Chapter 2

Leaf harvesting and processing: a literature review

An aloe tapper harvesting leaves from an *Aloe ferox* plant.

Chapter 2: Leaf harvesting and processing: a literature review

The aloe industry produces different commercial raw materials, including bitters, gels, whole leaf extracts, powders and so-called 'jelly' (see below). There are two distinct layers in aloe leaves which are clearly visible in transverse section (Fig. 2.1): the green outer leaf rind and the soft, colourless inner gel parenchyma. Processing techniques vary according to what part of the leaf is required for a particular product/use especially with regard to the bitters and gel. Some products comprise pure gel, while others are based on various mixtures of gel and bitters, depending on the end product. This chapter will be used to describe how aloe leaves are harvested and also how they are processed. The techniques described are not species-specific (except in the case of machine filleting of *Aloe vera*) and can be used for all species of *Aloe*. A diagram summarising this entire procedure is given in Figure 2.2, with definitions and terminology listed in Table 2.1.

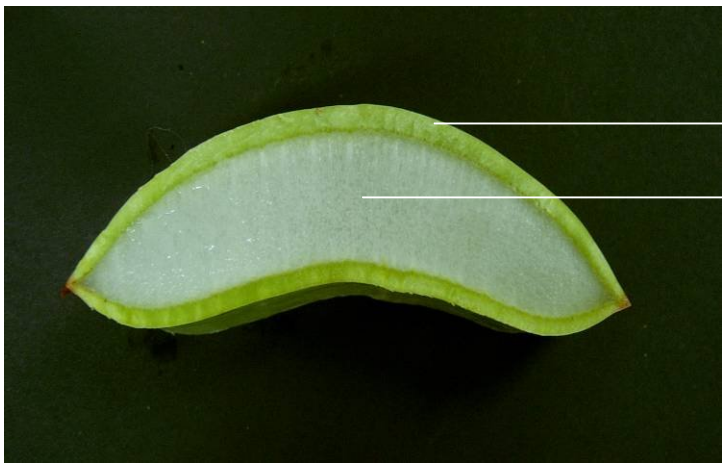

Figure 2.1: Transverse section of an aloe leaf. Note the distinct separation into two layers, the green leaf rind and colourless gel parenchyma.

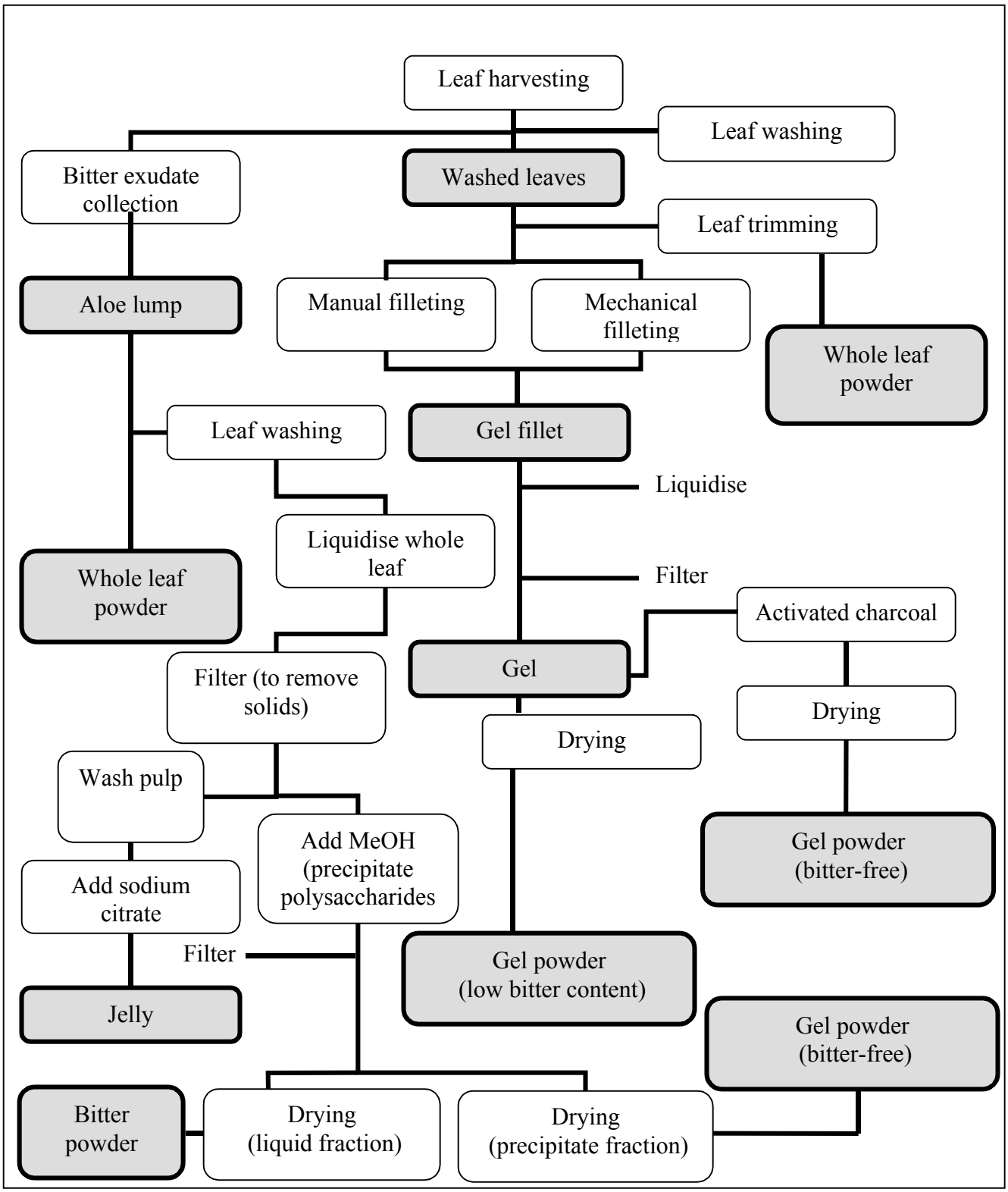

Figure 2.2: Flow diagram summarising the production steps and products in the aloe industry as discussed below. Shaded blocks represent the final products.

Table 2.1: Definitions and terminology used in the aloe industry.

Term	Definition
Bitter exudate	Usually a yellow sap released from the so-called aloin cells (oblong cells which may form continuous canals) situated below the leaf rind, close to the inner gel parenchyma. It contains phenolic compounds, and has a bitter taste and a laxative effect.
Dehydration	A form of drying. Gel fillets are exposed to warm air flow and dried. Fillets are then ground and powdered to form gel powder.
Filleting	This is a mechanical procedure whereby the outer rind of a leaf is removed from the inner parenchyma layer resulting in a gel fillet. This procedure can either be done manually or mechanically.
Freeze-drying	A form of drying. Gel is exposed to low temperatures and a strong vacuum for approximately 24 hours depending on the volume. Moisture is removed from the gel forming gel powder.
Gel	Once the gel fillet has being liquidised and filtered, the resultant juice is known as aloe gel. It is usually low in bitters or may be bitter-free.
Gel fillet	This is a term given to the clear, inner parenchyma of the leaf resulting after the filleting procedure.

Table 2.1: continued.

Term	Definition
Gel parenchyma	Layer of colourless, tasteless tissue found within the central portion of an aloe leaf.
Gel powder	A product obtained by freeze-drying or spray-drying of gel.
Jelly	Product formed after treating *Aloe ferox* gel with sodium citrate to release polysaccharides (patented process).
Leaf harvesting	Leaves are cut by tappers using a sickle. The leaves are removed close to their bases. Approximately eight leaves per plant are harvested, ensuring recovery of the plants so that the populations are not diminished.
Leaf rind	This refers to the leathery outer, green layer of a leaf.
Leaf tapping	A term referring to the collection of bitter exudate from aloe leaves. Harvested leaves are placed with their cut bases facing inward around a central basin lined with plastic. Bitter sap is collected over a period of approximately six hours.
Spray-drying	A form of drying. Gel is applied to a matrix which is then sprayed as a fine mist through a heated chamber allowing water to evaporate forming gel powder.

Table 2.1: continued.

Term	Definition
Tappers	Individual entrepreneurs (usually from local communities) who are responsible for the harvesting and tapping of aloe leaves. They are equipped with sickles, gloves, protective clothing and a plastic sheet allowing them to collect leaf sap.
Whole leaf powder	Whole leaves (rind and gel parenchyma) are ground into a fine powder which is air-dried in the *Aloe ferox* industry.

2.1 Leaf harvesting

Teams of tappers are usually assigned aloe populations or particular areas where they can harvest leaves. In the Eastern Cape, tappers traditionally operate as independent entrepreneurs. Payment for the right to harvest on a particular farm is made in the form of an agreed portion of the harvest that goes to the farmer. Leaves are cut from the plants using a sickle, cutting relatively close to the base of the leaf (Fig. 2.3). When any aloe leaf is cut, a yellow liquid drips from canals (the so-called aloin cells) situated just below the rind (Fig. 2.4). Leaves are stacked (cut edges facing inward) around a hollow in the ground which is lined with a plastic sheet (Fig. 2.5). The yellow bitter exudate which is released from the cut edges are collected in the central basin. This exudate is then boiled by the tappers in a drum to remove water. Once cooled, the exudate solidifies into a dark brown, amorphous, glass-like solid known as aloe lump (Fig. 2.6) and is sold as a laxative product. If the bitters is derived from *Aloe vera* leaves, the commercial product is known as Curaçao Aloes. In the case where *Aloe ferox* bitter exudate is used, the product is

known as Cape Aloes. Cape Aloes is still of commercial importance in the pharmaceutical industry where it is an important ingredient of traditional bitter tonics such as Lewensessens and Sweden-bitters. It is well known that bitter substances stimulate the flow of gastric juices, thus improving digestion (Schulz *et al*., 2001; Van Wyk and Smith, 2003). Aloin is responsible for the laxative effect of the bitters (Fig. 2.7) (Cohen, 2003). Aloesin is a chromone derivative used in cosmetics for a skin-lightening effect (Fig. 2.7) (Watson, 2005).

Figure 2.3: An aloe tapper demonstrating how Aloe ferox leaves are harvested.

Figure 2.4: Exposed inner portion of an aloe leaf illustrating the yellow exudate that is released. This sap is extremely bitter and has a laxative effect.

Figure 2.5: Harvested aloe leaves stacked around a central hollow basin lined with plastic. Bitter exudate is collected in this central hollow.

Figure 2.6: Aloe lump. An amorphous, glass-like solid sold as a laxative product.

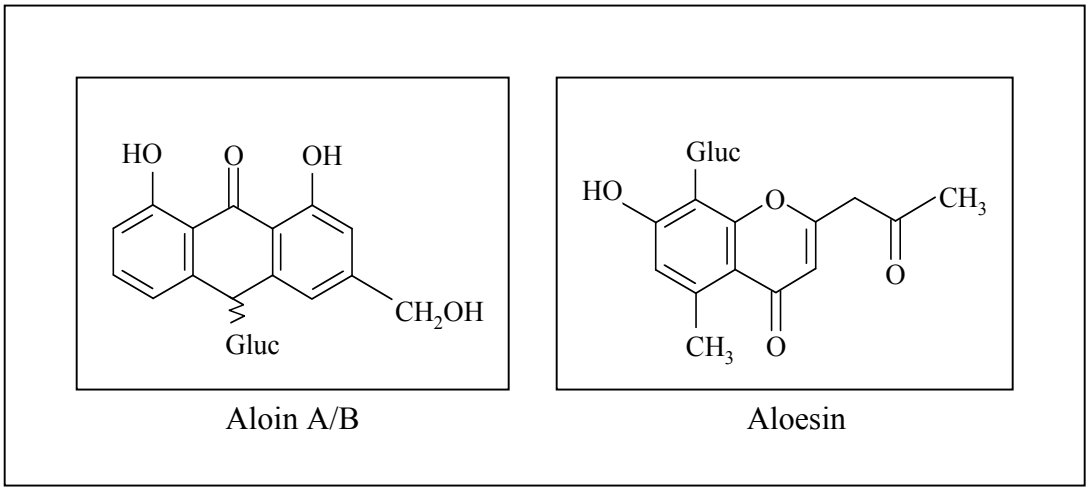

Figure 2.7: Two compounds present in the leaf exudate of Aloe ferox. Aloin is known for its purgative effect and aloesin for its skin-lightening properties.

Once tappers have extracted the bitter sap from harvested leaves, they sell the leaves to a gel factory. The inner portion of the aloe leaf (gel parenchyma) is now used to produce various aloe gel products. This initial tapping procedure is not always favoured. In the *Aloe vera* gel industry, leaves are harvested with the base of the leaf sealed (Waller *et al*., 2004) as shown in Figure 2.8. The leaf is peeled or pulled from the stem in order to prevent gel exposure. This results in a better quality gel as exposed gel allows for bacterial contamination (Waller *et al*., 2004). Leaves harvested for the bitter exudate are used to produce whole leaf powder. The whole leaves are simply sliced, dried and powdered (Fig. 2.9).

Figure 2.8: Aloe vera leaves showing the two ways of harvesting. On the left the leaf has been cut off the plant exposing the gel. On the right the leaf has been peeled from the stem leaving the leaf sealed and not exposing the inner gel.

Figure 2.9: Whole leaf powder made from Aloe ferox leaves. Whole leaves are powdered and dried in the sun.

2.2 Leaf processing

Harvested leaves have dried exudate and dirt on their surfaces. Washing is therefore the first step in the gel processing procedure. According to Waller *et al*. (2004), *Aloe vera* leaves ideally need to be washed within two to four hours after harvesting. Obviously in the *A. ferox* industry this does not happen as quickly as the leaves are first tapped, a procedure that takes about six hours (Newton and Vaughan, 1996). According to Waller *et al*. (2004), leaves are initially washed in a sterilising solution (a 200 ppm solution of sodium hypochlorite is used in the *A. vera* industry). Leaves are then further rinsed with water or in the case of *A. vera*, a diluted solution (20 ppm) of sodium hypochlorite. If leaves are extremely muddy when delivered to the gel factory they are pre-washed in a basin of deionised water. In some cases, the pre-wash step involves scouring the leaf rind with soft brushes (McAnalley, 1990). Washed leaves can either be sold by the factory or further processed for gel. Washed *Aloe vera* leaves are sold in the United States for approximately $4.00 per kilogram (Waller *et al*., 2004).

Washed leaves are now trimmed, meaning that the sides, tip and base of the leaf are cut away (Fig. 2.10). These trimmed pieces are collected (Fig. 2.11) and used to produce whole leaf powder as shown in Figure 2.9. Trimmed leaves can now be filleted. Filleting may be carried out in one of two ways; either manually (Fig. 2.12) or mechanically (Fig. 2.15). Hand filleting produces the best quality gel, but nowadays mechanical filleting is widely used. Another advantage of manual hand filleting is that leaves of any size, shape or thickness can be used. Gel fillets can be sold as an end product, but are often processed to make liquid gel or gel powder. Preservatives are added and the fillets are transported under refrigeration to prevent bacterial degradation and loss of quality.

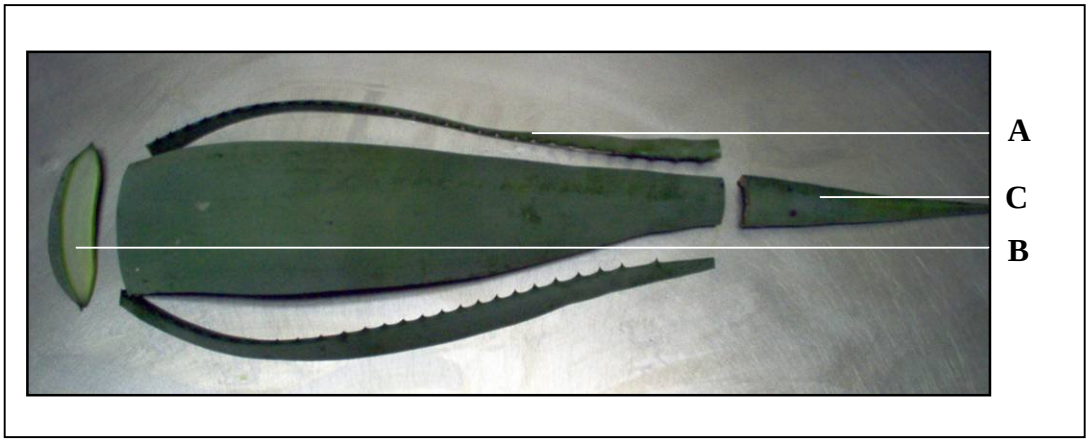

Figure 2.10: Leaf trimming procedure resulting in A, removal of the sides; B, removal of the base; C, removal of the tip of the leaf.

Figure 2.11: Cut off leaf bases are collected and used to make whole leaf powder.

Figure 2.12: Manual filleting technique. Aloe leaf gel is cut away from the leaf rind by hand, resulting in a high quality gel with low bitter content.

Manual filleting usually takes place on a stainless steel surface. It is the preferred method in the *A. ferox* gel industry and in the *A. vera* gel industry but in the latter mechanical filleting is often used. *Aloe ferox* leaves are firmer and easier to fillet by hand. In the

case of *A. ferox*, prior to filleting the inner portion of the leaf is cut longitudinally into strips (Fig. 2.13). The rind is then carefully removed from the inner gel using a sharp knife. Any rind or bruises left on the gel are cut away resulting in a blemish-free gel fillet (Fig. 2.14). Gel fillets are then soaked in water to ensure that any remaining bitters are washed off. Gel fillets are then drained, bagged and refrigerated. When filleting *A. vera* leaves by hand, the upper rind is removed and the gel is scooped from the lower rind with a blunt knife.

Figure 2.13: Aloe ferox leaf showing the various cuts that are made prior to filleting. Once the base, tip and thorny margins are removed, the middle portion of the leaf is cut into longitudinal sections to make filleting easier.

Figure 2.14: Hand filleting of Aloe ferox leaves, showing how blemishes present in the gel fillet can be cut away. Thus gel fillets that are manually filleted are of a higher quality than gel fillets obtained through mechanical filleting.

Figure 2.15: Mechanical filleting of Aloe vera leaves. On the left is a close-up photo showing the roller and conveyor belts. The photo on the right is of some of the filleting machines in the factory. (Photo from B-E. Van Wyk).

Mechanical filleting is well developed in the *A. vera* gel industry. This process takes place on a conveyer belt equipped with rollers and blades (Fig. 2.15). Firstly, the leaf (upper surface facing downwards) is passed over a blade mounted on a table. The upper rind is cut away in one swift movement. The exposed gel surface is then longitudinally sliced from the upper to lower surface but not completely through the lower rind surface so that the curved lower rind becomes flat. The lower rind can now be easily removed by passing it over the blade as before. The gel slices are collected.

The next step in gel processing is the removal of cellular material from the gel. Gel fillets are chopped into small chips and de-pulped using sieves (Waller *et al*., 2004). Gel fillets can also be liquidised as in the fruit juice industry and filtered to remove cellular material. After removal of the fibre, only the liquid gel remains.

The gel in this crude form is sold as a commercial product, but may also be mixed with activated charcoal, filter pressed, stabilized (preserved) and dried. Treatment with activated charcoal ensures that any anthraquinone compounds in the gel are removed. In the *A. vera* industry, 0.05 % w/v charcoal is added to 2000 L gel (Waller *et al*., 2004). After approximately one hour the gel is filtered through Celite Filteraide. Following filtration using this method, the filtrate is decolorized and free of fine charcoal particles (Qui *et al*., 1999).

For export purposes (especially for cosmetic industry), dried *Aloe* gel is favoured (Fig. 2.16). Gel fillets can be directly dried by dehydration under a low heat. However, gel liquid is mostly dried either by spray-drying or freeze-drying (Waller *et al*., 2004). Freeze-drying involves placing frozen gel under a high vacuum. Water sublimes from the frozen gel as it gradually heats. Spray-drying is a two step process. As described by Waller *et al*. (2004), the process begins with matrix development. The matrix is pumped through a spray dryer chamber. Fluid is sprayed as a fine mist out a series of nozzles through this chamber. The chamber is heated between 50 to 90 ˚C causing water to evaporate and the aloe matrix to dry. With temperature playing a crucial role in maintaining natural plant products, freeze-drying is favoured. Heat is not added so that

chemical transformations are minimized and the biological activity of the gel is not altered as may be the case with spray-drying.

Two other patented processes to obtain gel are commonly used in the aloe industry. The first is a method to extract gel polysaccharides by alcohol precipitation (McAnalley, 1990). As described in the McAnalley (1990) patent, 20 gallons of aloe gel are pumped into 100 gallon tanks. Ethanol (80 gallons) is added to the aloe gel and stirred for 20-30 minutes. The alcohol-aloe gel mixture is then left to stand for four hours. The clear supernatant that forms is decanted or siphoned off, without disturbing the precipitate on the bottom of the tank. The solution is then placed into centrifuging buckets and centrifuged. The precipitate formed is collected and washed with fresh ethanol. This fraction is then freeze-dried. The second process is used in the *Aloe ferox* industry in combination with alcohol precipitation (Botha, 1994). The pulp remaining after liquidised aloe gel is filtered is used for this process. This pulp is treated with sodium citrate that results in the freeing of polysaccharides from calcium. Water is added and the mixture is heated. This mixture is then filtered, and the liquid fraction, which contains the calcium free polysaccharides, is known as aloe 'jelly'.

Careful storage of gel (liquid or powder) is important to prevent loss of quality. Relative humidity and temperature affect product quality and shelf life (He *et al*., 2004). Freeze-dried gel has to be packaged in airtight containers or kept under dry conditions as it rehydrates rapidly (Femenia *et al*., 2003).

Figure 2.16: Aloe gel powder resulting from the freeze-drying of gel.

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