm × 2.5–5 cm, weight 20–30g.
  - Initially green but turning yellowish green or brown on maturity. About 5–8 cm in circumference
  - The fruit has a butterlike, mucous pericarp covering an oval brown or light brown seed surrounded by a fragile shining shell with a large hilum. 1(–2)-seeded.
- Seeds:
  - Globose or broadly ellipsoid, 3–5 cm × 2–3.5 cm, weight 8–10g.