



Cashew Byproduct Study:

Cashew apples and cashew shells

September 2010

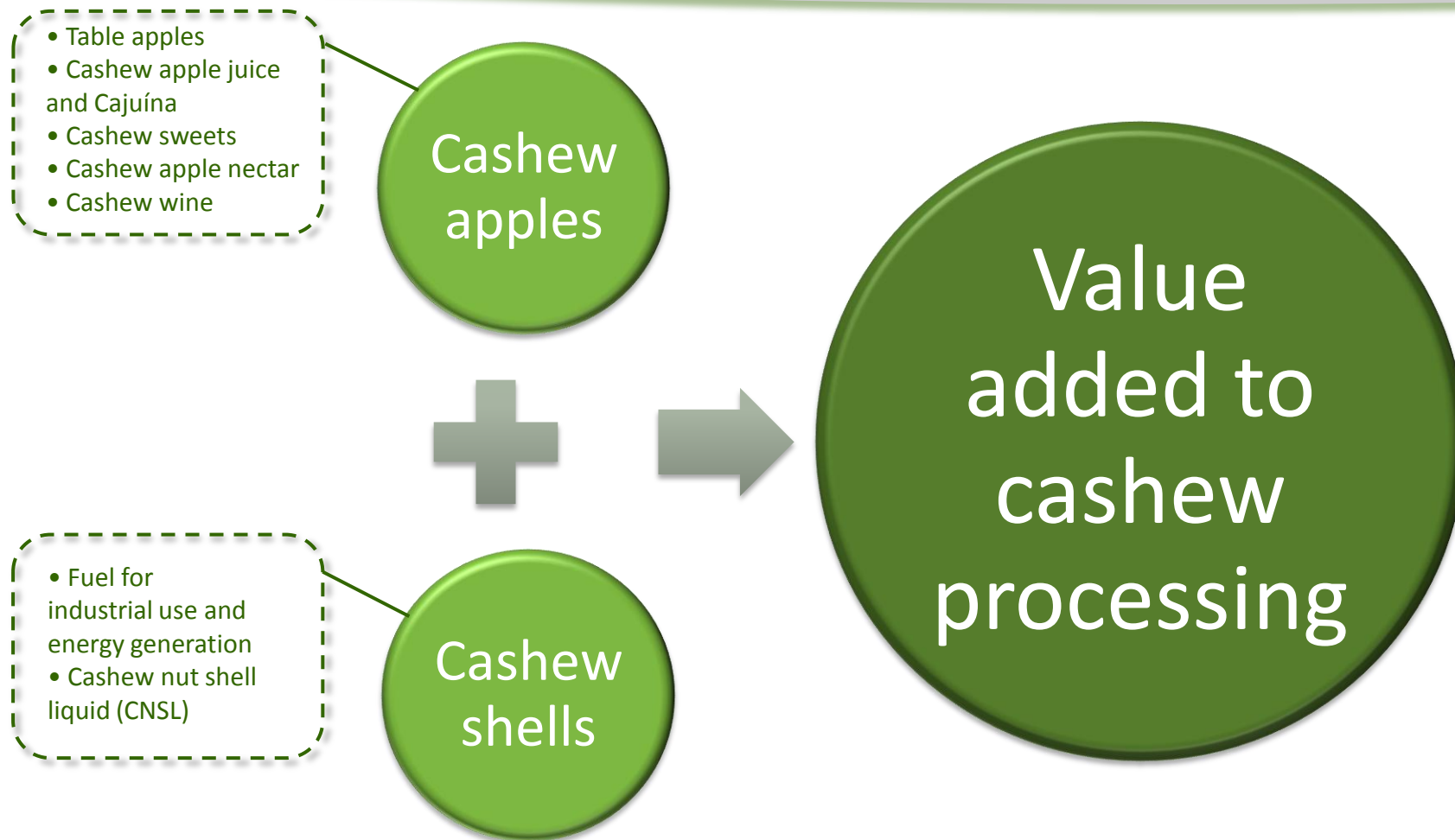


TechnoServe

BUSINESS SOLUTIONS TO POVERTY

- I. Objective of study and description of methodology and teams of implementers
- II. Country-specific reviews and industry potential in Burkina Faso, Ghana, Bénin, Mozambique and Côte d'Ivoire
- III. Areas for improvement in current practices and missed opportunities for adding value with cashew byproducts
- IV. Cashew apples and shell: pre-treatment procedure, overview of byproducts requiring additional processing with particular focus on cashew plum, sweets, fresh juices, and Cajuína from apple and CNSL, energy production from shell
- V. Selection criteria for determining suitable cashew byproducts for value addition
- VI. Five proposals for cashew byproduct value addition
 - I. Two-tiered processing of cashew apple juice would result in sustainable returns to the farmer
 - II. Establish a community-based integrated processing unit to produce cashew plum, cashew juice and Cajuína, cashew pulp, animal feed, and bio gas
 - III. Producing alcoholic beverages from cashew apples would be a highly profitable venture, though it requires a high initial investment
 - IV. Generating electricity from cashew shells and apples would require a substantial initial investment, but would ultimately be very low-cost
 - V. Extracting and refining CNSL is a repeatable strategy that would result in sustainable returns to the larger-scale processors
- VII. Next steps

This study aims to create three generic business plans for adding value to cashews through processing cashew apples and cashew shells, using Brazil as a source country



The project has two phases: (1) collecting information and identifying opportunities, and (2) devising business plans to capitalize on these opportunities.

Three teams from wide-ranging backgrounds working under Peter Keller and Shakti Pal of ACi conducted fieldwork and reviewed documents, blending global and local experience



1



- Composed of engineers from the United States
- Visited Ghana and Burkina Faso during the harvest season to meet cashew farmers and gain a better understanding of harvest procedures
- Evaluated community-based production of cashew apple juice
- Worked on low-emissions energy production using cashew shells

2



- Composed of TechnoServe staff from Mozambique
- Visited Brazil, the source country, to learn best practices for farming, processing, and marketing
- Provided recommendations for the West African adaptation of Brazilian technology for cashew apple processing

3



- Composed of TNS local staff from Ghana and Benin along with an independent consultant, Rakesh Gupta
- Analyzed options for value addition from cashew apples and CNSL
- Determined ideal products for current and future entrepreneurs in five countries
- Conducted studies on the cost of local transport, operations, etc.
- Gauged demand for a relatively new product

The potential by weight of cashew byproducts is significant, demonstrating the importance of this area as a focus for value addition



All ACi countries	Current production, broken down by country	Calculated by multiplying raw nut production by nine	Calculated by taking 70% of raw nut production
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	Raw nuts produced	Potential apple production	Potential shell production
Burkina Faso	25,000	225,000	17,500
Ghana	26,454	238,086	18,518
Mozambique	85,000	756,000	59,500
Bénin	98,938	890,442	69,257
Côte d'Ivoire	335,000	3,015,000	234,500

All values are given in tons

There are over one million in cashew cultivation in Mozambique with increasing numbers of small initiatives to process cashew byproducts



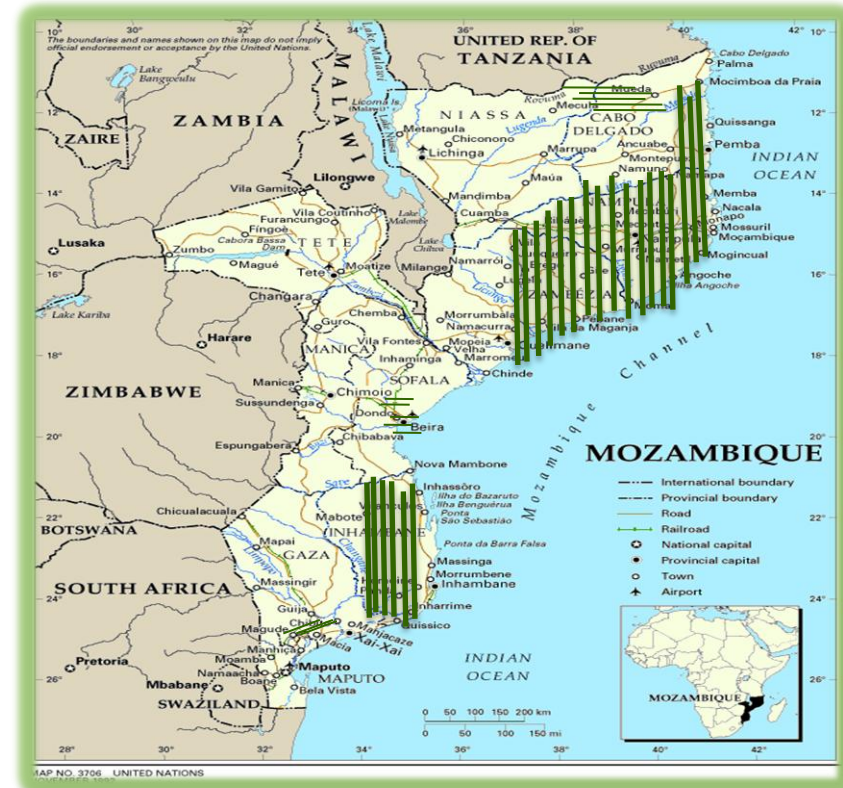
There are **over 23 processing plants** processing nearly 36,000 tons of raw nuts

There is only a limited use of cashew apples, with **ADPP** as the most active in their production of juice, Cajuína, and cashew plum, while also training local communities on the use of byproduct

Local producers use cashew apple in making local wines for local consumption. This is of low quality wine and most of the times dangerous to health

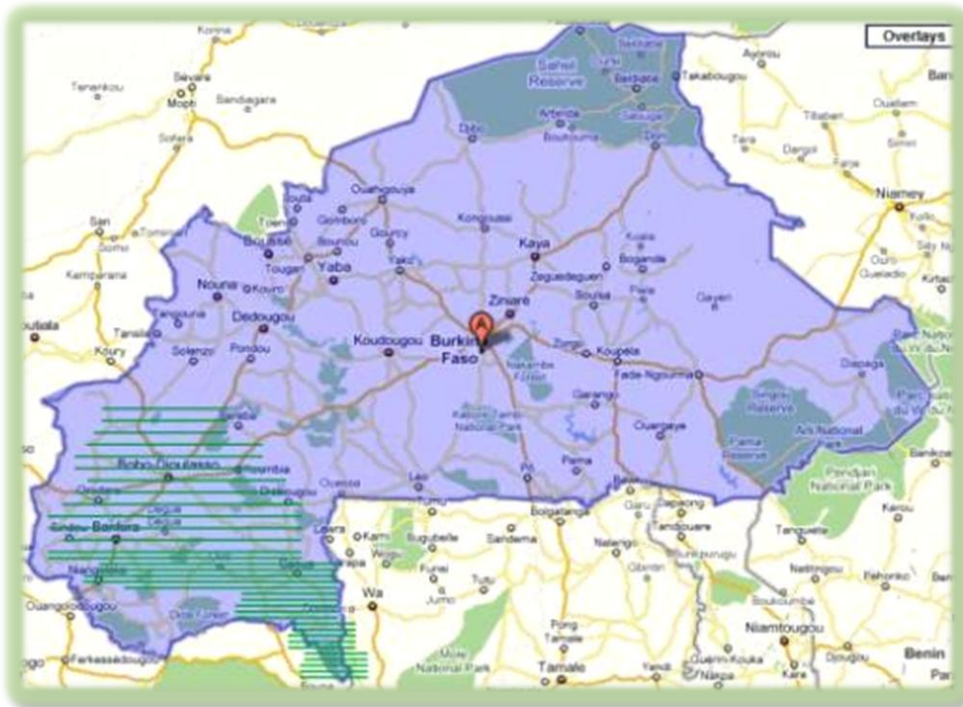
There is high potential for CNSL production as well as apple processing in **Nampula province** as a result of the high volume of shells and apples

There are **two current initiatives** for CNSL extraction in North



Mozambique has the most advanced cashew processing industry in Africa offers a good base to process Shell

Compared to farmers in the other countries under study, farmers in Burkina Faso are the poorest and thus stand to gain the most from opportunities for value addition



The high cost of energy and communication in Burkina Faso is a major obstacle to growth

There are two large cashew processors: **Sortia-B SARL in Banfora** and **ANATRANS in Bobo**

Burkina Faso currently has **no cashew apple processors**, though there is a large-scale and sophisticated **mango juice extraction and packing factory** near Bobo called Dafani

There is **high potential for cashew apple processing in Banfora**: farmers would extract the juice and then transfer it to a large juice factory for further processing, small qty of fresh juice can be sold for local markets , or process it locally for juice, Cajuína or cashew Plum for local markets

Sortia-B and ANATRANS are the two large size cashew processing facilities in the country, their annual capacity however is low, a detailed business plan is necessary to evaluate cost / benefit of **CNSL processing for CNSL and Energy production**

Though Ghana produces few of its own nuts, the country still has a relatively high supply of them due to shipments through its porous borders

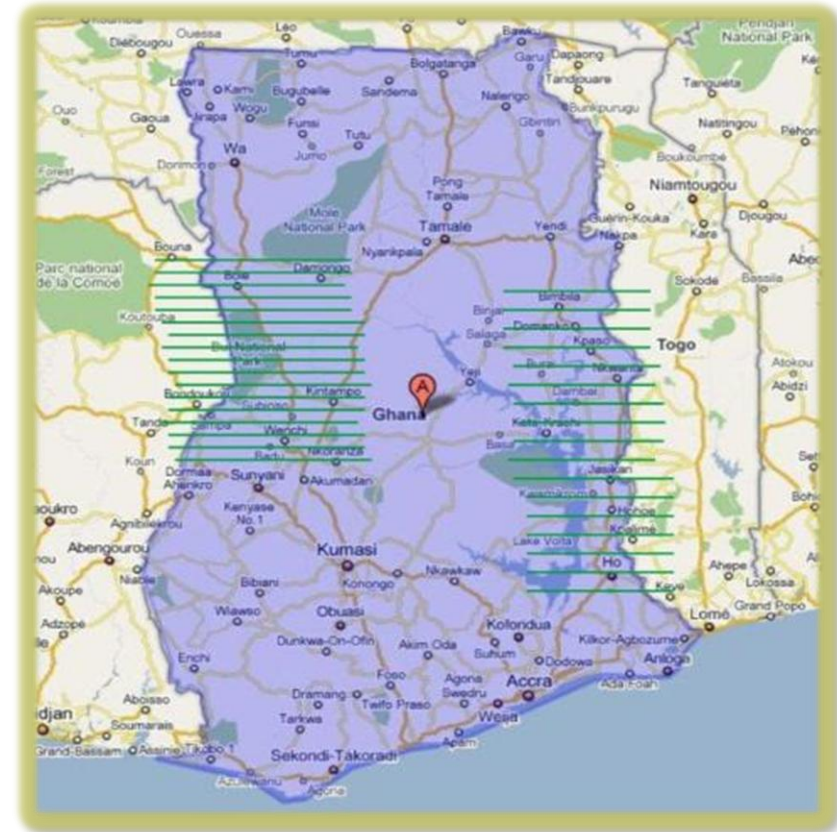
MIM, which opened this year, is one of the largest cashew processors in Ghana, few new are under construction/rehabilitation

MIM processes cashew apples for **alcoholic beverages** from its own 530 acres plantation

There are few organized plantations like **Damata farms** who can start processing of cashew apple targeting local markets

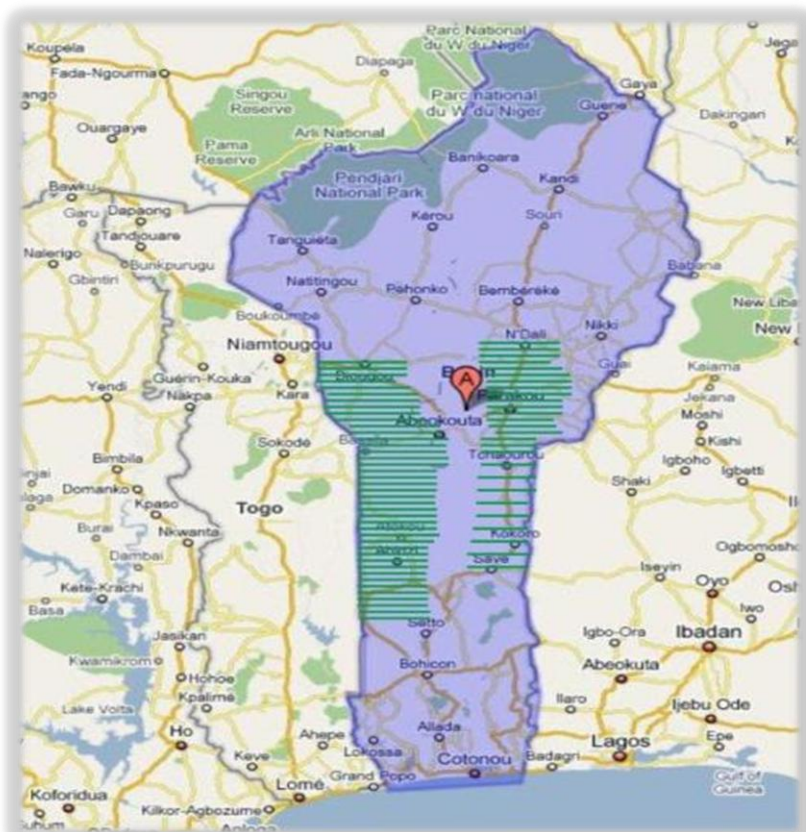
There is a small juice processor, **NATU Cashew Drink**, near Wenchi that produces juice, it sells domestically, though it faces marketing challenges related to sales volume. With a better technology quality and shelf life can be improved which is a big hurdle in marketing

In cooperation with the processing plants expected to open soon, Ghana will have **sufficient capacity for viable extraction of CNSL near MIM**



Farmers showed interest in small-scale cashew apple processing for juice if provided with technological and marketing support

Bénin is a small country that produces very high-quality nuts, an outgrowth of well-managed procedures for cashew growth and cultivation



Bénin is a well-organized country with good infrastructure and a motivated and progressive business community

Afokantan is the largest processor in Bénin

A women's cooperative near Savé currently produces 80 kg of cashew apples each day, representing about **30% of total production**, to extract cashew apple juice, which they pack in recycled beer bottles and sell locally

No other product is made from cashew apples at present

Central West of Bénin have a good dense production of cashew apple with a relatively good infrastructure offers a good potential for apple use

There are a number of new processors and several more are likely to begin operations in the near-future, giving Bénin sufficient combined capacity for CNSL recovery and other byproduct processing

Côte d'Ivoire is the 3rd largest cashew producing country in the world with the production of cashew nuts: 350,000 tons annually



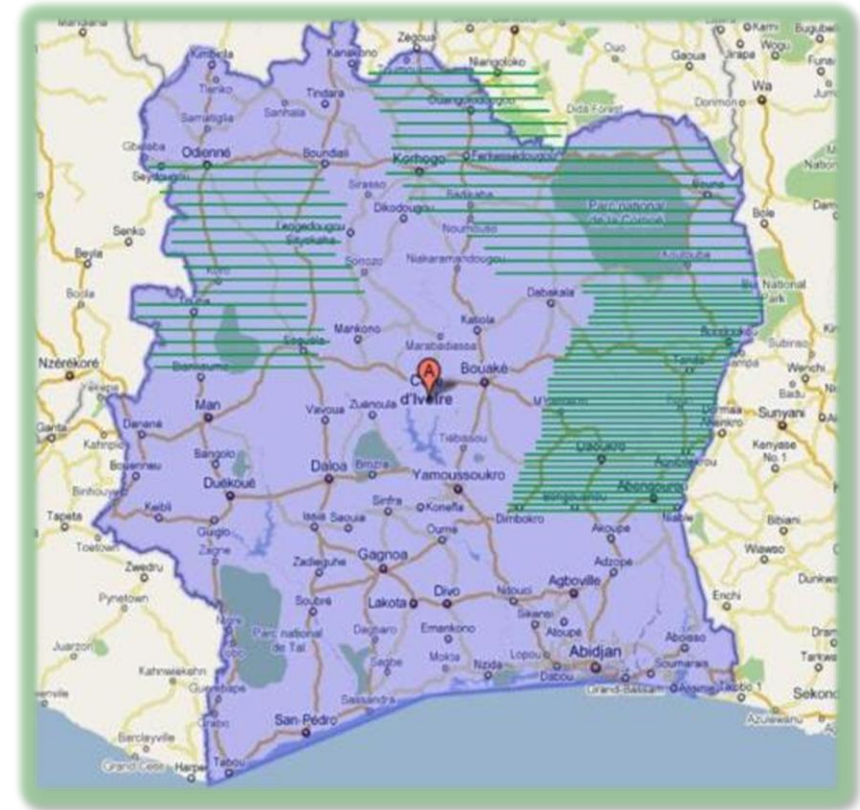
Ivoirian farmers are generally **wealthier than farmers elsewhere** because of the country's abundant natural resources—1.3 tons of cocoa and large quantities of palm oil and coffee—so **opportunities for small profits are not sufficient motivation**

OLAM, SITa, and Agri-Processing are the key players in cashew processing

Of these, **OLAM is the only one large enough** to begin CNSL processing and other value addition activities

The current scale of other processors is **still too limited** to pursue viable byproduct processing

Its **huge production of cashew apple** is an ideal base to set up a large ethanol production unit for energy substitution. **A detailed study** is required for **business planning** of this type of investments



Political and infrastructural problems slow progress in the sector, despite the country's high production rate

Current harvesting practices for cashew apples mean that most of them are left to rot on the ground, losing their ability to add value

Current practices in Africa

Apart from a small percentage of apples used for animal feed or juice production at the community level, almost all apples go to waste

Lack of awareness and know-how about proper harvest and post-harvest procedures

Traditionally, only the nut is thought to be valuable

Current practices in Brazil

Almost 15% of apples are used for a variety of value-added products

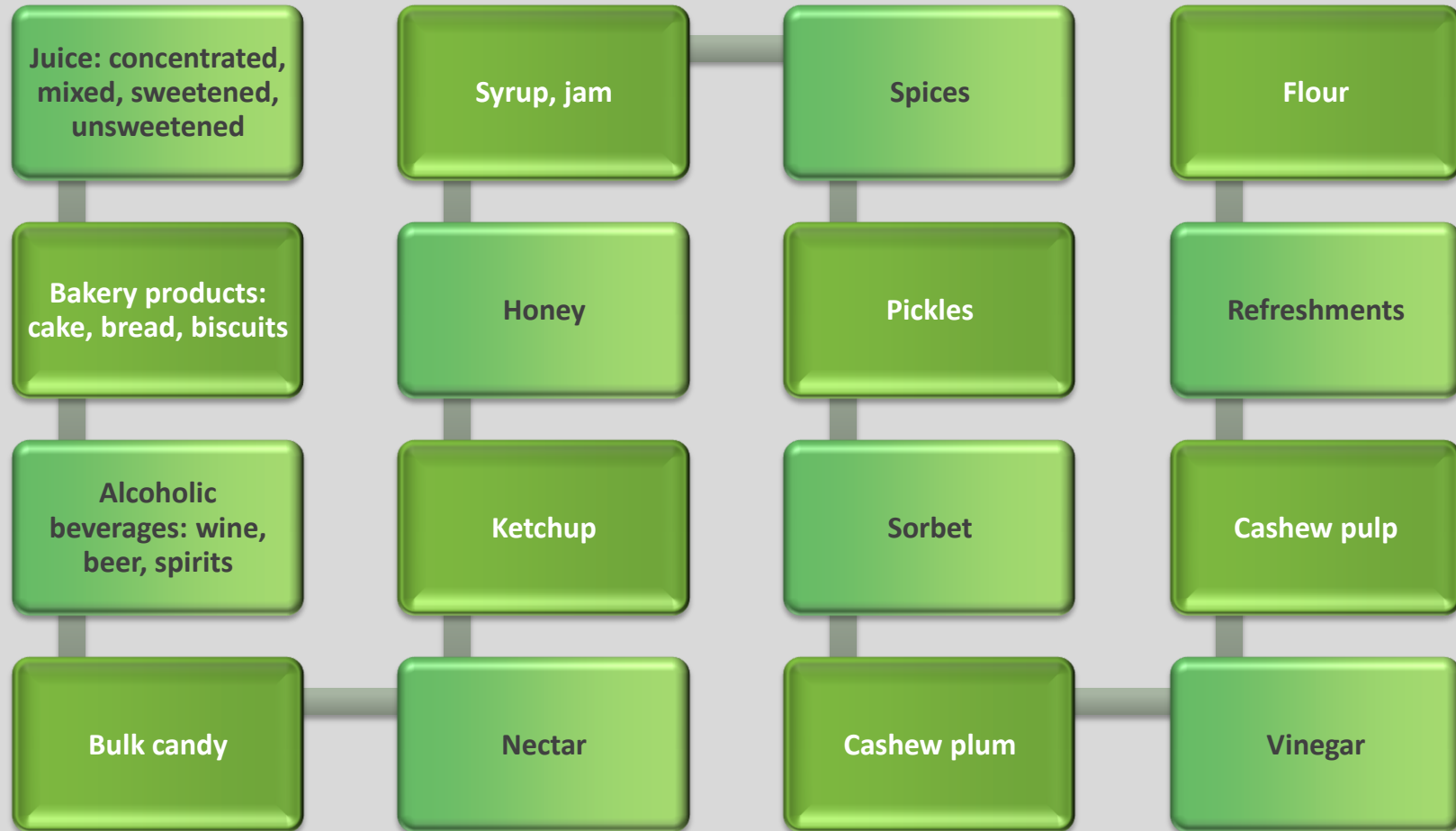
Clear procedures for post-harvest handling

Cashew apple juice and its blends are some of the most well-known products in Brazil



Training farmers on better collection methods and establishing micro processing centers close to plantations may help address these problems

Correct post-harvest handling, transportation, and storage are essential for improving and increasing processing of a wide range of cashew apple byproducts



Derivatives of cashew apples can be **juice-based** or **pulp-based**

Cashew shells contain a toxic acid—cashew nut shell liquid, or CNSL—which adds to the difficulty of kernel processing, but provides opportunities for adding value

CNSL is used as an additive in many **industrial applications**

- Phenolic resin
- Medication for leprosy, psoriasis, and ringworm
- Brake lining powder
- Paint, varnish
- Insecticide

Cashew shells, which have a high calorific value, can be used as **fuel**

- Shell cake could serve as a coal substitute if compressed
- Can be sold as an industrial fuel if produced in large quantities
- Replacing coal would reduce deforestation

Cashew shells have a **long shelf life**, facilitating further processing

Cashew shells are a **byproduct of cashew kernel processing**, so because the shells are already in the same place, there is **no initial transportation cost**



Typical storage procedures for cashew shells—which contain a toxic acid—result in conditions that are potentially hazardous to the environment



CNSL seeps into the ground after rains

The acid causes all existing trees to die and renders the soil unfit for producing new trees for many years

The shells are highly flammable, potentially resulting in fires that are difficult to contain

The controlled fires that many processors routinely set are a major cause of wild bush fires and environmental pollution like dense, heavy smoke

Firing the shells directly produces high heat, reducing the life of nearby equipment because of the rapid release of energy

Upon harvesting, reserve the best apples as table fruit and discard the remaining apples or send them for further processing on the same day

Proper post-harvest procedure for table apples



Arrival at working area

Washing and cleaning

Drying

Selection and classification

Packing

Palletization

Pre-cooling

Warehousing



Table Cashew Apple processing steps are simple



Separate good apples (In appearance, complete skin etc) from all other type of apples at the field level, marking them table apples and bring them for washing. Wash all brought in apples by plain water followed by 10 ppm chlorinated water and then again two washes of plain water for rinsing.

Following the wash, fruits should be allowed to rest for a while and natural air should be circulated for drying, Avoid use of hot air.

Second round of selection is done in this step, all apples which are bad in color, smell, skin etc are removed and sent for industrial usage. The classification is based on the number of apples per tray ranging usually four to eight, and the larger ones are most sought by the consumer and, therefore, finds the best price. Apples should be placed in trays with 14 cm x 21cm in size which will be covered with plastic film (PVC flexible and self-adhesive).

Use of packing film results in the change of atmosphere around the apple, reducing the respiratory activity and development of fungi, prolonging life, provided that a minimum temperature is maintained. The trays, properly labelled, shall be packed in cardboard boxes, without lids, which will form pallets.

Two sizes can be used for palletizing and loading into vehicles A) 0.92 x 1.12 m to 200 boxes, or B) 0.92 x 0.92 m to 160 boxes. The arrangement of boxes in pallet is made of arrays of eight or ten boxes, each pallet has a height corresponding to 20 boxes. For loading, the pallets are placed two by two, totalling twelve or fourteen, depending on the size of the vehicle. The first two pallets, located near the evaporators of the vehicle should be at only ten boxes.

Pre-cooling should be carried out after palletizing and loading, for this purpose, Pls arrange the pallets in two rows, 80 cm apart from each other, which are placed against the wall, seal up the space on pallets and operate fans throwing cold air at high speed within and between boxes.

This system allows you to make the cooling of the packaged product, which reduces moisture loss. The stalk of the cashew apple is highly perishable when stored at room temperature. Under this situation, life of apple after the harvest does not exceed 48 hours. After this period, the stalk becomes a wrinkled, ferments and consequently loses its attractiveness.

However, properly packed (Modified atmosphere) and stored under appropriate conditions (under refrigeration at 5 ° C and 85-90% relative humidity) the minimum life cashew is around ten to fifteen days, without showing damage by cold.

Any additional processing on a community level will require the following six steps for pre-treatment, keeping in mind the necessity of proper hygiene throughout

- 1 Collect the apples, can be directly collected from the tree once its matured ensuring that they are taken as soon as possible after they have fallen to the ground to avoid fermentation.
- 2 Remove the nut from the fruit using a nylon string, so that no fruit remains attached to the nut. Any fruit left will affect the quality of the nut.
- 3 Transport the apples to a processing facility and weigh them upon arrival.
- 4 Wash the apples in clean, room temperature water to remove any larger impurities.
- 5 Separate the apples depending on the byproduct for which they will be used.
- 6 Wash the apples again in room temperature water containing 10 ppm of chlorine in order to clear microorganisms.



Cashew juice, Cajuina, cashew nectar, and cashew wine can be produced with some additional processing



Cashew juice is bottled using hot fill technology



Producing cashew wine can be very lucrative

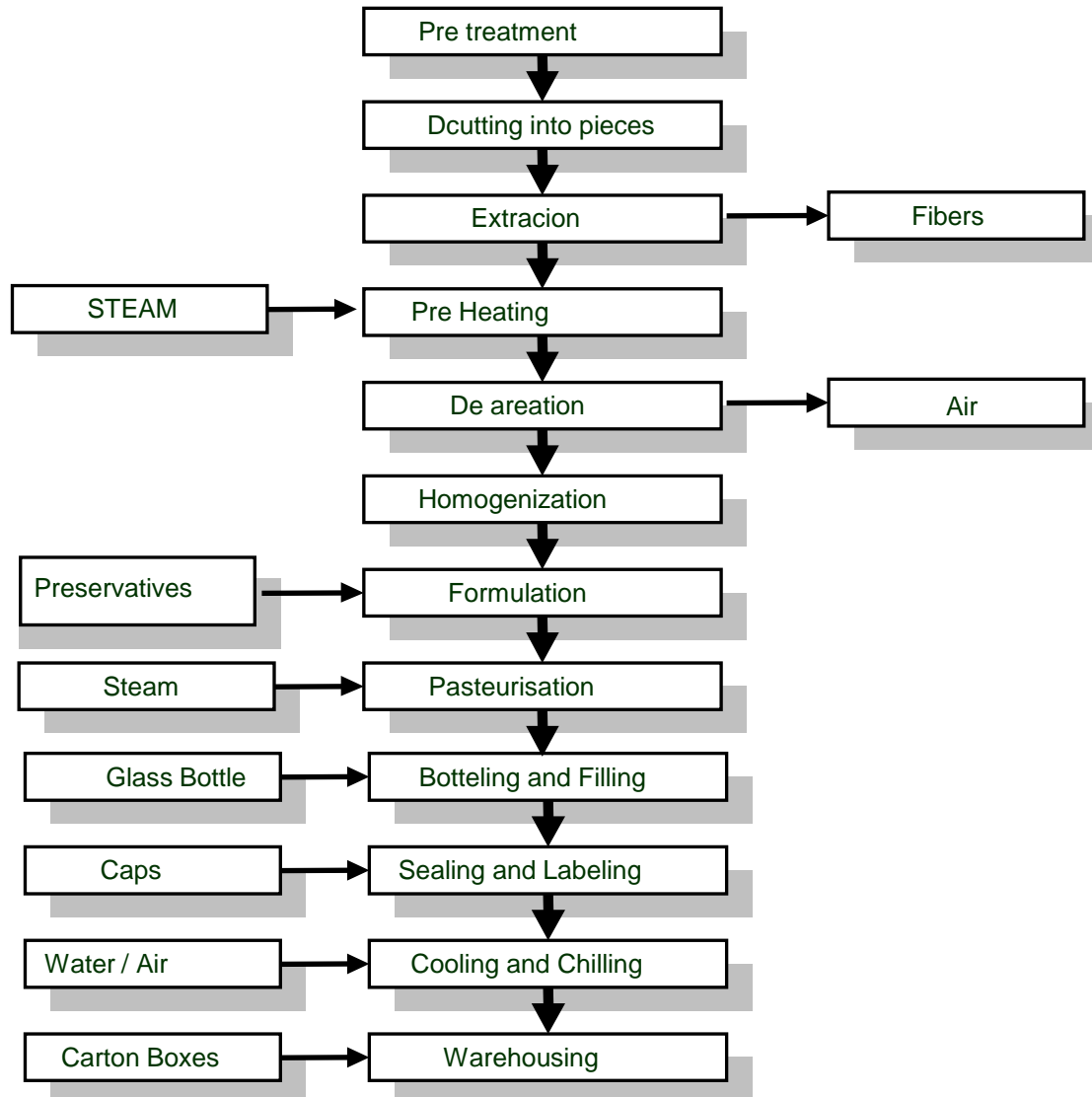
Cashew apple nectar is a well-known beverage in Brazil



Cajuina, a famous drink in Brazil

Though cashew apples are only available for two months, they can be processed into pulp to meet market demand throughout the year

Cashew apple juice manufacturing process through Hot Fill Technology



Cashew apple juice - Process Description



Cutting and Squeezing Here apples are crushed in a machine for extraction of pulp and juice.

Extraction is done in a helical type Expeller, where the fibre and residue are pressed against a stainless steel screen to remove the residual juice which also contains pulp. Typical yield at this operation is 65% -70%.

Pre- Heating is carried out at a temperature of 60 Deg C for 2-3 minutes, aiming to inactivate enzymes, to improve the colour of the juice and remove any air.

De-aeration is to minimize the dissolved oxygen content in the juice. This operation is performed by a simple equipment, which, by reducing the oxygen in the juice, prevents of oxidation of vitamin C.

Homogenization Operation which aims to reduce the size of particles and to make a uniform mixture of solids and liquids.

Formulation After the juice extraction, it is important to adjust certain physical and chemical characteristics (pH, pulp, etc.), which is done through the addition of acids and preservatives. Some common preservatives are sodium benzoate and sodium meta-bi-sulfite in quantities defined by local law.

Heat Treatment Juice is Pasteurised in order to minimize microbiological and enzymatic activities. In the case of cashew juice, which has a pH around 4.2 to 4.4, it is recommended the addition of citric acid to lower the pH and ensure the effectiveness of pasteurization. The process is to raise the temperature to 85-90 o C for 15 seconds.

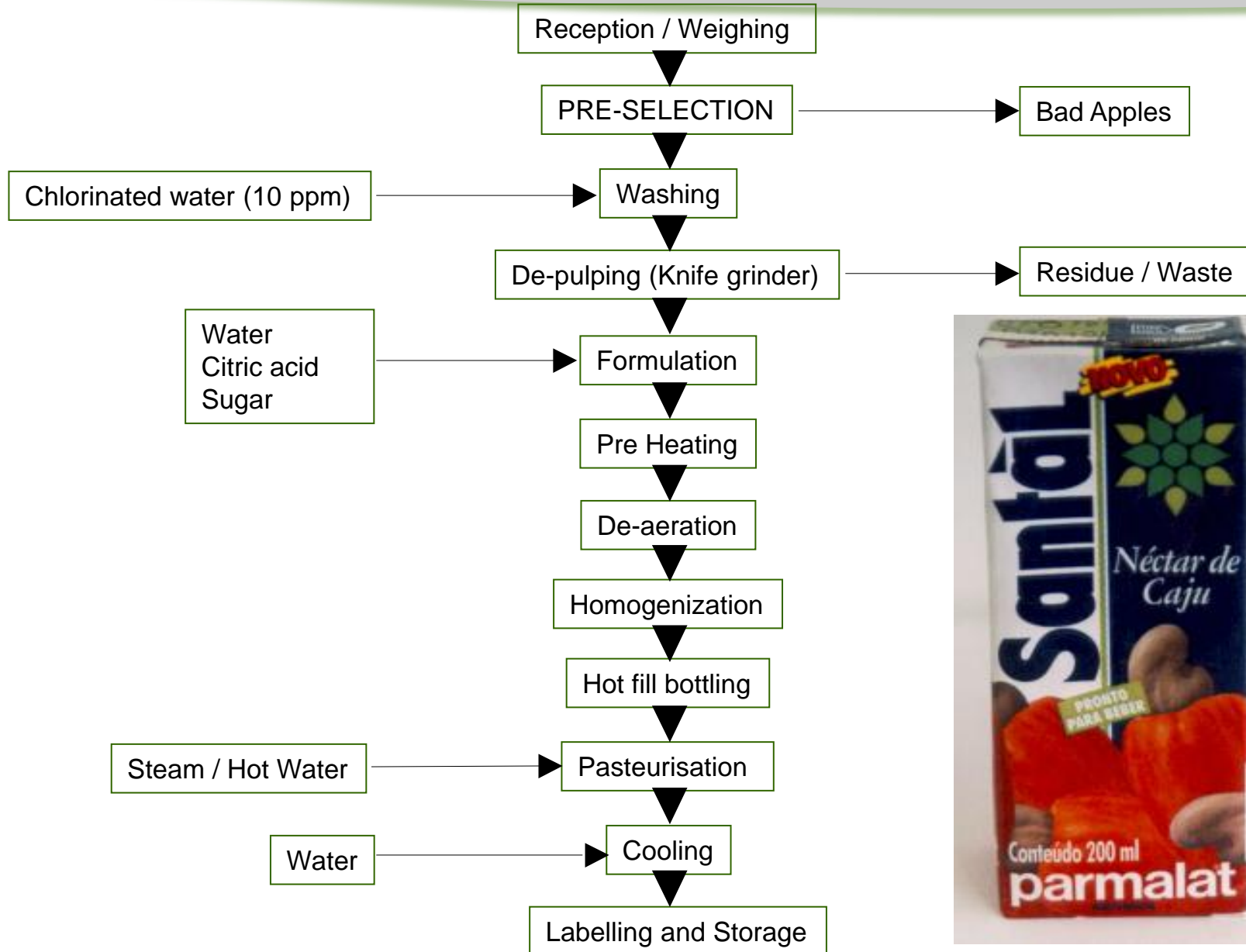
Filling The juice is packaged in 500 ml bottles, white or greenish-white. This is not aseptic filling, although the contamination is greatly reduced in this operation. Hot product is filled in pre sterilised bottles.

Closing Here pre sterilized crowns are fixed to the bottles manually while the product is still hot.

Cooling is done by placing these bottles in cold and clean drinking water. This is to avoid the over heating of juice and thus caramelization, change of colour, flavour and odour.

Storage The product is labelled and packaged in boxes of 12 or 24 units

Cashew Apple Nectar – a famous drink of Brazil Manufacturing Process



Caju Nectar is a non fermented, non aerated product for human consumption



Cutting and Squeezing by passing the apples through a ripper blade type grinder where the mass is disintegrated.

Extraction Held in helical extractor diffuse type "Expeller," where the fibres and waste is pressed against a metal screen, to remove the residual juice.

Formulation The addition of components to the pulp and acid syrup is made in tanks fitted with agitators and homogenizers in order to avoid addition of air to the product. For a uniform and standardized nectar, it is suggested that the product contains 14% soluble solids, 5% -7% of dry pulp and 7% -9% of total solids

Pre Heating Performed at a temperature of 60 o C for 2-3 minutes, in order to inactivate enzymes, to improve the colour of the juice and remove the air.

De-aeration Aims to remove air. It is performed on equipment operating under high vacuum, which is more efficient for products pre-heated at around 50 o C, and for less viscous products.

Homogenization Operation that aims to reduce the particle size of suspended solids, making a uniform mixture

Pasteurization In the pasteurization, the time / temperature is the function of the process that was previously submitted to pulp. The Pulp undergoes enzymatic inactivation at 80 Deg C for 20 seconds, or 85 C for 10 seconds. If the mass is enzymatically inactivated, pasteurization should be done at temperatures of 90-95 C for 30 seconds time.

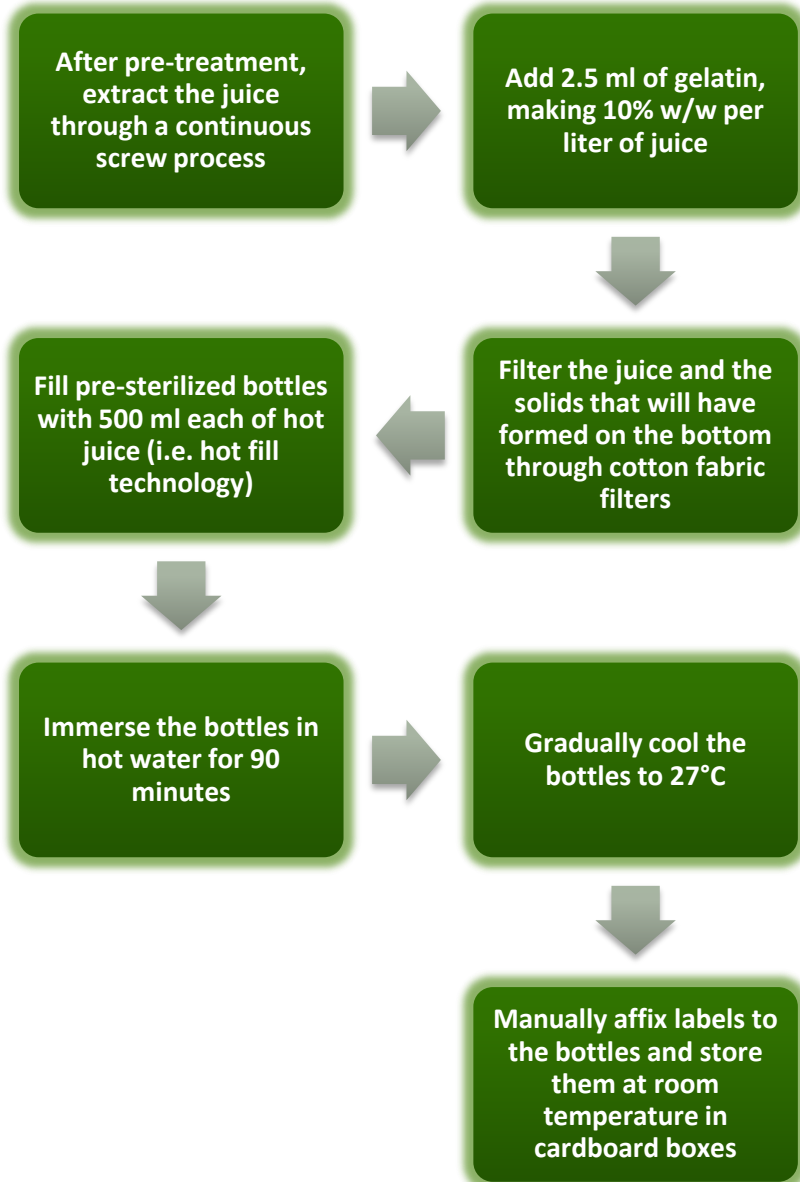
Cooling nectar is cooled by exchange of heat, until the temperature 23-25 o C in closed circuit by running water.

Aseptic Packing Aseptic filling is done mechanically without any human contact. The product is placed in hermetically sealed packaging system Tetrapack Machinery manufacturing packaging reels with 5,000 units 2,500 units or 200 ml.

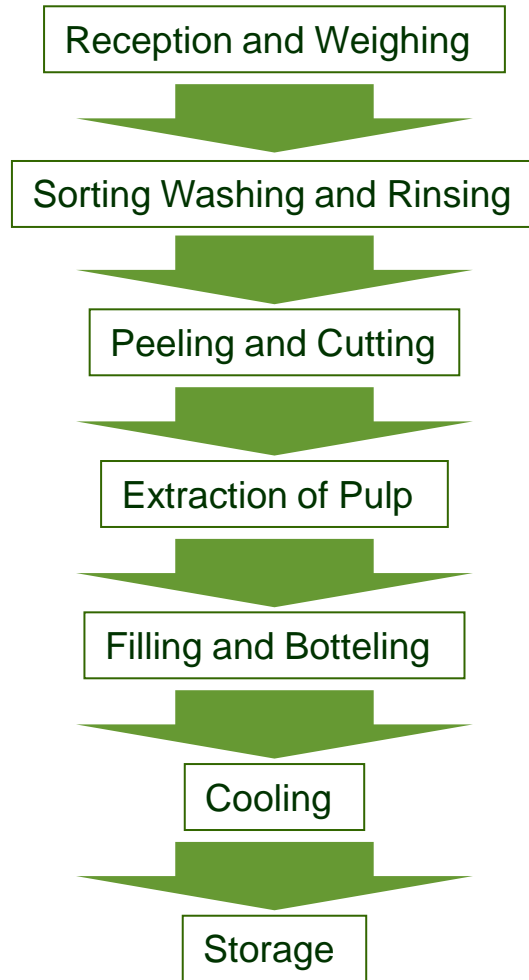
Closing The transaction closing is accomplished by packing equipment Tetrapack through a sealing longitudinal and transverse closure, so as not to allow free space.

Storage The product is stored in a cool, ventilated and packed in boxes of 24 units. It should be consumed within six months after the date of manufacture.

Producing Cajuína, best known of cashew apple byproducts, requires a seven-step process and, if made properly, can be stored for three to six months



Cashew pulp can be made to be utilized throughout the year to meet market demands, as cashew apple is available only 2 months in a year, flow chart for cashew pulp



Cashew Pulp

The freezing of fruit pulp is a method of conservation that preserves the characteristics of the fruit and allows its use in the periods between harvests.



Reception and weighing The fruit received in boxes, bags or in bulk should be weighed. During peak season, it may be necessary to store the fruits for some time, and, where possible, under refrigeration (5 ° C and 12 °C).

Sorting, washing and rinsing It is suggested to use properly matured fruit which does not have any apparent contamination, rotting, physical injuries such as broken skin and kneading etc. In that stage, good lighting is important in the environment. At the beginning of the cleaning process, pre-wash the fruit with water to remove most of the sand. After this stage, the fruit should be immersed in chlorinated water for 20-30 minutes, using a bleach solution in the proportion 1-2 tbsp for every 2 L of water, corresponding to approximately 50-100 ppm of free chlorine. The solution should be changed for every 400 or 500 kg of fruit. After immersion in chlorinated water, fruit should be rinsed with clean water to remove all traces of chlorine

Pulp It is the process used to extract the fruit pulp consisting of the materials like fibres, seeds and remnants of shells. The pulping should be preceded by grinding the material in blender or industrial disintegrator. The pulp should be collected in clean buckets (stainless steel or PVC) from the bottom of the equipment, and solid waste, ahead of it.

Packaging and bottling The extracted pulp is wrapped by hand in plastic bags. Common packing sizes are 100 mL or 1000 mL of Polyethylene. These Plastic bags are hot sealed after filling with a manual sealer and then moved to refrigeration

Refrigeration The mass should be kept frozen up to the time of consumption or further processing, The recommended temperature for storage, ranges from -18 °C to -22 °C. They can also be used domestic freezers.

It is important not to break the cold chain throughout the time distribution and sale of fruit pulp by their consumption, to ensure maintenance of product quality.

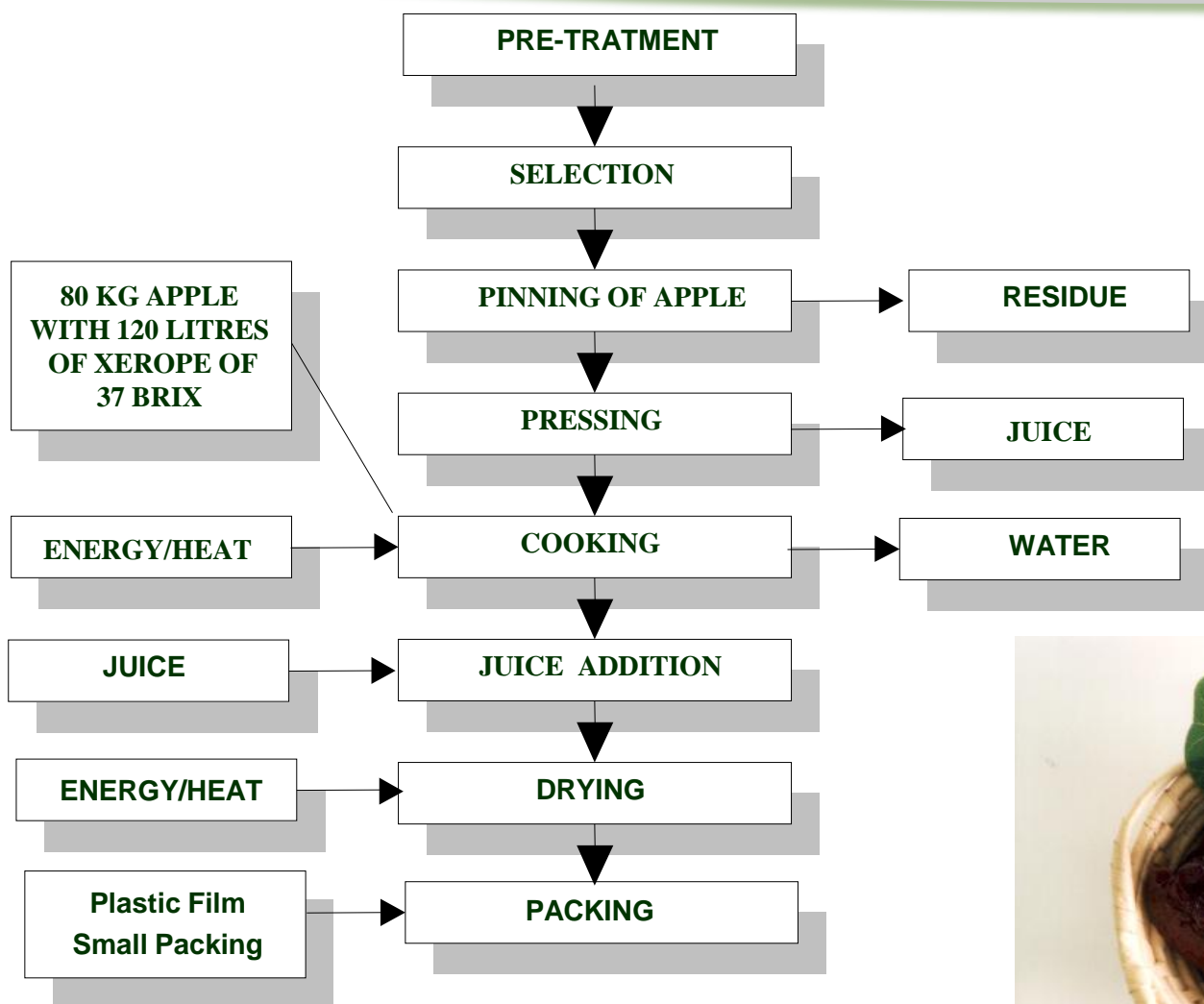
Producing cashew plum and cashew sweets, often processed with other cashew apple byproducts, requires a seven-step process



Cashew sweets on sale in Brazil



Cashew Plum looks like dry mangoes sweet and nutritious, have a good place in local markets, can be easily made on farmer level



Cashew Plum – Production Process Description



Selection of Apples The stems should be selected according to the degree of maturity and integrity. The appearance factor in this case is not as important as the final product acquires a dark colour and loses its initial form.

Pinning Apples Aiming to facilitate the removal of juice during the pressing, the apples should be pinned with the help of fork.

Pressing the apples are pressed manually for extraction of juice, apples will take a certain shape, which will make it easy to be placed in layers in the baking container. The juice extracted should be reserved for later reinstatement proceedings.

Cooking of Sugar immersed Apple Cashew are arranged in layers equal spaced with sugar in the pan where they will be cooked, so that the first layer is sugar, followed by an intermediate layer and then four layers of apples and sugar.

The product can also be obtained by cooking the whole stalk in sucrose syrup, with the following formulation:

- 80 kg with a stem length of approximately 8 cm
- 120 kg of syrup of 37 Brix.

Cooking Cooking should be very slow, a factor which depends on the product's success. A quick cooking will cause burning of the sugar and cashew drying, losing the characteristics of flavour and texture desired for the product.

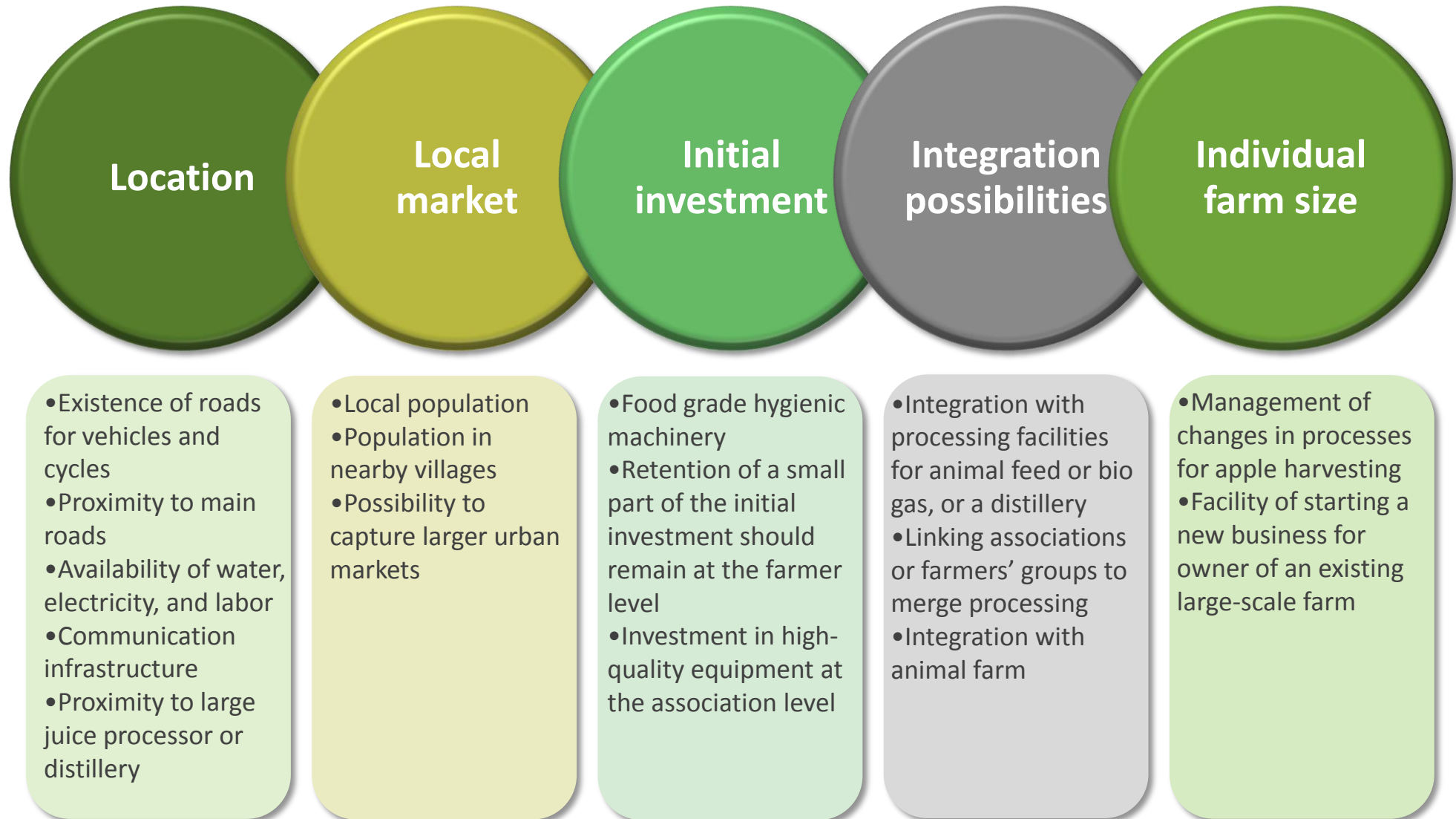
Adding Juice back while Heating At the beginning of the cooking process, apples would lose little water, however, with prolonged cooking, the water evaporates and must be replaced gradually by the previously extracted juice. If necessary add more water if the juice is insufficient. The amount of liquid to be added should be controlled by the operator, so that at the end of the process remains only a thick syrup and lightly caramelized.

Light Agitation during Cooking The cooking of this product is quite long, about 10 hours, and the end point is given by the colour of candy. The fruit must achieve a dark colour (caramelized) and uniform texture.

Drying After the initial cooking, the product undergoes a drying process. You can dry the product on tray dryers with hot air circulation and a temperature of 60-70 C, to prevent hardening of the product.

Packing The high sugar content and drying makes the cashew-plum a product which does not allow development of micro-organisms. The packages that are recommend for this type of product are: polyethylene, polypropylene

In selecting suitable cashew byproducts for value addition, there are several important factors to consider



PROPOSAL 1: Processing of cashew apple juice would result in sustainable returns to the farmer

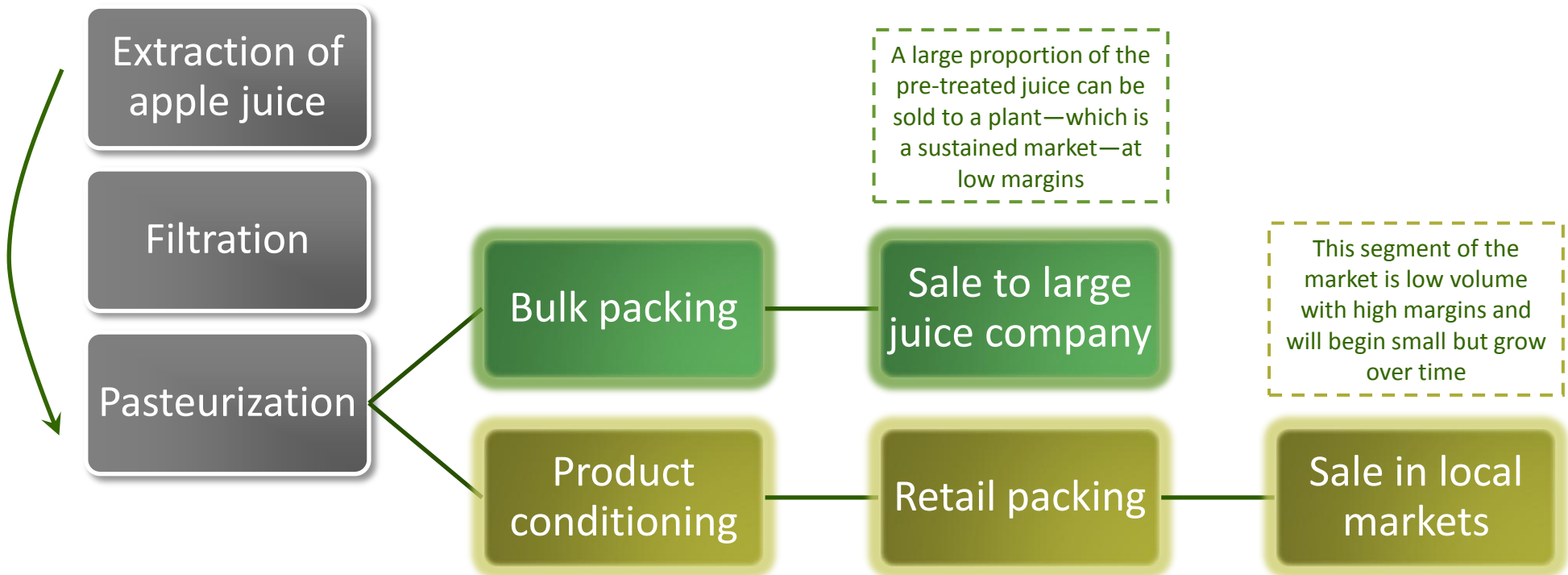


Two-tiered processing: primary processing occurs at the farm level and then apples are transported to a larger juice manufacturing plant

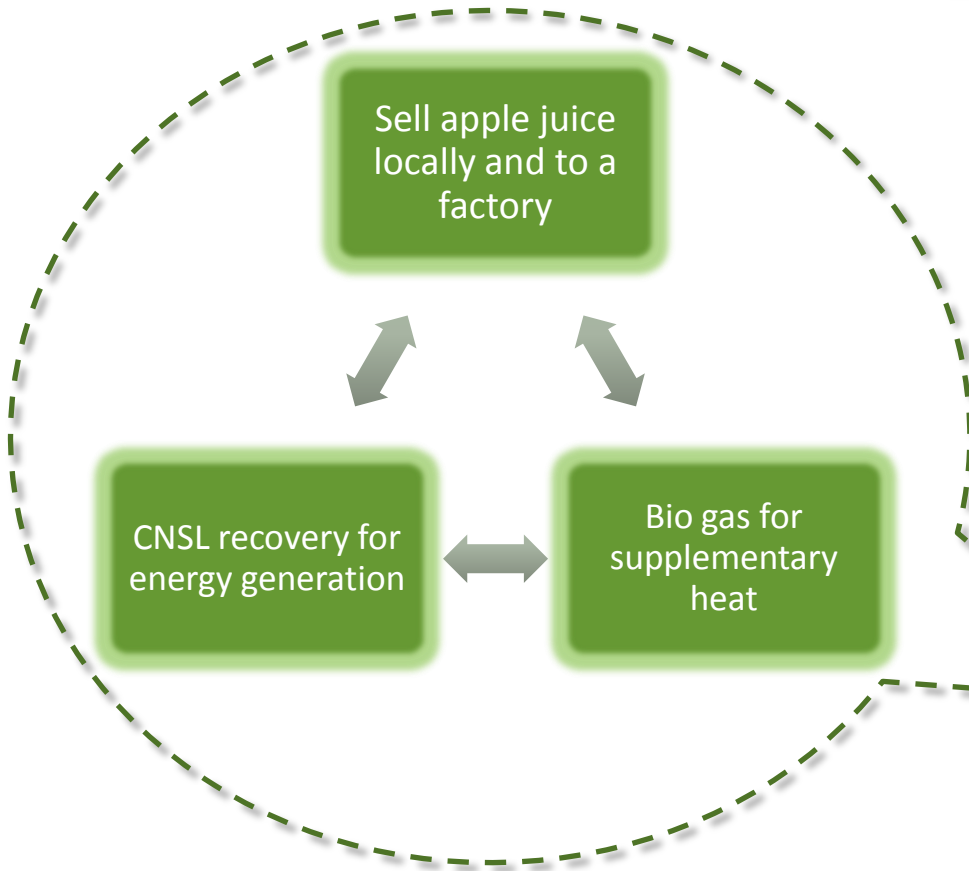
The success of this strategy is predicated on the **proximity of a large juice manufacturer**, which should be located no more than 100 km away, cutting down on the need for workers and allowing those who are there to focus on incoming apple quality

Key financials

Investment required	27,000 USD
EBIT	5,400 USD
Payback	2.5 years
IRR	> 38%

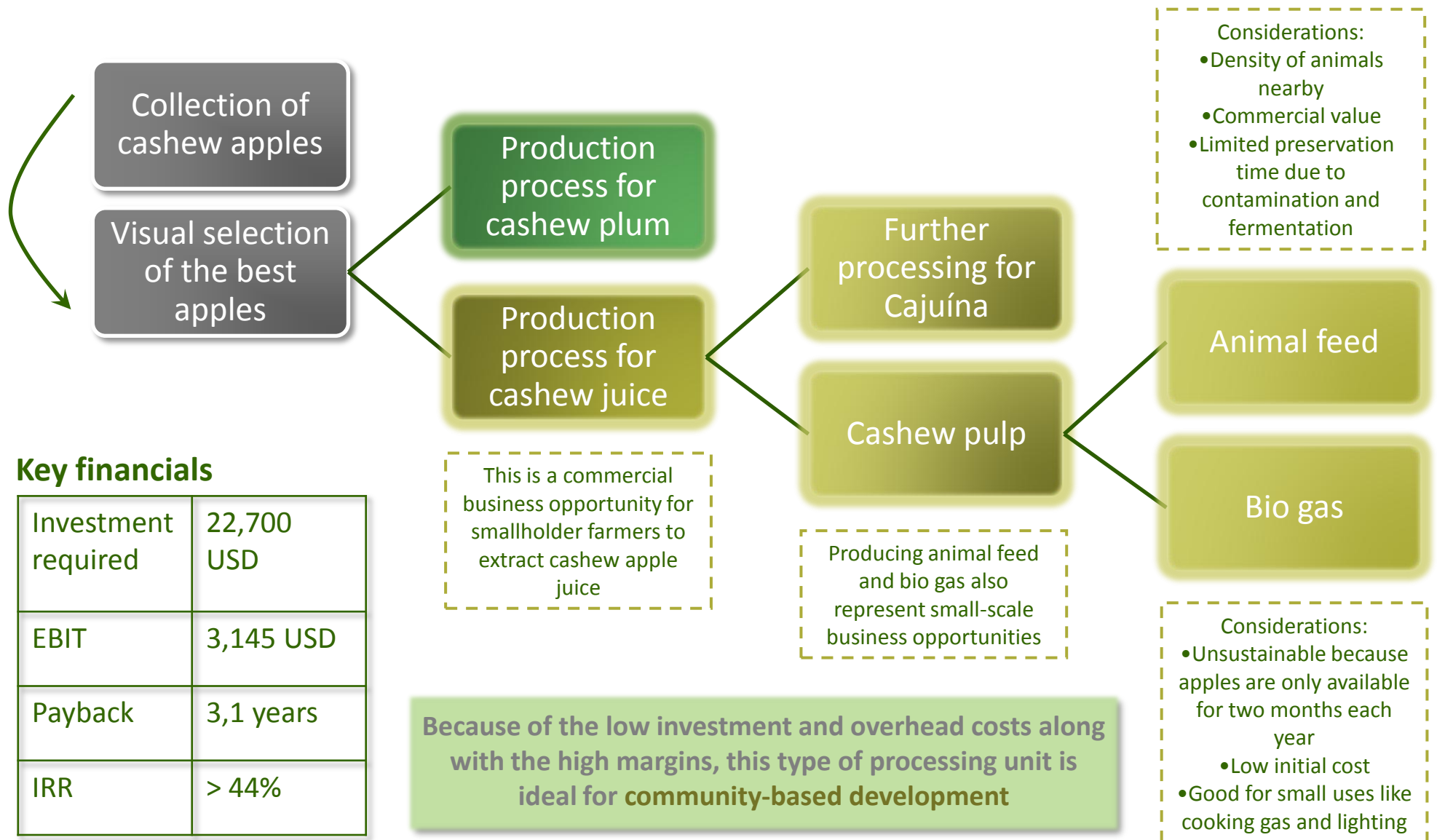


Banfora, Burkina Faso is an ideal location for implementing this proposal: there are large cashew farms and substantial cashew and juice processing plants within 100 km of each other



Though many conditions are favorable for the establishment of this business, a long-term agreement with the juice factory is a prerequisite for investment

PROPOSAL 2: Establish a community-based integrated processing unit to produce cashew plum, cashew juice and Cajuína, cashew pulp, animal feed, and bio gas



A farmers' association in Savé, Bénin extracts cashew apple juice, which it packages in recycled beer bottles and sells in the local market for 250 FCFA



Selection of cashew apple trees is determined based on the taste of the apples

The association demands visibly high-quality apples from the owners of the trees

Of the apples that the farmers select, 70% are used for juice extraction, allowing the association to collect 300-500 kg of apples daily



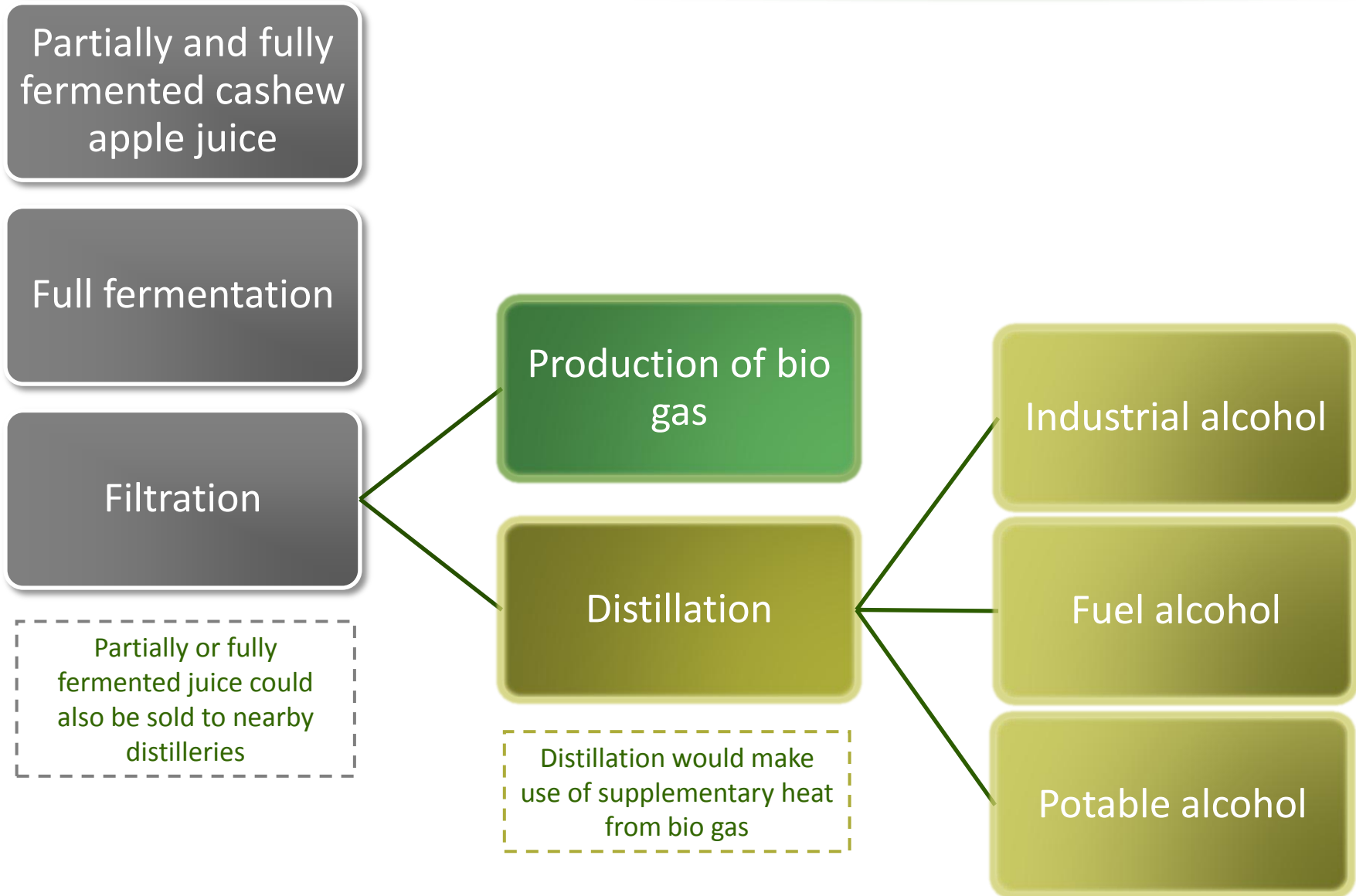
The available bottles are limited, preventing the association from looking into larger, city-based markets

The juice is filtered through a cloth and packaged in recycled beer bottles



The juice is pasteurized in simple, open vats for 30 minutes at 85°C, resulting in 500 ml of juice per kilogram of apples

PROPOSAL 3: Producing alcoholic beverages from cashew apples would be a highly profitable venture, though it requires a high initial investment

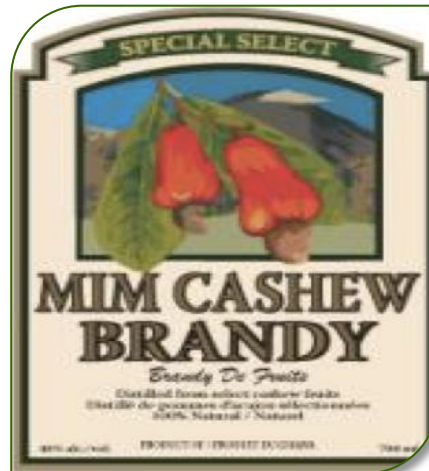


MIM in Ghana is currently producing alcohol from all of the apples on its plantation

Because the apples must be fermented for alcohol production, the apples can be collected from the ground

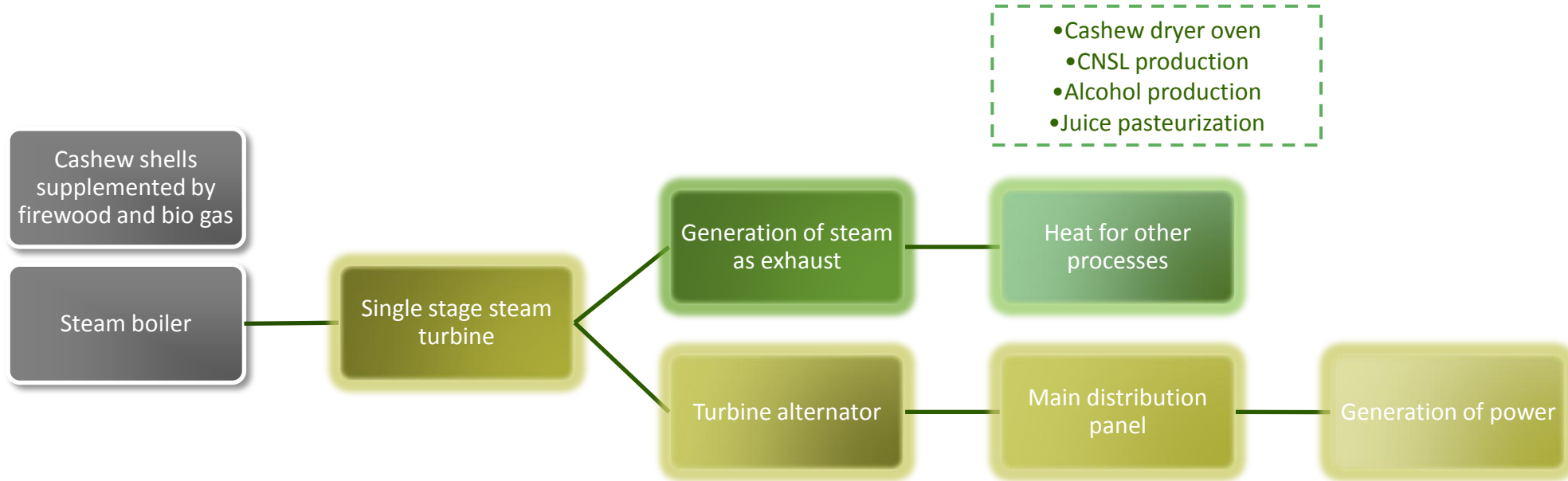


There is the potential for the incorporation of other value added products, including cashew apple juice and bio gas



MIM test-marketed the product in 2009 and is now prepared to create a market through branding and promotion

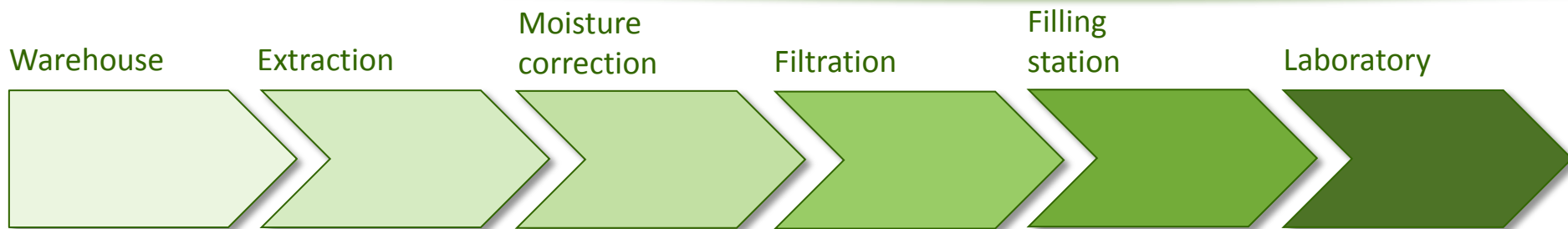
PROPOSAL 4: Generating electricity from cashew shells and apples would require a substantial initial investment, but would ultimately be very low-cost



This strategy is best suited for a large processing plant with substantial capacity in order to justify high initial investments



PROPOSAL 5: Extracting and refining CNSL is a repeatable strategy that would result in sustainable returns to a larger-scale farmer



	Warehouse	Extraction	Moisture correction	Filtration	Filling station	Laboratory
Description	Storage in a dry place	Press shells to extract CNSL	Heat CNSL at a high temperature to eliminate any water	Separate liquid and precipitate	CNSL held in storage tanks before being packed and transported	Ensure that product meets international standards
Required equipment	Pre-fabricated structure	1 expeller, 1 oil tank	Heating pan with cooling coils, pumps	Centrifuge with powerful motor, pumps	Hose with accessories, pumps	Tools to check quality parameters

This strategy—which would target mostly South African, Korean, and Japanese industries—requires little initial investment and has low overheads and high margins

CNSL has several advantages over several existing synthetic alternatives, including lower impact on the environment and lower price

Key financials

Investment required	128,000 USD
EBIT	21,072 USD
Payback	3 years
IRR	>70%

